

Objective

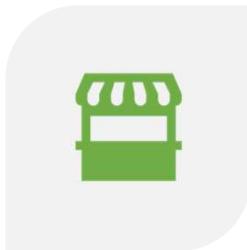
To reduce the average waiting time of vehicles at toll Plaza.

Overview

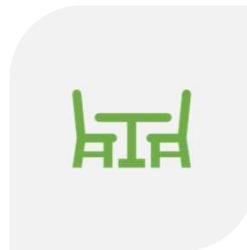
At Toll booth, the driver must stop the vehicle to pay toll taxes to drive any further. The data used here are collected from Daffi Toll Plaza (N.H-19) between 5:30 PM to 6:30 PM. All vehicles have **FASTag** so that their service time is less, if due to any reason **FASTag** is not working then they can pay manually by cash. In this model we investigate several alternative configuration for potential improvement that can be made in this in system.



Assumptions



THERE IS ALWAYS A BOOTH OPERATOR PRESENT AT TOLL BOOTH.



THERE IS NO BALKING, RENEGING AND JOCKEYING IN THE SYSTEM.



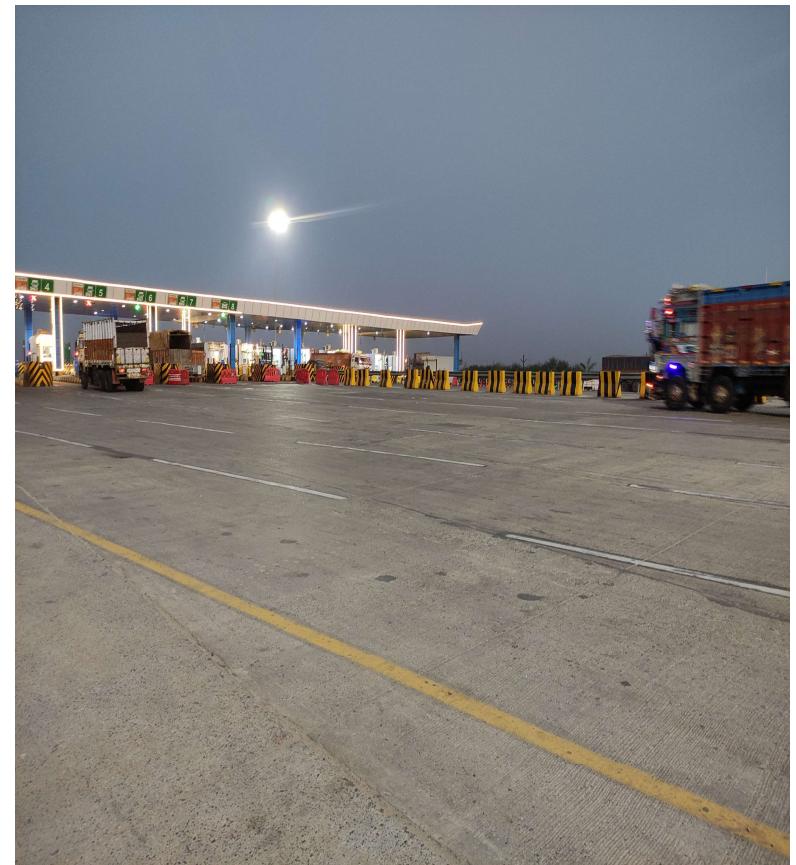
IF THE VEHICLE IS IN QUEUE, THEN IT WILL ALWAYS BE SERVED.



THERE ARE SEVERAL (PARALLEL) SERVERS, AND THE SERVICE DISCIPLINE IS FIFO.

Entities and their Attributes

Entities	Attributes
Vehicles	InterArrival Time
Toll Booth	Service Time , Number of operational booth



