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GreenLine Simulation

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A discrete event simulation project was made to help schedule and improve metro service.

Abstract

This program was written to simulate the Greenline transportation system and give the feedback to the Client. The result and recommendation is shown in below chapters.

According to our simulation result, the average waiting time for each passenger is decreased when the number of trains is increases. However, increase the number of cars for each train could minimize the average waiting time in some situation.

A schedule table with 22 to 24 trains in total (westbound and eastbound) is recommended; the number of each train could be 2 or 3. This schedule minimizes the average waiting time for each passenger and avoid wasting resources—put more trains into the service could not deliver the passenger faster. There will not be any passenger accumulation in each station under this plan, no matter what the number of cars is.

More specific information is provided and analyzed in section below.

Background:

The average inter-arrival rate was chosen to be 1 person/30 sec. The program modified the rate by making campus stations and downtown station busier (5 and 10 sec less for each coming passenger). Downtown stations are 5 times likely to be the destination of a passenger than a normal station. That likelihood for campus station is 3.

There passenger flow is varying during the simulation. The possibility is shown below and a function modifies the possibility for each station

10% of the time: 75% above average arrival interval
15% of the time: 50% above average arrival interval
20% of the time: 20% above average arrival interval
10% of the time: right at average arrival interval
20% of the time: 20% below average arrival interval
15% of the time: 50% below average arrival interval
10% of the time: 75% below average arrival interval

A train will take 3 minutes (180 seconds) between each stop and will wait for at least 15 seconds at each stop. The capacity of each car is 50. It takes a passenger 2 seconds to get off and 1 second to get on. When a car is full, the passenger must was for the next coming train. For each simulation, the trains were arranged evenly to both eastbound and westbound direction. The time lag between trains was set to be same, the minimum time needed to finish the travel divided by the number of train-1 in the railway.

Data and analysis

The data was collected from the output file, organized in tables and analyzed as charts. Result is shown below.

Table 1 Overall result of simulation

Number of Trains	Number of Cars	Total Number of passenger	Average waiting time(s)	Total number of waiting passengers	Ave number of waiting passengers	Max number of waiting passengers
10	2	2787	2412	2264	98	201
12	2	3083	2225	1494	65	168
14	2	3288	2117	819	36	93
16	2	3327	2038	648	28	67
20	2	3401	1984	240	10	33
22	2	3431	1912	129	6	12
24	2	3439	1931	128	6	12
10	3	3216	2305	928	40	74
12	3	3353	2121	457	20	54
14	3	3415	2066	356	15	38
16	3	3329	2007	326	14	33
20	3	3411	1963	296	13	50
22	3	3421	1898	118	5	14
24	3	3463	1955	122	5	14

Table 2 Detailed data for each station

Num of Trains	Num of Cars	Station Number and Number of passenger waiting in that station																						
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	2
10	2	51	33	30	21	46	102	53	123	201	170	164	187	157	158	155	182	133	118	40	22	27	37	5
12	2	3	39	29	24	7	23	8	66	150	137	122	109	156	168	79	75	95	107	8	26	25	36	
14	2	24	10	5	37	19	13	12	29	93	79	69	69	75	78	32	21	29	28	19	30	9	13	2
16	2	25	15	10	29	19	9	14	20	49	40	67	56	45	53	28	37	15	21	20	29	6	14	2
20	2	9	14	8	28	29	13	9	1	8	0	10	2	7	1	6	0	5	10	20	33	4	16	
22	2	11	1	8	1	9	2	9	1	6	1	9	2	8	1	9	1	5	11	9	0	11	2	1
24	2	10	0	10	2	10	1	8	1	7	2	9	0	9	4	9	3	8	1	10	1	10	1	1
10	3	45	40	21	20	18	12	19	33	42	44	70	73	65	74	71	63	33	26	16	18	30	43	5
12	3	54	40	32	21	13	8	12	29	35	10	11	23	10	11	13	23	2	13	7	21	34	35	
14	3	22	10	4	28	21	14	14	12	12	9	13	11	16	6	9	13	11	9	20	36	38	10	1
16	3	25	12	2	32	12	11	9	17	13	5	10	15	12	14	13	9	11	8	19	33	5	15	2
20	3	11	0	50	27	18	8	10	1	9	1	8	0	8	2	7	1	9	3	26	35	49	1	1
22	3	7	1	9	2	11	3	9	0	7	1	7	1	7	1	7	2	6	1	11	0	10	1	1
24	3	9	1	10	1	7	10	7	1	8	1	7	1	6	1	6	1	8	0	14	0	10	2	1

