

Process Modeling of Bus Services in a Bus Station

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Abstract

Modeling is one important parts in designing a product or a service system. It aims to reduce the cost and minimize the improper of early production/service stage that could be ended by high loss of economic value. Process modeling of bus service is required to obtain proper information regarding number of buses required based on the prediction number of passengers and time consumes. This paper is aimed to investigate the very early stage of bus service modeling using Visual Basic Excel Program. The result shows that the model system that using five inclusive sheets programming for covering the main item in the bus service system is sufficient to represent the real condition in the practical condition.

Keywords: Modeling, Bus Service, and Visual Basic Excel Programming.

I. INTRODUCTION

Modeling is an important part of process design of a product or a service [1]. Modeling could avoid an economic losses due to improper design [2]. There are many product and subjects have involved modeling part in their studies, for example; modeling and simulation on fluid flow on vortex [3], modeling of electric machinery control [4], modeling of SMES application in smart grid system [5] and modeling of Wind Turbine Generator [6].

Buses services are the most important in the residential city. As a public transport it plays an important role in human activities [7]. Therefore, it is pivotal to design the process of bus service in picking or dropping passengers.

The purpose of modeling the bus services is to determine whether the number of buses operating is suitable with the number of passengers. This is to allow for future enhancement of the currently implemented system.

This is done by observing the delay time of each passenger. An example of a scenario of which such model observations would be applicable would be as follows: In the process, the number of bus services available has to be added if the currently available services cannot accommodate the huge number of passengers who needs to catch the buses. This would allow for the bus services to achieve effectiveness and efficiency.

II. METODE PENELITIAN

In this model, the number of buses to stop and pick up the passengers is three: **Bus 101**,

bus 102, bus 103. All the buses have different routes and destinations. The simulation of this model was done by using Visual Basic in Excel. There are 5 sheets in this modeling:

1. Input Sheet, where the initial data is entered for the whole process.
2. Match Pass Bus Sheet. In this sheet, the calculation of time for passenger arrival is not written in this sheet (it is written in the "Simulation Sheet"). The filtered id passenger with the bus to be caught is recorded in this sheet
3. Bus Process Sheet. All bus processes are calculated and recorded in this sheet.
4. Time Depart Sheet, where In this part, we are going to see departure time of every passenger and as previous sheet, all information are grouped according to the bus number.
5. Simulation Sheet. In this final sheet, we can see id passenger, arrival time, bus to be caught by the passengers, bus service order for each bus, the time the passenger will depart and delay time of each passenger.

III. RESULT AND DISCUSSION

1. Input Sheet

Input sheet is aimed to input all the data required for this modeling, which can be changed by another set of data and see the difference. As can be seen from the figure below, the number of passengers that arrives at the bus station platform A is 50 passengers per hour or 0.833 pass per minute.

The total number of passengers simulated in this modeling is 600 passengers and the maximum number of passengers that can be entered is 1000 passengers (according to the Visual Basic dimension) but if the number of passenger is higher then 600, it will result a delay time in “#####” form of simulation sheet, it means that the passengers actually were not picked up.

All passengers are assumed to be obeying the queuing process. Assisted value is added to the sheet to determine the bus to be caught by the passengers using *normal distribution*. The number of passengers that is allowed to enter the bus also needs an assisted value with *normal distribution*. The number of passengers that is allowed to enter the bus *depends on the number of seats available and the space that is available for standing after other fellow passengers gets off the bus.*

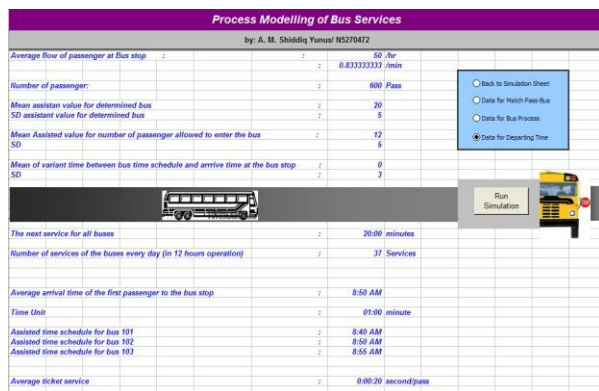


Figure 1. Model of Input Sheet.

In this sheet, the time variance is also determined to calculate the arrival time of the buses. This is to determine the frequency and punctuality of the buses. Determining the precise timings of the buses that are on time are not easy to achieve as the precise timing used in this modeling is of the time format in *hour: minute: second*.