Data Collection for Delhi-Kolkata Lane

S.No.	Booth 1						Booth 2						Booth 3					
	Arrival Time	InterArrival	Service Starts	Service Ends	Service Time	Waiting Time (sec)	Arrival Time	InterArrival	Service Starts	Service End	Service Time	Waiting Time (sec)	Arrival Time	InterArrival	Service Starts	Service End	Service Time	Waiting Time (sec)
1	17:45:20		17:45:20	17:45:32	0:00:12	0:00:00	17:45:10		17:45:10	17:45:18	0:00:08	0:00:00	17:45:00		17:45:00	17:45:18	0:00:18	0:00:00
2	17:45:25	0:00:05	17:45:32	17:45:58	0:00:26	0:00:07	17:45:15	0:00:05	17:45:18	17:45:38	0:00:20	0:00:03	17:45:12	0:00:12	17:45:18	17:45:36	0:00:18	0:00:06
3	17:45:46	0:00:21	17:45:58	17:47:12	0:01:14	0:00:12	17:45:36	0:00:21	17:45:38	17:45:59	0:00:21	0:00:02	17:45:15	0:00:03	17:45:36	17:45:59	0:00:23	0:00:21
4	17:46:00	0:00:14	17:47:12	17:48:27	0:01:15	0:01:12	17:45:55	0:00:19	17:45:59	17:46:12	0:00:13	0:00:04	17:45:32	0:00:17	17:45:59	17:46:28	0:00:29	0:00:27
5	17:48:22	0:02:22	17:48:27	17:51:14	0:02:47	0:00:05	17:46:08	0:00:13	17:46:12	17:47:27	0:01:15	0:00:04	17:45:51	0:00:19	17:46:28	17:47:04	0:00:36	0:00:37
6	17:50:48	0:02:26	17:51:14	17:51:26	0:00:12	0:00:26	17:47:07	0:00:59	17:47:27	17:48:24	0:00:57	0:00:20	17:46:02	0:00:11	17:47:04	17:47:22	0:00:18	0:01:02
7	17:50:54	0:00:06	17:51:26	17:53:55	0:02:29	0:00:32	17:47:38	0:00:31	17:48:24	17:48:47	0:00:23	0:00:46	17:46:18	0:00:16	17:47:22	17:47:46	0:00:24	0:01:04
8	17:52:37	0:01:43	17:53:55	17:54:15	0:00:20	0:01:18	17:48:26	0:00:48	17:48:47	17:49:08	0:00:21	0:00:21	17:46:55	0:00:37	17:47:46	17:48:58	0:01:12	0:00:51
9	17:53:42	0:01:05	17:54:15	17:55:12	0:00:57	0:00:33	17:48:50	0:00:24	17:49:08	17:49:26	0:00:18	0:00:18	17:47:24	0:00:29	17:48:58	17:49:24	0:00:26	0:01:34
10	17:54:29	0:00:47	17:55:12	17:55:24	0:00:12	0:00:43	17:49:26	0:00:36	17:49:42	17:49:42	0:00:16	0:00:00	17:47:47	0:00:23	17:49:24	17:49:45	0:00:21	0:01:37
11	17:54:58	0:00:29	17:55:24	17:56:12	0:00:48	0:00:26	17:49:39	0:00:13	17:49:42	17:50:59	0:01:17	0:00:03	17:48:16	0:00:29	17:49:45	17:50:51	0:01:06	0:01:29
12	17:55:02	0:00:04	17:56:12	17:56:59	0:00:47	0:01:10	17:50:12	0:00:33	17:50:59	17:51:21	0:00:22	0:00:47	17:48:41	0:00:25	17:50:51	17:51:12	0:00:21	0:02:10
13	17:56:00	0:00:58	17:56:59	17:57:36	0:00:37	0:00:59	17:50:48	0:00:36	17:51:21	17:52:09	0:00:48	0:00:33	17:50:02	0:01:21	17:51:12	17:51:32	0:00:20	0:01:10
14	17:56:25	0:00:25	17:57:36	17:57:50	0:00:14	0:01:11	17:51:52	0:01:04	17:52:09	17:52:37	0:00:28	0:00:17	17:50:12	0:00:10	17:51:32	17:51:53	0:00:21	0:01:20
15	17:57:07	0:00:42	17:57:50	17:58:08	0:00:18	0:00:43	17:51:58	0:00:06	17:52:37	17:53:26	0:00:49	0:00:39	17:51:12	0:01:00	17:51:53	17:52:13	0:00:20	0:00:41
16	17:58:02	0:00:55	17:58:08	17:58:18	0:00:10	0:00:06	17:52:07	0:00:09	17:53:26	17:54:26	0:01:00	0:01:19	17:51:28	0:00:16	17:52:13	17:52:31	0:00:18	0:00:45
17	17:58:06	0:00:04	17:58:18	17:58:32	0:00:14	0:00:12	17:52:38	0:00:31	17:54:26	17:54:48	0:00:22	0:01:48	17:51:55	0:00:27	17:52:31	17:52:56	0:00:25	0:00:36
18	17:58:10	0:00:04	17:58:32	17:58:58	0:00:26	0:00:22	17:52:43	0:00:05	17:54:48	17:55:22	0:00:34	0:02:05	17:52:28	0:00:33	17:52:56	17:53:08	0:00:12	0:00:28
19	17:58:32	0:00:22	17:58:58	17:59:12	0:00:14	0:00:26	17:53:03	0:00:20	17:55:22	17:55:49	0:00:27	0:02:19	17:52:51	0:00:23	17:53:08	17:53:26	0:00:18	0:00:17
20	17:58:46	0:00:14	17:59:12	17:59:23	0:00:11	0:00:26	17:53:22	0:00:19	17:55:49	17:56:19	0:00:30	0:02:27	17:53:28	0:00:37	17:53:28	17:53:51	0:00:23	0:00:00
21	17:58:58	0:00:12	17:59:23	17:59:31	0:00:08	0:00:25	17:53:39	0:00:17	17:56:19	17:56:41	0:00:22	0:02:40	17:53:49	0:00:21	17:53:51	17:54:31	0:00:40	0:00:02
22	17:59:33	0:00:35	17:59:33	17:59:42	0:00:09	0:00:00	17:54:01	0:00:22	17:56:41	17:57:22	0:00:41	0:02:40	17:53:58	0:00:09	17:54:31	17:54:58	0:00:27	0:00:33
23	17:59:48	0:00:15	17:59:48	17:59:52	0:00:04	0:00:00	17:54:19	0:00:18	17:57:22	17:57:58	0:00:36	0:03:03	17:54:22	0:00:24	17:54:58	17:55:12	0:00:14	0:00:36
24	18:00:02	0:00:14	18:00:02	18:00:15	0:00:13	0:00:00	17:54:29	0:00:10	17:57:58	17:58:35	0:00:37	0:03:29	17:54:48	0:00:26	17:55:12	17:55:37	0:00:25	0:00:24
25	18:00:22	0:00:20	18:00:22	18:00:45	0:00:23	0:00:00	17:54:57	0:00:28	17:58:35	17:58:55	0:00:20	0:03:38	17:55:48	0:01:00	17:55:48	17:55:56	0:00:08	0:00:00
26	18:00:44	0:00:22	18:00:45	18:01:16	0:00:31	0:00:01	17:55:55	0:00:58	17:58:55	17:59:44	0:00:49	0:03:00	17:55:58	0:00:10	17:55:58	17:56:28	0:00:30	0:00:00
27	18:00:56	0:00:12	18:01:16	18:01:45	0:00:29	0:00:20	17:56:33	0:00:38	17:59:44	18:00:00	0:00:16	0:03:11	17:56:23	0:00:25	17:56:28	17:56:49	0:00:21	0:00:05
28	18:01:12	0:00:16	18:01:45	18:02:08	0:00:23	0:00:33	17:56:58	0:00:25	18:00:00	18:00:32	0:00:32	0:03:02	17:56:38	0:00:15	17:56:49	17:57:42	0:00:53	0:00:11
29	18:01:18	0:00:06	18:02:08	18:02:32	0:00:24	0:00:50	17:57:44	0:00:46	18:00:32	18:00:55	0:00:23	0:02:48	17:57:19	0:00:41	17:57:42	17:58:31	0:00:49	0:00:23
30	18:01:28	0:00:10	18:02:32	18:02:41	0:00:09	0:01:04	17:58:22	0:00:38	18:00:55	18:01:10	0:00:15	0:02:33	17:57:46	0:00:27	17:58:31	17:58:42	0:00:11	0:00:45
31	18:01:40	0:00:12	18:02:41	18:02:55	0:00:14	0:01:01	17:59:23	0:01:01	18:01:10	18:01:28	0:00:18	0:01:47	17:58:42	0:00:56	17:58:42	17:58:59	0:00:17	0:00:00
TOTAL					0:17:10	0:15:23					0:16:18	0:46:06					0:13:44	0:19:34
MAX					0:02:47	0:01:18					0:01:17	0:03:38					0:01:12	0:02:10
MIN					0:00:04	0:00:00					0:00:08	0:00:00					0:00:08	0:00:00
AVERAGE					0:00:33	0:00:30					0:00:32	0:01:29					0:00:27	0:00:38