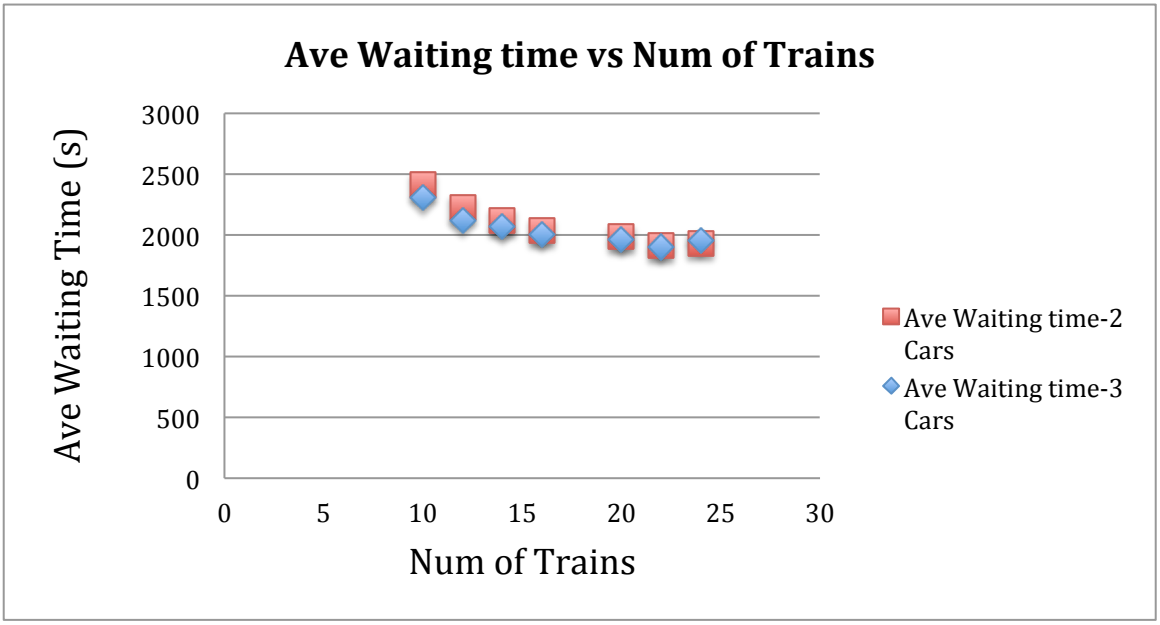

Figure 1 Average waiting time vs. number of trains

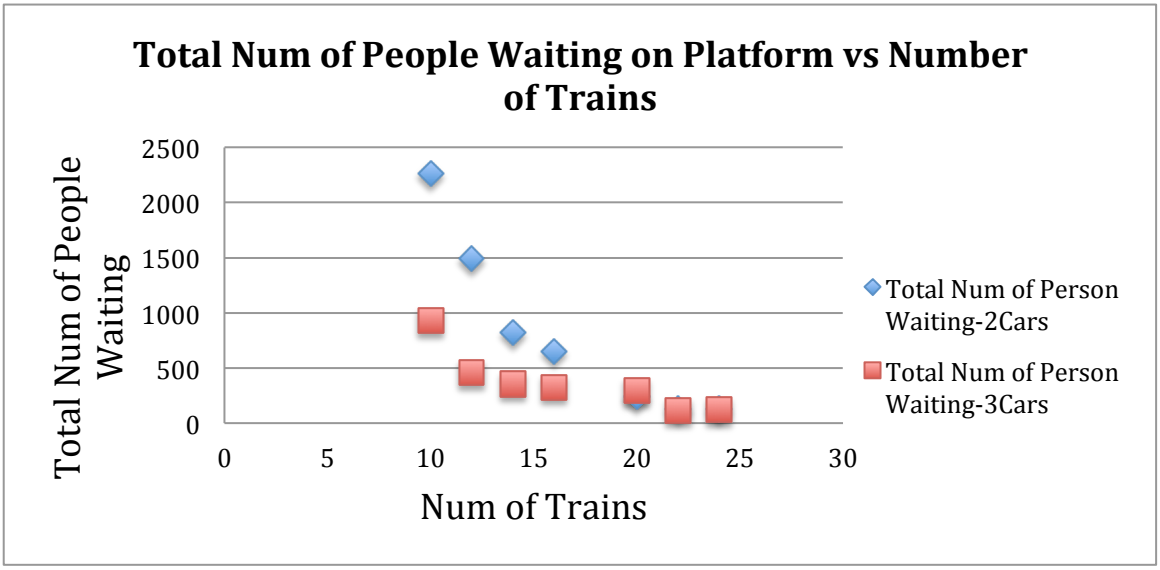