For example: the scheduled time of arrival for bus 101 is at 9:00:00 AM, and with time variance of 00:00:01, it is determined to be late. Therefore, the bus is not on time even if the difference is by 1 second.

The time schedules for the buses 101, 102 and 103 are also determined here and they have *20 minutes interval*. The number of bus services in this modeling is *37 services* and it finishes at around 9:00:00 PM. It is decided in this sheet that the average time of the first

passenger to come to the bus station is at 8:50 AM, so the modeling can now be measured.

The time unit in this sheet is *one minute* and the average time for ticketing service for each passenger on the bus is *20 second*.

To run this process modeling, you can simply press the “**Run Simulation**” or simply press **CTRL+Q** in your keyboard. You can also have access to every single sheet by clicking on the blue box for sheet selection on the right side of this sheet.

2 Match Pass-Bus sheet

In this sheet, the calculation of time for passenger arrival is not written in this sheet (it is written in the “Simulation Sheet”). The filtered passenger id with the bus to be caught is recorded in this sheet. As can be seen from this sheet, all id passengers for bus 101, 102 and 103 are reallocated together with their arrival time. The first column is for id passenger and the second column is for arrival time of passenger using *continuous random* event. To convert it to real time in o'clock, it needs to be multiplied with *time unit* and added to the *average time* that the first passenger comes to the bus station as can be seen in the third column.

$$\text{Arrival Time in O'clock} = \text{Arrival Time} \times \text{Time Unit} + 8:50 \text{ AM}$$

Process Modelling of Bus Services									
Bus 101			Bus 102			Bus 103			
Pass #	Arrival Time	Arrival Time (o'clock)	Pass #	Arrival Time	Arrival Time (o'clock)	Pass #	Arrival Time	Arrival Time (o'clock)	
4	2:02	8:52:01 AM	1	0:42	8:50:25 AM	3	1:27	8:51:16 AM	
6	7:29	8:57:17 AM	2	0:70	8:50:42 AM	7	6:37	8:56:22 AM	
7	9:14	8:59:08 AM	5	3:46	8:53:28 AM	9	8:92	8:58:55 AM	
8	12	13:01	9:03:00 AM	6	5:35	8:55:21 AM	14	14:81	9:04:49 AM
9	13	14:64	9:04:38 AM	11	11:12	9:01:07 AM	16	16:31	9:06:19 AM
10	15	16:08	9:06:05 AM	20	22:15	9:12:09 AM	18	17:97	9:07:58 AM
11	17	17:33	9:07:20 AM	21	22:17	9:12:10 AM	23	24:98	9:14:59 AM
12	19	21:24	9:11:14 AM	26	29:04	9:19:02 AM	24	26:33	9:16:20 AM
13	22	24:19	9:14:11 AM	27	30:17	9:20:10 AM	29	32:64	9:22:38 AM
14	25	28:84	9:18:50 AM	28	30:38	9:20:23 AM	31	36:25	9:26:16 AM
15	30	35:75	9:25:45 AM	34	40:28	9:30:17 AM	35	40:95	9:30:57 AM
16	32	38:51	9:28:31 AM	38	43:40	9:33:24 AM	37	42:61	9:32:37 AM
17	33	38:65	9:28:39 AM	39	43:42	9:33:25 AM	43	45:48	9:35:29 AM
18	36	41:21	9:31:12 AM	42	45:21	9:35:12 AM	45	48:03	9:38:02 AM
19	40	43:85	9:33:51 AM	46	51:22	9:41:13 AM	48	54:91	9:44:55 AM
20	41	44:89	9:34:54 AM	47	51:55	9:41:33 AM	49	58:83	9:48:50 AM
21	44	46:95	9:36:57 AM	51	61:78	9:51:43 AM	52	63:77	9:53:46 AM
22	50	60:93	9:50:56 AM	59	70:22	10:00:13 AM	55	66:83	9:56:50 AM

Figure 2: Match the passenger with bus to be caught

As mentioned before, all data of the id passenger, arrival time and arrival time in o'clock are recorded or written in simulation sheet and then filtered in this sheet.

3 Bus Process sheet

All bus processes are calculated and recorded in this sheet as depicted in figure a, b and c. The first column is a column for bus service order (from scheduled service 1 until service 37). The number of services for all buses is set up to serve passengers from 9:00 AM to 9:00 PM for bus 101, from 9:10 AM to 9:10 PM for bus 102 and from 9:15 AM to 9:15 PM for bus 103 everyday.