Data Collection for Delhi-Kolkata Lane

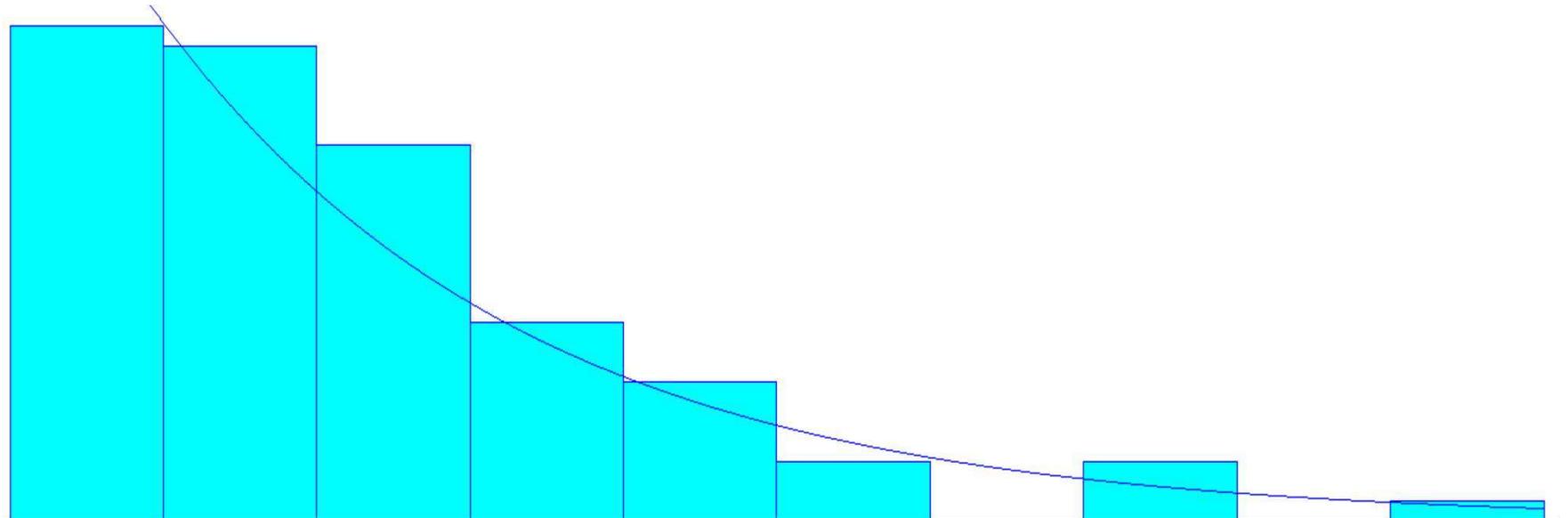
Booth 14						Booth 15						Booth 16					
Service Starts	Service End	Arrival Time	InterArrival	Service Time	Waiting Time	Arrival Time	InterArrival	Service Starts	Service End	Service Time	Waiting Time	Arrival Time	InterArrival	Service Starts	Service End	Service Time	Waiting Time
18:15:00	18:15:22	18:15:00		0:00:22	0:00:00	18:15:00		18:15:00	18:15:22	0:00:22	0:00:00	18:15:10		6:15:10 PM	18:15:22	0:00:12	0:00:00
18:15:22	18:15:49	18:15:22	0:00:22	0:00:27	0:00:00	18:15:12	0:00:12	18:15:22	18:15:39	0:00:17	0:00:10	18:15:18	0:00:08	18:15:22	18:15:55	0:00:33	0:00:04
18:15:49	18:16:15	18:15:32	0:00:10	0:00:26	0:00:17	18:15:32	0:00:20	18:15:39	18:15:58	0:00:19	0:00:07	18:15:20	0:00:02	18:15:55	18:16:15	0:00:20	0:00:35
18:16:15	18:16:39	18:15:36	0:00:04	0:00:24	0:00:39	18:15:50	0:00:18	18:15:58	18:16:24	0:00:26	0:00:08	18:16:00	0:00:40	18:16:15	18:16:38	0:00:23	0:00:15
18:16:39	18:17:00	18:15:48	0:00:12	0:00:21	0:00:51	18:16:02	0:00:12	18:16:24	18:16:49	0:00:25	0:00:22	18:16:34	0:00:34	18:16:38	18:17:22	0:00:44	0:00:04
18:17:00	18:17:21	18:16:00	0:00:12	0:00:21	0:01:00	18:16:18	0:00:16	18:16:49	18:17:24	0:00:35	0:00:31	18:16:45	0:00:11	18:17:22	18:17:52	0:00:30	0:00:37
18:17:21	18:17:36	18:16:12	0:00:12	0:00:15	0:01:09	18:16:32	0:00:14	18:17:24	18:17:49	0:00:25	0:00:52	18:17:22	0:00:37	18:17:52	18:18:22	0:00:30	0:00:30
18:17:36	18:17:58	18:16:28	0:00:16	0:00:22	0:01:08	18:16:55	0:00:23	18:17:49	18:18:15	0:00:26	0:00:54	18:17:58	0:00:36	18:18:22	18:18:54	0:00:32	0:00:24
18:17:58	18:18:24	18:16:49	0:00:21	0:00:26	0:01:09	18:17:05	0:00:10	18:18:15	18:19:32	0:01:17	0:01:10	18:18:21	0:00:23	18:18:54	18:19:22	0:00:28	0:00:33
18:18:24	18:18:46	18:17:21	0:00:32	0:00:22	0:01:03	18:17:31	0:00:26	18:19:32	18:20:57	0:01:25	0:02:01	18:18:32	0:00:11	18:19:22	18:19:59	0:00:37	0:00:50
18:18:46	18:19:22	18:17:38	0:00:17	0:00:36	0:01:08	18:17:52	0:00:21	18:20:57	18:21:46	0:00:49	0:03:05	18:19:12	0:00:40	18:19:59	18:20:34	0:00:35	0:00:47
18:19:22	18:19:49	18:17:58	0:00:20	0:00:27	0:01:24	18:18:55	0:01:03	18:21:46	18:22:13	0:00:27	0:02:51	18:20:12	0:01:00	18:20:34	18:20:56	0:00:22	0:00:22
18:19:49	18:20:18	18:18:13	0:00:15	0:00:29	0:01:36	18:19:28	0:00:33	18:22:13	18:22:39	0:00:26	0:02:45	18:20:28	0:00:16	18:20:56	18:21:56	0:01:00	0:00:28
18:20:18	18:20:41	18:18:27	0:00:14	0:00:23	0:01:51	18:20:12	0:00:44	18:22:39	18:22:59	0:00:20	0:02:27	18:21:18	0:00:50	18:21:56	18:22:34	0:00:38	0:00:38
18:20:41	18:21:48	18:19:35	0:01:08	0:01:07	0:01:06	18:21:52	0:01:40	18:22:59	18:23:55	0:00:56	0:01:07	18:22:07	0:00:49	18:22:34	18:23:00	0:00:26	0:00:27
18:21:48	18:22:13	18:19:48	0:00:13	0:00:25	0:02:00	18:22:12	0:00:20	18:23:55	18:24:49	0:00:54	0:01:43	18:22:12	0:00:05	18:23:00	18:23:29	0:00:29	0:00:48
18:22:13	18:22:33	18:21:55	0:02:07	0:00:20	0:00:18	18:22:42	0:00:30	18:24:49	18:24:57	0:00:08	0:02:07	18:22:42	0:00:30	18:23:29	18:23:55	0:00:26	0:00:47
18:22:33	18:22:54	18:22:15	0:00:20	0:00:21	0:00:18	18:22:56	0:00:14	18:24:57	18:25:13	0:00:16	0:02:01	18:22:56	0:00:14	18:23:55	18:24:12	0:00:17	0:00:59
18:22:54	18:23:15	18:22:53	0:00:38	0:00:21	0:00:01	18:23:05	0:00:09	18:25:13	18:25:26	0:00:13	0:02:08	18:23:15	0:00:19	18:24:12	18:24:28	0:00:16	0:00:57
18:23:15	18:23:47	18:22:55	0:00:02	0:00:32	0:00:20	18:23:16	0:00:11	18:25:26	18:25:42	0:00:16	0:02:10	18:23:26	0:00:11	18:24:28	18:24:58	0:00:30	0:01:02
18:23:47	18:24:18	18:23:12	0:00:17	0:00:31	0:00:35	18:23:39	0:00:23	18:25:42	18:26:04	0:00:22	0:02:03	18:24:41	0:01:15	18:24:58	18:25:10	0:00:12	0:00:17
18:24:18	18:24:36	18:23:38	0:00:26	0:00:18	0:00:40	18:23:58	0:00:19	18:26:04	18:26:26	0:00:22	0:02:06	18:24:55	0:00:14	18:25:10	18:25:22	0:00:12	0:00:15
18:24:36	18:25:09	18:23:57	0:00:19	0:00:33	0:00:39	18:24:09	0:00:11	18:26:26	18:26:43	0:00:17	0:02:17	18:25:03	0:00:08	18:25:22	18:25:31	0:00:09	0:00:19
18:25:09	18:25:36	18:24:03	0:00:06	0:00:27	0:01:06	18:24:18	0:00:09	18:26:43	18:27:02	0:00:19	0:02:25	18:25:18	0:00:15	18:25:31	18:26:22	0:00:51	0:00:13
18:25:36	18:25:56	18:24:16	0:00:13	0:00:20	0:01:20	18:24:36	0:00:18	18:27:02	18:28:22	0:01:20	0:02:26	18:26:12	0:00:54	18:26:22	18:26:54	0:00:32	0:00:10
18:25:56	18:26:15	18:24:29	0:00:13	0:00:19	0:01:27	18:24:42	0:00:06	18:28:22	18:28:45	0:00:23	0:03:40	18:26:28	0:00:16	18:26:54	18:27:13	0:00:19	0:00:26
18:26:15	18:26:26	18:24:41	0:00:12	0:00:11	0:01:34	18:24:56	0:00:14	18:28:45	18:28:58	0:00:13	0:03:49	18:26:53	0:00:25	18:27:13	18:27:44	0:00:31	0:00:20
18:26:26	18:26:56	18:24:45	0:00:04	0:00:30	0:01:41	18:25:15	0:00:19	18:28:58	18:29:45	0:00:47	0:03:43	18:27:12	0:00:19	18:27:44	18:27:58	0:00:14	0:00:32
18:26:56	18:27:59	18:24:58	0:00:13	0:01:03	0:01:58	18:25:36	0:00:21	18:29:45	18:29:56	0:00:11	0:04:09	18:27:46	0:00:34	18:27:58	18:28:07	0:00:09	0:00:12
18:27:59	18:29:42	18:25:15	0:00:17	0:01:43	0:02:44	18:25:58	0:00:22	18:29:56	18:30:18	0:00:22	0:03:58	18:27:58	0:00:12	18:28:07	18:28:12	0:00:05	0:00:09
18:29:42	18:29:55	18:27:18	0:02:03	0:00:13	0:02:24	18:26:18	0:00:20	18:30:18	18:30:28	0:00:10	0:04:00	18:28:12	0:00:14	18:28:12	18:28:37	0:00:25	0:00:00
		TOTAL		0:14:55	0:33:26					0:15:28	1:03:15					0:13:27	0:14:00
		MAX		0:01:43	0:02:44					0:01:25	0:04:09					0:01:00	0:01:02
		MIN		0:00:11	0:00:00					0:00:08	0:00:00					0:00:05	0:00:00
		AVERAGE		0:00:29	0:01:05					0:00:30	0:02:02					0:00:26	0:00:27

