



MARMARA UNIVERSITY

**FACULTY OF ENGINEERING
COMPUTER SCIENCE & ENGINEERING
DEPARTMENT**

**IE3081
MODELING AND DISCRETE SIMULATION
Project - Phase #2**

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Highway Booth Simulation

System Explanation

In our system, we've tried to implement a Highway Booth Mechanism that simulates various occasions. Our aim is to observe the waiting time of the vehicles based on their decisions between Fast Passing System or Cash Payment System. To build a better model, increase creativity, provide variety, we have defined two various simulations in our system. One of them consists 4 Cash Payment Booth and 4 Fast Passing Booth; for the other one, we've converted all booths into Fast Passing Booth. With the help of these different outputs, we'd be able to see data output much more clearly.

Components of the System

- 2x Car Source
- 1x Sink
- 4x FPS Delay
- 2x FPS Queue
- 2x FPS Hold
- 4x CPS Delay
- 2x CPS Queue
- 2x CPS Hold
- 2x Highway Delay

Relationships Between Components

- Sources are connected to both CPS and FPS Queues.
- Each Queue is connected to their own hold components.
- Vehicle that leaves one of the queues redirects to one of the available appropriate booths.
- Vehicle that leaves booth, enters to the highway which will lead it to the sink.

Statistical Values (Input & Output Parameters)

In our system, we have two major different setups. Each of them consists various time schedules that enable us to monitor the density of the traffic. Totally we have 6 different time distributions as follows:

- Between 12 AM to 6 AM
- Between 6 AM to 10 AM (Rush Hour for left-side of the highway)
- Between 10 AM to 12 PM
- Between 12 PM to 16 PM
- Between 16 PM to 20 PM (Rush Hour for right-side of the highway)
- Between 20 PM to 12 AM

In addition to setups above, we've declared the capacity of the highway as 1000 cars.

- If the number of cars on highway is below 100, vehicles have to wait 1 to 1.5 minutes to enter highway.
- If the number of cars on highway is below 600, vehicles have to wait 1.6 to 2 minutes to enter highway.
- If it is higher than 600, vehicles have to wait 2.1 to 4.5 minutes.

The tables below show our outputs as well as their values.

Outputs and the Values of Setup 1 (4 CPS, 4 FPS)

Seeds	Average Time Spend In System (Minute)	Average FPS Queue Time (Second)	Average FPS Booth Service Time (Second)	Average CPS Queue Time (Minute)	Average CPS Booth Service Time (Second)	Average Travel Time In Highway (Min)
10	7,6929	1,6286	0,3732	167,6081	15,7025	1,8709
20	7,7271	1,7683	0,3764	166,7813	15,8039	1,9682
30	7,7625	1,6051	0,3761	171,2092	15,7272	1,8299
40	7,4891	1,4977	0,374	163,0664	15,7275	1,8306
50	7,5855	1,6092	0,3749	166,0443	15,727	1,8228
60	7,7728	1,7731	0,3766	171,1416	15,7416	1,8292
70	7,9946	1,6915	0,3761	174,5212	15,7119	1,9496
80	7,7802	1,6719	0,3754	166,9095	15,7443	1,9746
90	7,7044	1,5824	0,3753	169,8861	15,7145	1,7927
100	7,6683	1,564	0,3767	165,6616	15,7325	1,9125
110	7,6573	1,616	0,3752	163,8824	15,7195	1,9763
120	7,8553	1,6823	0,3758	168,4605	15,7386	1,9564
130	7,4799	1,4681	0,3753	164,3531	15,7059	1,7597
140	7,8174	1,5554	0,3761	168,1251	15,7395	1,991
150	7,7938	1,4893	0,3738	171,3497	15,7981	1,8915
160	7,6607	1,5902	0,3758	162,7641	15,7998	1,977
170	7,5637	1,6172	0,3746	161,995	15,782	1,9306
180	7,8064	1,4774	0,3751	173,7244	15,7106	1,7587
190	7,7035	1,5097	0,3739	167,6894	15,7636	1,8901
200	7,8448	1,5912	0,3736	170,8095	15,7448	1,9207
210	7,6988	1,6483	0,3771	168,8707	15,7945	1,8623
220	7,6729	1,5464	0,3748	165,6222	15,8442	1,9507
230	8,0127	1,5738	0,3737	173,5004	15,7002	1,9689
240	7,6249	1,6443	0,3763	169,4869	15,7953	1,7608
250	8,0998	1,6455	0,3754	173,9255	15,7221	2,0727