As can be seen in column 2, information about the time schedule for each bus services are available to determine whether the bus *comes early* or *comes late*.

Time variance is sitting in column 3. Time variance is determined by *normal distribution event*. It is aimed to determine *the status of the bus*. If time variant is in the (-) mark, then the status of the bus is coming earlier from its schedule. If time variant is in the (+) mark (which is not written in the spread sheet), then the bus is coming later than its schedule, therefore, the status of the bus is written in column 4.

To make the calculation easier, the time variance is then converted to real time in *min : sec* as can be seen in the column 5.

$$Real\ Time\ Variant = Time\ variant \times Time\ Unit$$

Bus 101						
Bus Service Order	Time Schedule (O'clock)	Time Variant	Status	Time Variant (min:sec)	Arrival Time of Bus (o'clock)	Number of Pass. Allowed to enter the Bus (Person)
1	9:10:00 AM	0.10	Comes Late	00:00:06	09:10:06 AM	12
2	9:40:00 AM	-2.72	Comes Earlier	00:02:43	09:37:17 AM	6
3	10:10:00 AM	-1.79	Comes Earlier	00:01:47	10:08:13 AM	5
4	10:40:00 AM	-3.07	Comes Earlier	00:03:04	10:36:56 AM	15
5	11:10:00 AM	-1.86	Comes Earlier	00:01:51	11:08:09 AM	17
6	11:40:00 AM	-3.74	Comes Earlier	00:03:44	11:36:16 AM	18
7	12:10:00 PM	2.38	Comes Late	00:02:23	12:12:23 PM	10
8	12:40:00 PM	2.27	Comes Late	00:02:16	12:42:16 PM	17
9	1:10:00 PM	-1.60	Comes Earlier	00:01:36	01:08:24 PM	14
10	1:40:00 PM	0.92	Comes Late	00:00:55	01:40:55 PM	16

a. Bus Process for 101

Bus 102						
Bus Service Order	Time O'clock	Time Variant	Status	Time Variant (min:sec)	Arrival Time of Bus (o'clock)	Number of Pass. Allowed to enter the Bus (Person)
1	9:10:00 AM	-2.52	Comes Earlier	02:31	09:07:29 AM	14
2	9:30:00 AM	-2.81	Comes Earlier	02:48	09:27:12 AM	14
3	9:50:00 AM	-4.65	Comes Earlier	04:39	09:45:21 AM	16
4	10:10:00 AM	-1.44	Comes Earlier	01:26	10:08:34 AM	16
5	10:30:00 AM	0.08	Comes Late	00:05	10:30:05 AM	8
6	10:50:00 AM	-5.10	Comes Earlier	05:06	10:44:54 AM	9
7	11:10:00 AM	-2.35	Comes Earlier	02:21	11:07:39 AM	16
8	11:30:00 AM	-2.31	Comes Earlier	02:18	11:27:42 AM	9
9	11:50:00 AM	1.05	Comes Late	01:03	11:51:03 AM	15
10	12:10:00 PM	6.43	Comes Late	06:26	12:16:26 PM	10
11	12:30:00 PM	2.25	Comes Late	02:15	12:32:15 PM	1
12	12:50:00 PM	-0.40	Comes Earlier	00:24	12:49:36 PM	5
13	1:10:00 PM	-0.75	Comes Earlier	00:45	01:09:15 PM	4
14	1:30:00 PM	0.67	Comes Late	00:40	01:30:40 PM	6
15	1:50:00 PM	5.02	Comes Late	05:01	01:55:01 PM	10