Data Collection Result

	Booth 1	Booth 2	Booth 3	Booth 14	Booth 15	Booth 16
Max. Service Time	02:47	01:17	01:12	01:43	01:25	01:00
Min. Service Time	00:40	00:08	00:18	00:11	00:08	00:05
Max. Waiting Time	01:18	03:38	02:10	02:44	04:09	01:02
Min. Waiting Time	00:00	00:00	00:00	00:00	00:00	00:00
Average Service Time	00:33	00:27	00:34	00:29	00:30	00:26
Average Waiting Time	00:30	01:29	00:38	01:05	02:02	00:27

- Time in minutes

Data Fitting



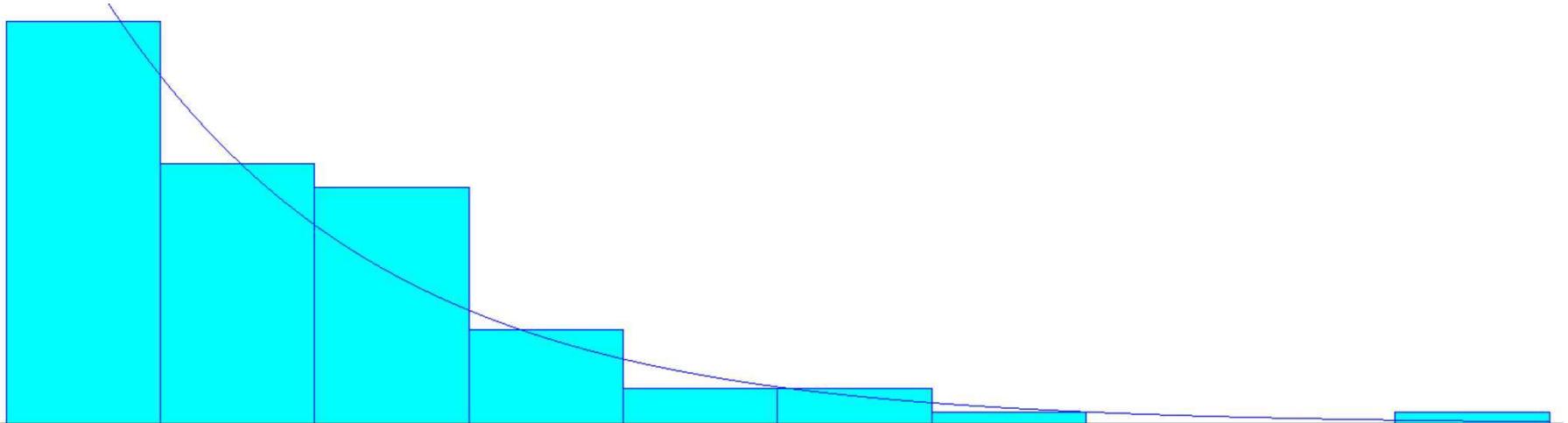
Distribution Summary

Distribution: Exponential
Expression: $-0.5 + \text{EXP0}(11.4)$
Square Error: 0.013069

Chi Square Test

Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 4.9
Corresponding p-value = 0.0895

- InterArrival distribution at Delhi-Kolkata lane



Distribution Summary

Distribution: Exponential
Expression: -0.5 + EXPO(9.11)
Square Error: 0.009122

Chi Square Test

Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 4.6
Corresponding p-value = 0.1

Data Summary

Number of Data Points = 92
Min Data Value = 0
Max Data Value = 50
Sample Mean = 8.61
Sample Std Dev = 8.52