Without Narrowing CI for 10%

Standart Deviation	0,126642314	0,088003661	0,001050551	3,611693112	0,031771127	0,075706792
Mean	7,71801	1,59943	0,375195	167,799125	15,741765	1,89165
Confidence Interval	0,055503441	0,038569305	0,000460424	1,582894297	0,01392431	0,033179965
95% Confidence Intervals	7,718 ±0,056	1,599 ±0,039	0,375 ±0	167,799 ±1,583	15,742 ±0,014	1,892 ±0,033
10% of CI	0,049953097	0,034712374	0,000414382	1,424604868	0,012531879	0,029861968
Prediction Interval	0,254348721	0,176746759	0,00210993	7,253732934	0,063809206	0,1520497
95% Prediction Intervals	7,718 ±0,254	1,599 ±0,177	0,375 ±0,002	167,799 ±7,254	15,742 ±0,064	1,892 ±0,152

With Narrowing CI for 10%

Standart Deviation	0,149670462	0,080878454	0,001083636	3,654076971	0,039031503	0,083697799
Mean	7,738772	1,601876	0,375248	168,295528	15,747664	1,897936
Confidence Interval	0,058670821	0,031704354	0,000424785	1,432398173	0,015300349	0,032809537
95% Confidence Intervals	7,739 ±0,059	1,602 ±0,032	0,375 ±0	168,296 ±1,432	15,748 ±0,015	1,898 ±0,033
10% of CI	0,052803739	0,028533919	0,000382307	1,289158355	0,013770314	0,029528584
Prediction Interval	0,299163661	0,161661121	0,002165988	7,303826234	0,078016779	0,167296471
95% Prediction Intervals	7,739 ±0,299	1,602 ±0,162	0,375 ±0,002	168,296 ±7,304	15,748 ±0,078	1,898 ±0,167

Outputs and the Values of Setup 2 (8 FPS)

Seeds	Average Time Spend In System (Minute)	Average FPS Queue Time (Second)	Average FPS Booth Service Time (Second)	Average Travel Time In Highway (Min)
10	2,1838	0,7945	0,3771	2,1631
20	2,0479	0,9317	0,3781	2,0246
30	2,1719	0,8003	0,3779	2,151
40	2,0585	0,6794	0,3776	2,0392
50	1,9355	0,7822	0,3779	1,915
60	2,0618	0,7645	0,3799	2,0414
70	1,9401	0,7491	0,3763	1,92
80	1,9501	0,7552	0,3756	1,9301
90	2,1243	0,7661	0,3774	2,104
100	2,1281	0,9345	0,3812	2,1046
110	2,1258	0,7379	0,3772	2,106
120	1,8913	0,6489	0,3774	1,8728
130	2,0799	0,7642	0,3791	2,0592
140	1,982	0,7267	0,3771	1,9622
150	1,8652	0,696	0,3745	1,8463
160	2,1921	0,7325	0,3768	2,1723
170	2,0092	0,8181	0,3822	1,9872
180	1,9047	0,7436	0,3781	1,8848
190	1,9975	0,7297	0,3807	1,9773
200	1,9246	0,6909	0,3741	1,9058
210	2,1861	0,9631	0,385	2,1615
220	2,1179	0,9208	0,3761	2,095
230	1,9612	0,6849	0,3746	1,9423
240	2,1571	0,6818	0,3762	2,1382
250	1,9693	0,7323	0,3764	1,9494

Without Narrowing CI for 10%

Standart Deviation	0,103302373	0,071809712	0,002051931	0,102756193
Mean	2,028715	0,7623	0,37781	2,008345
Confidence Interval	0,045274261	0,031471994	0,000899298	0,045034887
95% Confidence Intervals	2,029 ±0,045	0,762 ±0,031	0,378 ±0,001	2,008 ±0,045
10% of CI	0,040746835	0,028324795	0,000809369	0,040531399
Prediction Interval	0,207472729	0,144222794	0,004121103	0,20637578
95% Prediction Intervals	2,029 ±0,207	0,762 ±0,144	0,378 ±0,004	2,008 ±0,206

With Narrowing CI for 10%

Standart Deviation	0,103599931	0,085541131	0,002495663	0,102852555
Mean	2,038636	0,769156	0,37778	2,018132
Confidence Interval	0,040611173	0,033532123	0,0009783	0,040318202
95% Confidence Intervals	2,039 ±0,041	0,769 ±0,034	0,378 ±0,001	2,018 ±0,04
10% of CI	0,036550056	0,030178911	0,00088047	0,036286381
Prediction Interval	0,207077164	0,170980951	0,00498837	0,205583297
95% Prediction Intervals	2,039 ±0,207	0,769 ±0,171	0,378 ±0,005	2,018 ±0,206

Questions

- 1) Are these two systems (first one and the changed one) statistically different? Please answer your question for the 95% confidence interval.

Answer: As seen clearly above, the statistical values between our setups are totally different. That shows the importance of the quantity of FPS Booth dramatically affects the traffic density.

- 2) Estimate the additional replications needed to reduce the half-width of the confidence interval by 10% for the differences of the estimated values of the performance parameters.

Answer: Based on our experiments, we've declared that we have to specify at least 10 more additional replications to satisfy the constraint.