b. Bus Process for 102

Bus 103						
Bus Service Order	Time O'clock	Time Variant	Status	Time Variant (min:sec)	Arrival Time of Bus (o'clock)	Number of Pass. Allowed to enter the Bus (Person)
1	9:15:00 AM	-2.40	Comes Earlier	02:24	09:12:36 AM	13
2	9:35:00 AM	-1.97	Comes Earlier	01:58	09:33:02 AM	6
3	9:55:00 AM	4.28	Comes Late	04:17	09:59:17 AM	14
4	10:15:00 AM	-4.55	Comes Earlier	04:33	10:10:27 AM	16
5	10:35:00 AM	3.36	Comes Late	03:22	10:38:22 AM	6
6	10:55:00 AM	1.52	Comes Late	01:31	10:56:31 AM	3
7	11:15:00 AM	-4.91	Comes Earlier	04:54	11:10:06 AM	12
8	11:35:00 AM	5.97	Comes Late	05:58	11:40:58 AM	4
9	11:55:00 AM	0.70	Comes Late	00:42	11:55:42 AM	8
10	12:15:00 PM	1.53	Comes Late	01:32	12:16:32 PM	20
11	12:35:00 PM	-0.59	Comes Earlier	00:35	12:34:25 PM	6
12	12:55:00 PM	1.95	Comes Late	01:57	12:56:57 PM	13
13	1:15:00 PM	-2.53	Comes Earlier	02:32	01:12:28 PM	6
14	1:35:00 PM	-0.04	Comes Earlier	00:02	01:34:58 PM	9
15	1:55:00 PM	1.11	Comes Late	01:06	01:56:06 PM	18
16	2:15:00 PM	3.29	Comes Late	03:17	02:18:17 PM	16

c. Bus Process for 103

Figure 3: Bus Process of all buses in platform A

Arrival time is then calculated by summing the bus schedule with its time variance. It is placed at column 6.

$$Arrival\ Time\ of\ Bus = Bus\ Schedule - Time\ variant\ (for\ status\ bus:\ comes\ earlier)$$

$$Arrival\ Time\ of\ Bus = Bus\ Schedule + Time\ variant\ (for\ status\ bus:\ comes\ late)$$

To determine the number of passengers that is to be allowed to enter the bus, *normal distribution event* is also applied in this calculation. It is assumed that the number of passengers that is allowed to enter the bus is dependant on the number of seats and space to stand after the other passengers get off from the bus. Information about this is written in column 7.

4 Time Depart sheet

In this part, we are going to see departure time of every passenger and as previous sheet, all information are grouped according to the bus number, e.g., Bus 101, 102 and 103. Column one is Id of passenger which is followed by their arrival time in the second column. All of this data are referring to the previous sheet. The third column is filled with the matching bus order with every passenger, so the bus driver will allow them to enter the bus when *two conditions* are fulfilled.

- **First condition:** Arrival Time of passenger is less or at least equal to the expected time that the bus will depart.
- **Second condition:** The Number of passengers allowed to enter the bus
So, even though the time when the passenger arrives at the bus stop is less or the

same with the time when the bus is expected to depart, they have to see whether there are available seats or space to stand..

Ticket service time in column four is calculated as below:

$$\text{Ticket service time} = \text{Arrival time of bus at platform} + \text{number of passengers getting on} * \text{average ticket service}$$

	Bus 101				
	Id_pass	Arrival time	Bus Service in order	Ticket Service Time	Time Depart
6	2	08:53:23 AM	1	9:09:13 AM	9:13:20 AM
7	3	08:54:28 AM	1	9:09:33 AM	9:13:20 AM
8	9	09:05:09 AM	1	9:09:53 AM	9:13:20 AM
9	15	09:11:35 AM	1	9:11:55 AM	9:13:20 AM
10	17	09:13:00 AM	1	9:13:20 AM	9:13:20 AM
11	20	09:17:10 AM	2	9:35:12 AM	9:38:32 AM
12	21	09:17:55 AM	2	9:35:32 AM	9:38:32 AM
13	23	09:22:25 AM	2	9:35:52 AM	9:38:32 AM
14	24	09:23:18 AM	2	9:36:12 AM	9:38:32 AM
15	26	09:23:23 AM	2	9:36:32 AM	9:38:32 AM
16	30	09:28:45 AM	2	9:36:52 AM	9:38:32 AM

a. Departure time of passengers of bus 101

	Bus 102				
	Id_pass	Arrival time	Bus Service in order	Ticket Service Time	Time Depart
4		08:55:19 AM	1	9:23:50 AM	9:25:30 AM
6		08:56:16 AM	1	9:24:10 AM	9:25:30 AM
13		09:09:53 AM	1	9:24:30 AM	9:25:30 AM
14		09:10:29 AM	1	9:24:50 AM	9:25:30 AM
16		09:11:39 AM	1	9:25:10 AM	9:25:30 AM
18		09:14:19 AM	1	9:25:30 AM	9:25:30 AM
41		09:42:51 AM	2	9:49:08 AM	9:53:04 AM
42		09:45:00 AM	2	9:49:28 AM	9:53:04 AM
45		09:48:29 AM	2	9:49:48 AM	9:53:04 AM
47		09:52:44 AM	2	9:53:04 AM	9:53:04 AM
58		10:07:21 AM	3	10:19:18 AM	10:20:30 AM

b. Departure time of passengers of bus 102

Ticket service time here can also be defined as time when the bus is expected to depart

$$\text{Expected time the bus will depart} = \text{Arrival time of bus at platform} + \text{number of passengers getting on} * \text{average ticket service time}$$