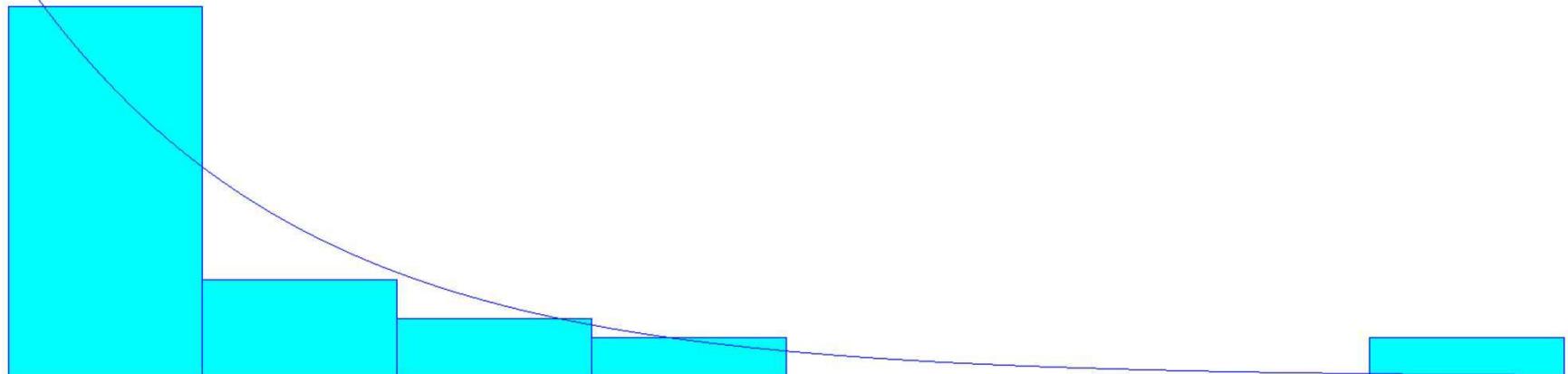
Histogram Summary

Histogram Range = -0.5 to 50.5
Number of Intervals = 10

InterArrival distribution at Kolkata-Delhi lane

Input Analyzer - [Input1]

File Edit View Fit Options Window Help



Distribution Summary

Distribution: Exponential
Expression: $4 + \text{EXPO}(29.2)$
Square Error: 0.025878

Chi Square Test
Number of intervals = 3
Degrees of freedom = 1
Test Statistic = 1.88
Corresponding p-value = 0.189

Kolmogorov-Smirnov Test
Test Statistic = 0.139
Corresponding p-value > 0.15

Data Summary

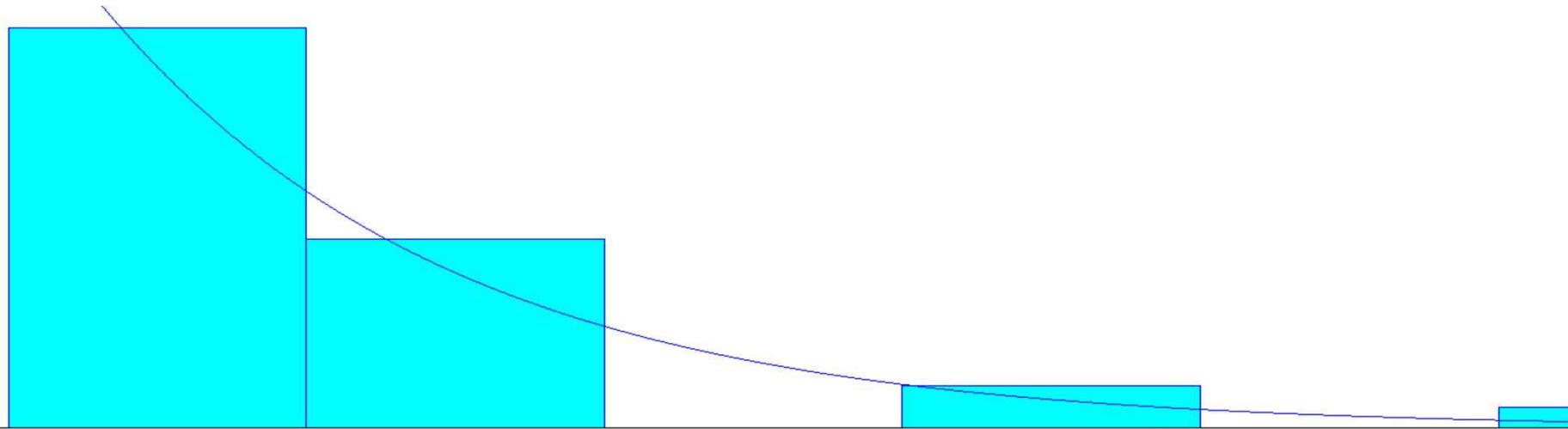
Number of Data Points = 31
Min Data Value = 4
Max Data Value = 167
Sample Mean = 33.2
Sample Std Dev = 38.1

Histogram Summary

Histogram Range = 4 to 167
Number of Intervals = 8

Service Rate distribution at Booth 1

Service Rate distribution at Booth 14



Distribution Summary

Distribution: Exponential
Expression: $10.5 + \text{EXPO}(18.4)$
Square Error: 0.015031

Chi Square Test
Number of intervals = 3
Degrees of freedom = 1
Test Statistic = 3.12
Corresponding p-value = 0.082

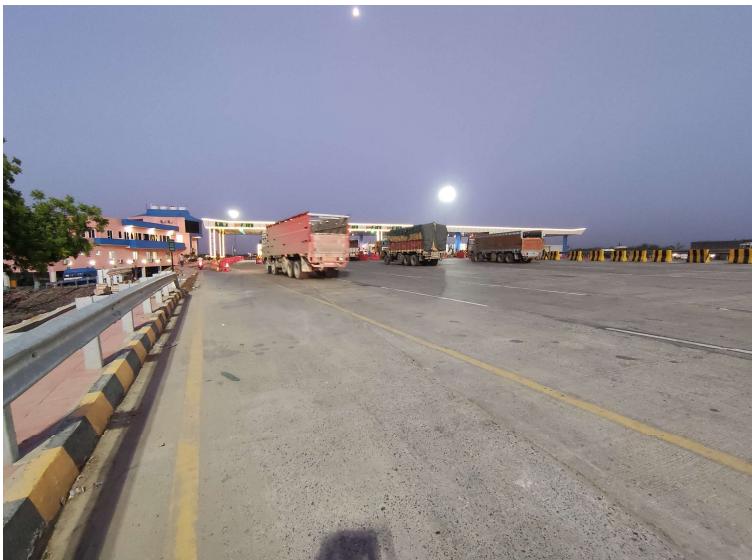
Data Summary

Number of Data Points = 31
Min Data Value = 11
Max Data Value = 103
Sample Mean = 28.9
Sample Std Dev = 18.1

Histogram Summary

Histogram Range = 10.5 to 104
Number of Intervals = 6

Process and Distribution

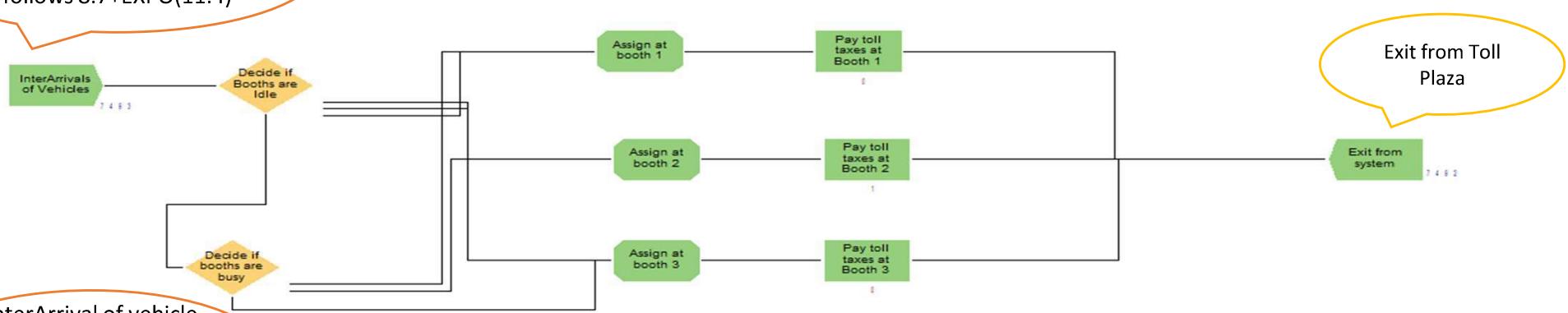


	InterArrival	Service
Booth 1	8.7 + Exponential (11.4)	4 + Exponential (29.2)
Booth 2	8.7 + Exponential (11.4)	7.5 + Exponential (24)
Booth 3	8.7 + Exponential (11.4)	7.5 + Exponential (19.1)
Booth 14	7.2 + Exponential(10.18)	10.5 + Exponential (18.4)
Booth 15	7.2 + Exponential(10.18)	7.5 + Exponential (22.4)
Booth 16	7.2 + Exponential(10.18)	4.5 + WEIB(23.9, 1.71)

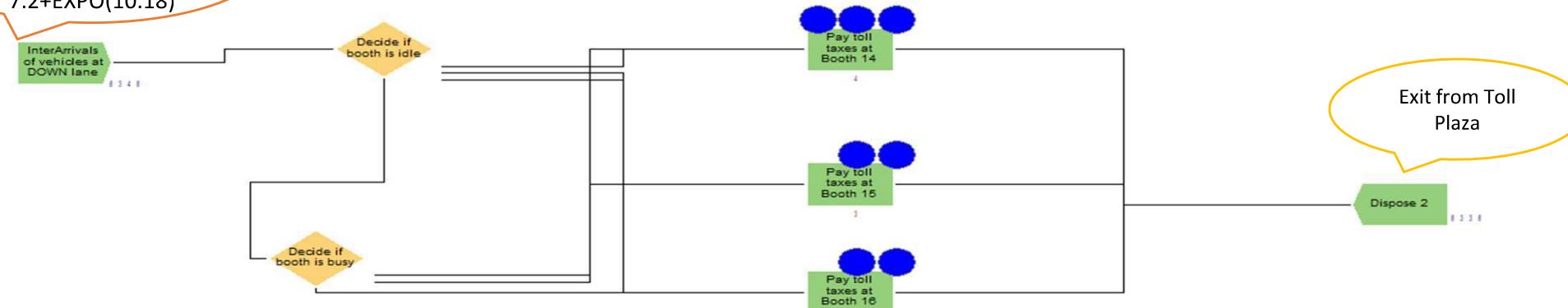
Initial Model

Given simulation model is run for 24 hours replication length

InterArrival of vehicle from Delhi-Kolkata Lane follows $8.7 + \text{EXPO}(11.4)$



InterArrival of vehicle from Kolkata-Delhi Lane follows $7.2 + \text{EXPO}(10.18)$



Simulation Model for (Kolkata-Delhi) Lane at DAFI Toll Plaza (NH-19)

Initial Result

ARENA Simulation Results
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Summary for Replication 1 of 1

Project: Initial Model
Analyst: ashish

Run execution date : 4/24/2023
Model revision date: 4/24/2023

Replication ended at time : 86400.0 Seconds
Base Time Units: Seconds

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Entity 1.VATime	30.452	.47146	4.0391	227.25	7492
Entity 1.NVATime	.00000	.00000	.00000	.00000	7492
Entity 1.WaitTime	48.973	10.007	.00000	428.96	7492
Entity 1.TranTime	.00000	.00000	.00000	.00000	7492
Entity 1.OtherTime	.00000	.00000	.00000	.00000	7492
Entity 1.TotalTime	79.426	10.187	4.0604	458.14	7492
Entity 2.VATime	28.078	.35042	4.6759	185.22	8338
Entity 2.NVATime	.00000	.00000	.00000	.00000	8338
Entity 2.WaitTime	56.953	12.216	.00000	445.55	8338
Entity 2.TranTime	.00000	.00000	.00000	.00000	8338
Entity 2.OtherTime	.00000	.00000	.00000	.00000	8338
Entity 2.TotalTime	85.032	12.302	4.7604	480.72	8338
Pay toll taxes at Booth 1.Queue.WaitingTim	66.152	10.209	.00000	428.96	2255
Pay toll taxes at Booth 16.Queue.WaitingTi	46.324	12.577	.00000	299.19	2853
Pay toll taxes at Booth 15.Queue.WaitingTi	66.850	14.014	.00000	358.05	2742
Pay toll taxes at Booth 14.Queue.WaitingTi	58.125	15.811	.00000	445.55	2746
Pay toll taxes at Booth 2.Queue.WaitingTim	51.102	9.0777	.00000	287.47	2397
Pay toll taxes at Booth 3.Queue.WaitingTim	33.525	6.7492	.00000	261.36	2841

Results



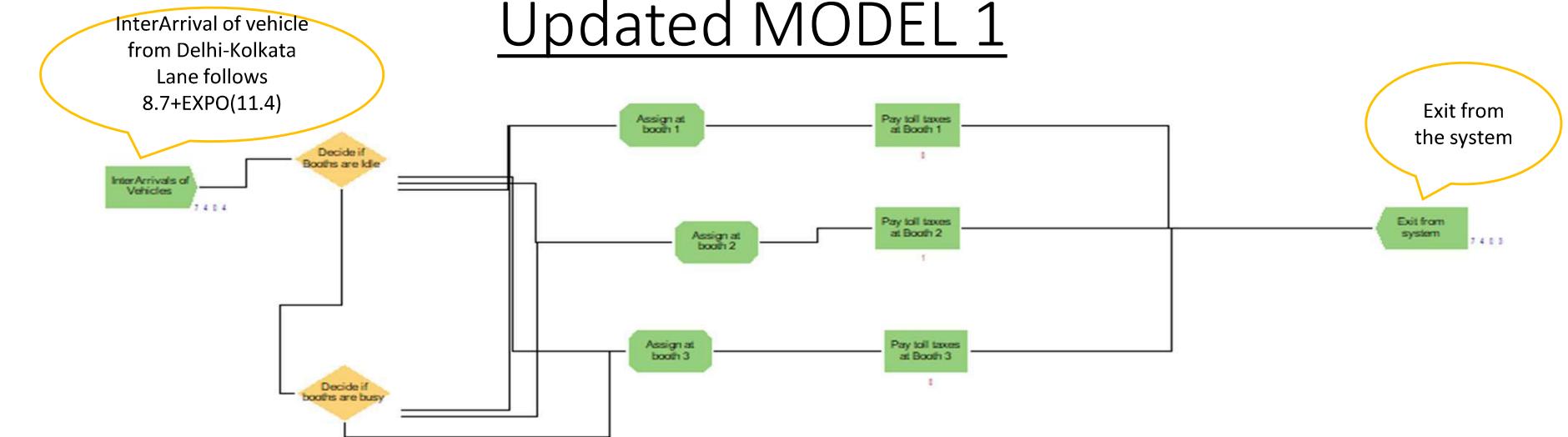
	Average Waiting Time (sec.)	Average Queue Length	Utilization Fraction
Booth 1	66.15	1.72	0.89
Booth 2	51.10	1.41	0.88
Booth 3	33.52	1.10	0.87
Booth 14	58.12	1.84	0.93
Booth 15	66.85	2.12	0.93
Booth 16	46.32	1.53	0.84