	Bus 103				
	Id_pass	Arrival time	Bus Service in order	Ticket Service Time	Time Depart
1		08:50:21 AM	1	9:24:52 AM	9:29:12 AM
5		08:55:43 AM	1	9:25:12 AM	9:29:12 AM
7		08:59:35 AM	1	9:25:32 AM	9:29:12 AM
8		08:59:46 AM	1	9:25:52 AM	9:29:12 AM
10		09:07:15 AM	1	9:26:12 AM	9:29:12 AM
11		09:07:57 AM	1	9:26:32 AM	9:29:12 AM
12		09:08:56 AM	1	9:26:52 AM	9:29:12 AM
19		09:16:49 AM	1	9:27:12 AM	9:29:12 AM
22		09:18:35 AM	1	9:27:32 AM	9:29:12 AM
25		09:23:19 AM	1	9:27:52 AM	9:29:12 AM
27		09:25:00 AM	1	9:28:12 AM	9:29:12 AM
28		09:25:32 AM	1	9:28:32 AM	9:29:12 AM
29		09:27:11 AM	1	9:28:52 AM	9:29:12 AM
31		09:28:48 AM	1	9:29:12 AM	9:29:12 AM

c. Departure time of passengers of bus 103

Figure 4. Departure Time process

The number of passengers getting on here refers to the final number of passengers allowed to enter the bus after fulfilling those two conditions that we discussed before.

Average ticket service is the average time required to serve the passengers with their bus ticket by the bus driver or special machine for ticketing.

Column for “departure time” is the time the bus will depart after serving all passengers who get on the bus. As can be seen from figure 4, in column 5, a passenger who departs with bus order one will depart until all eligible passengers have been serviced. Have a look at the *arrow signal*.

5. Simulation sheet

In this final sheet, we can see id passenger, arrival time, bus to be caught by the passengers, bus service order for each bus, the time the passenger will depart and delay time of each passenger.

All of the data here comes from another sheet (re-filter) except id passenger and arrival time in column one, two and three respectively. The delay time is determined by:

$$\text{Delay Time} = \text{Time passenger depart} - \text{Arrival Time in bus station platform A}$$

Pass. #	Arrival Time	Arrival Time (O'clock)	Bus to be caught	Bus Service Order #	Time Pass. Depart	Delay Time
1	0.42	8:50:25 AM	102	1	9:09:09 AM	00:18:44
2	0.70	8:50:42 AM	102	1	9:09:09 AM	00:18:27
3	1.27	8:51:16 AM	103	1	9:16:40 AM	00:25:23
4	2.02	8:52:01 AM	101	1	9:06:25 AM	00:14:24
5	3.46	8:53:28 AM	102	1	9:09:09 AM	00:15:41
6	5.35	8:55:21 AM	102	1	9:09:09 AM	00:13:48
7	6.37	8:56:22 AM	103	1	9:16:40 AM	00:20:18
8	7.29	8:57:17 AM	101	1	9:06:25 AM	00:09:07
9	8.92	8:58:55 AM	103	1	9:16:40 AM	00:17:44
10	9.14	8:59:08 AM	101	1	9:06:25 AM	00:07:16
11	11.12	9:01:07 AM	102	1	9:09:09 AM	00:08:02
12	13.01	9:03:00 AM	101	1	9:06:25 AM	00:03:24
13	14.64	9:04:38 AM	101	1	9:06:25 AM	00:01:47
14	14.81	9:04:49 AM	103	1	9:16:40 AM	00:11:51
15	16.08	9:06:05 AM	101	1	9:06:25 AM	00:00:20
16	16.31	9:06:19 AM	103	1	9:16:40 AM	00:10:21
17	17.33	9:07:20 AM	101	2	9:19:10 AM	00:11:51

Figure 5: Simulation sheet

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IV. CONCLUSION

The purpose of this project is to determine whether the number of buses operating is suitable with the number of passengers. From this modeling, the design of the bus operation system could achieve the best service for the public.

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