Updated MODEL 1 (Ensuring all Vehicles have FASTag)

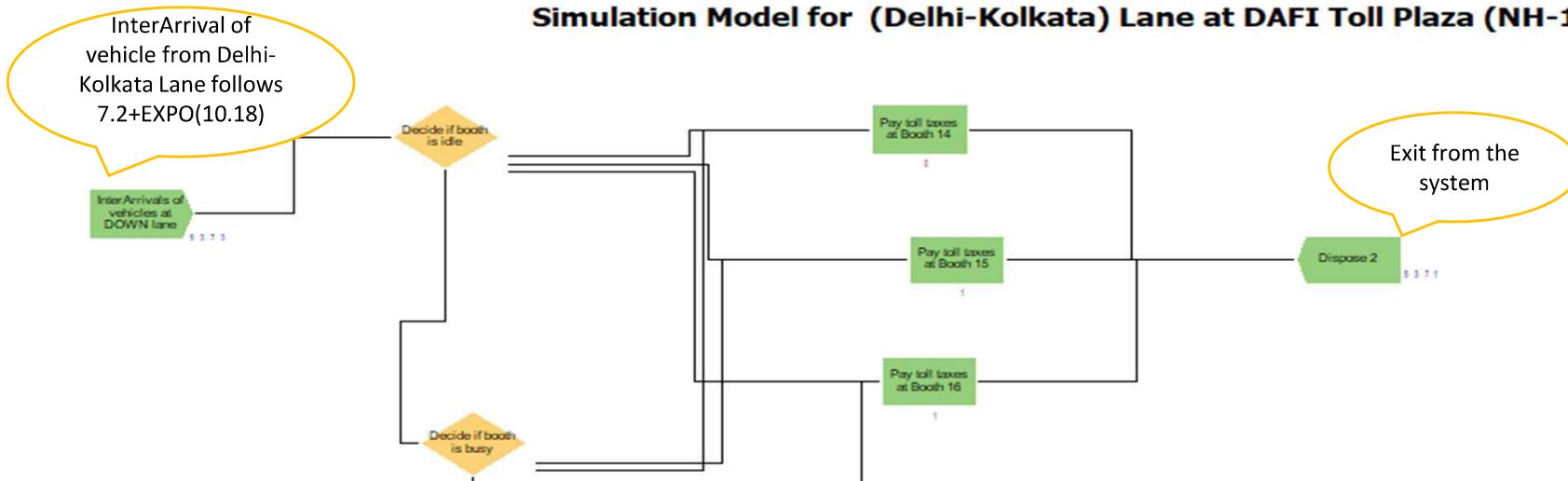
- During our visit at Toll Plaza, we found that vehicles having FASTag gets faster service (6 sec-20 sec) as compared to those vehicles who doesn't have any fasTag.
- Although it is not in our control to ensure all vehicles have FASTag, but it could be a possible scope of improvement of this model (**RFID enabled Toll Plaza**).
- We also simulate this by considering the service rate follows Exponential distribution with mean 10 sec.



Updated MODEL 1



Simulation Model for (Delhi-Kolkata) Lane at DAFI Toll Plaza (NH-19)



Simulation Model for (Kolkata-Delhi) Lane at DAFI Toll Plaza (NH-19)

Result

ARENA Simulation Results
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Summary for Replication 1 of 1

Project: Updated| Model 2
Analyst: ashish

Run execution date : 4/24/2023
Model revision date: 4/24/2023

Replication ended at time : 86400.0 Seconds
Base Time Units: Seconds

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Entity 1.VATime	9.9709	.20673	9.4010E-4	77.004	7403
Entity 1.NVATime	.00000	.00000	.00000	.00000	7403
Entity 1.WaitTime	.62676	.12292	.00000	68.928	7403
Entity 1.TranTime	.00000	.00000	.00000	.00000	7403
Entity 1.OtherTime	.00000	.00000	.00000	.00000	7403
Entity 1.TotalTime	10.597	.30739	9.4010E-4	80.742	7403
Entity 2.VATime	9.9739	.22609	.00191	89.692	9371
Entity 2.NVATime	.00000	.00000	.00000	.00000	9371
Entity 2.WaitTime	1.0102	.13490	.00000	59.415	9371
Entity 2.TranTime	.00000	.00000	.00000	.00000	9371
Entity 2.OtherTime	.00000	.00000	.00000	.00000	9371
Entity 2.TotalTime	10.984	.27192	.00191	96.496	9371
Pay toll taxes at Booth 1.Queue.WaitingTim	2.7142	.42312	.00000	68.928	1174
Pay toll taxes at Booth 16.Queue.WaitingTi	.48106	.23845	.00000	50.105	1579
Pay toll taxes at Booth 15.Queue.WaitingTi	2.0976	.26182	.00000	59.415	3137
Pay toll taxes at Booth 14.Queue.WaitingTi	.45670	.09254	.00000	50.035	4657
Pay toll taxes at Booth 2.Queue.WaitingTim	.48644	.11738	.00000	49.509	2225
Pay toll taxes at Booth 3.Queue.WaitingTim	.09266	.05265	.00000	44.239	4005

DISCRETE-CHANGE VARIABLES

Results

- From given result we can see that average waiting time and average queue length is very less, and that's why there is hardly any queue formed.
- Although it is not in our control to ensure all vehicle must have FASTag but high service rate is required for smooth operation of Toll Plaza.
- From December 2022 **NHAI** announces if any vehicles waits for more than 10 seconds in queue ,then they can pass the booth exempted from Toll taxes.
- That can only be possible if all vehicles use FASTag rather than using conventional method of Toll tax payment.



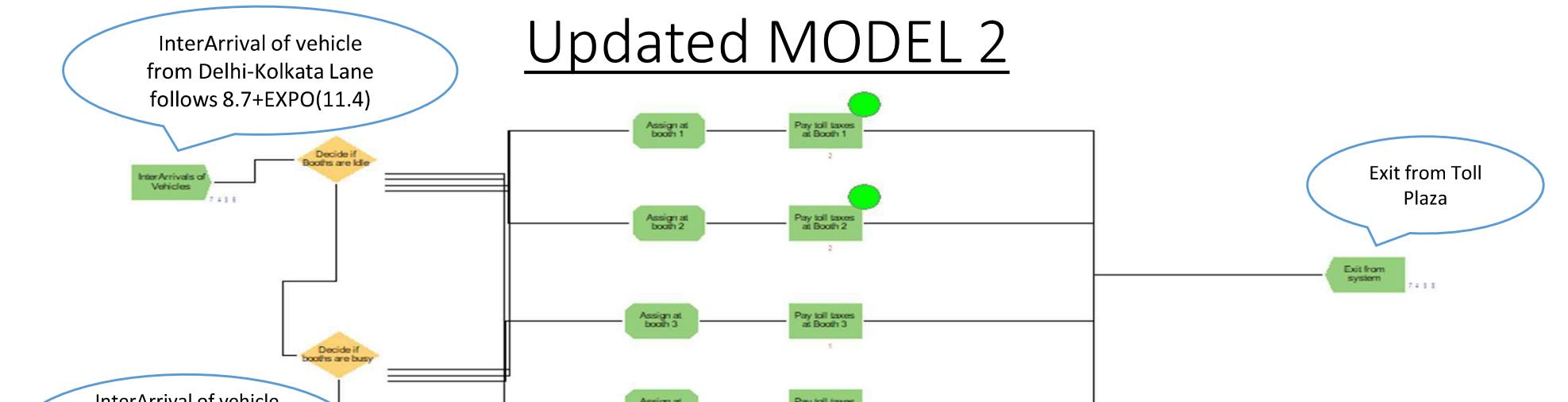
	Average Waiting Time (sec.)	Average Queue Length	Utilization Fraction
Booth 1	2.714	0.036	0.133
Booth 2	0.486	0.0125	0.261
Booth 3	0.926	0.004	0.459
Booth 14	0.456	0.026	0.531
Booth 15	2.096	0.076	0.371
Booth 16	0.481	0.008	0.179

Updated MODEL 2 (Increasing Number of Toll Booth)

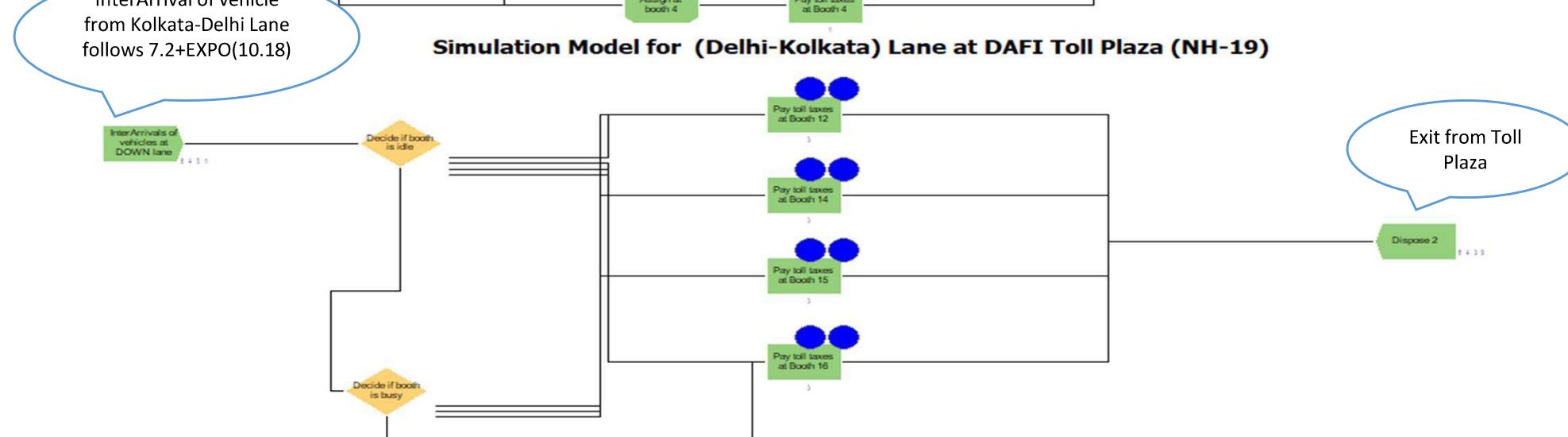
- During our visit at Toll Plaza, we found that some of the Booths were unoperational.
- Here we will be going to increase one more booth from both the lanes.
- After that we will be going to analyze and compare this result from initial model.



Updated MODEL 2



Simulation Model for (Delhi-Kolkata) Lane at DAFI Toll Plaza (NH-19)



Simulation Model for (Kolkata-Delhi) Lane at DAFI Toll Plaza (NH-19)

Result

ARENA Simulation Results
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Summary for Replication 1 of 1

Project: Updated model 2
Analyst: ashish

Run execution date : 4/24/2023
Model revision date: 4/24/2023

Replication ended at time : 86400.0 Seconds
Base Time Units: Seconds

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Entity 1.VATime	26.407	.68428	.01031	225.00	7490
Entity 1.NVATime	.00000	.00000	.00000	.00000	7490
Entity 1.WaitTime	7.0899	1.0859	.00000	181.38	7490
Entity 1.TranTime	.00000	.00000	.00000	.00000	7490
Entity 1.OtherTime	.00000	.00000	.00000	.00000	7490
Entity 1.TotalTime	33.496	1.5837	.01031	286.89	7490
Entity 2.VATime	28.307	.57271	5.0160	183.95	8439
Entity 2.NVATime	.00000	.00000	.00000	.00000	8439
Entity 2.WaitTime	10.024	1.8583	.00000	183.31	8439
Entity 2.TranTime	.00000	.00000	.00000	.00000	8439
Entity 2.OtherTime	.00000	.00000	.00000	.00000	8439
Entity 2.TotalTime	38.331	2.3313	5.0160	216.77	8439
Pay toll taxes at Booth 1.Queue.WaitingTim	17.696	1.6932	.00000	181.38	1329
Pay toll taxes at Booth 12.Queue.WaitingTi	13.992	1.9763	.00000	173.37	2572
Pay toll taxes at Booth 16.Queue.WaitingTi	6.8075	1.7371	.00000	163.24	1545
Pay toll taxes at Booth 15.Queue.WaitingTi	10.062	1.5907	.00000	127.63	2189
Pay toll taxes at Booth 14.Queue.WaitingTi	7.6204	1.7794	.00000	183.31	2137
Pay toll taxes at Booth 2.Queue.WaitingTim	8.5570	1.3425	.00000	172.33	1728
Pay toll taxes at Booth 4.Queue.WaitingTim	2.6236	(Corr)	.00000	136.52	2308
Pay toll taxes at Booth 3.Queue.WaitingTim	4.1064	.98748	.00000	145.16	2129

Results



	Average Waiting Time (sec.)	Average Queue Length	Utilization Fraction
Booth 1	17.70	0.27	0.45
Booth 2	8.55	0.17	0.50
Booth 3	4.10	0.10	0.60
Booth 4	2.62	0.07	0.72
Booth 12	14.00	0.41	0.84
Booth 14	7.62	0.19	0.73
Booth 15	10.06	0.26	0.65
Booth 16	6.80	0.12	0.52

Improvement and Conclusion

- Given comparison is based on Initial Model and Updated Model 2 (Increasing number of servers).
- Based on observed results i.e. adding one more Booth at both lanes will result in reduction of average waiting time.
- However, this should not be considered as only measure of improvement because adding one more booth will incurred some cost like operating cost, handling cost and maintenance cost as well.
- Therefore, **Economic Analysis** should be done before adding any number of booth in toll plaza.

	Earlier Waiting time (sec)	Current Waiting time (sec)	% change
Booth 1	66.15	17.70	73.24
Booth 2	51.10	8.55	83.26
Booth 3	33.52	4.10	87.76
Booth 4	-	2.62	-
Booth 12	-	14.00	-
Booth 14	58.12	7.62	86.89
Booth 15	66.85	10.06	84.95
Booth 16	46.32	6.80	85.31