Figure 2 Total Num of People Waiting on Platform vs Number of Trains

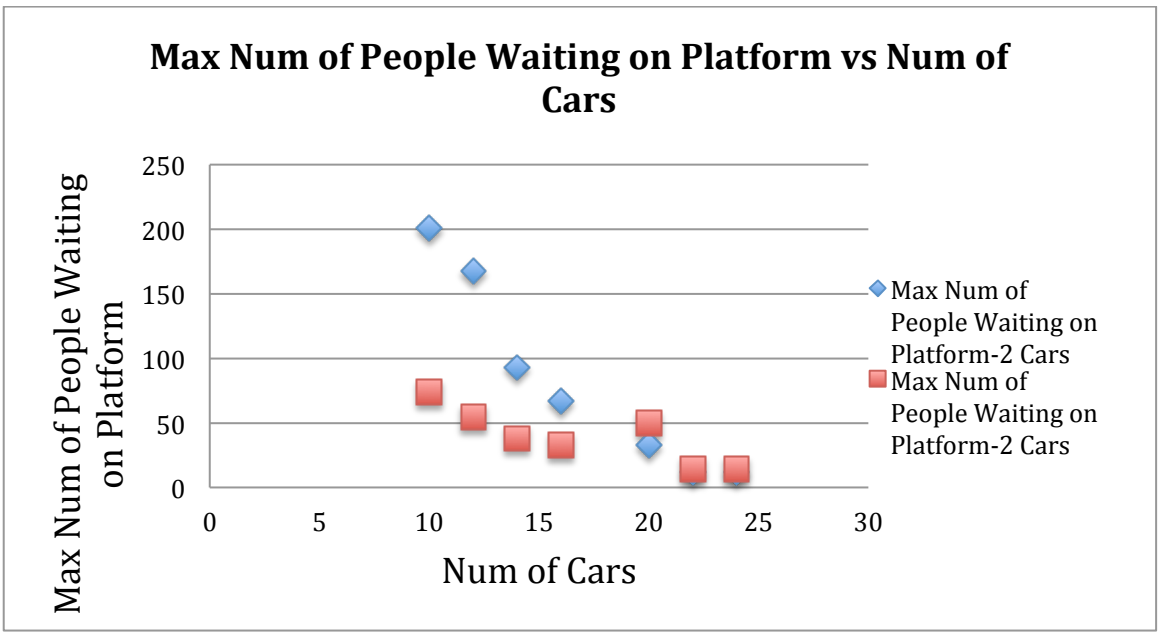

Figure 3 Max Number of People Waiting on Platform vs. Number of Cars

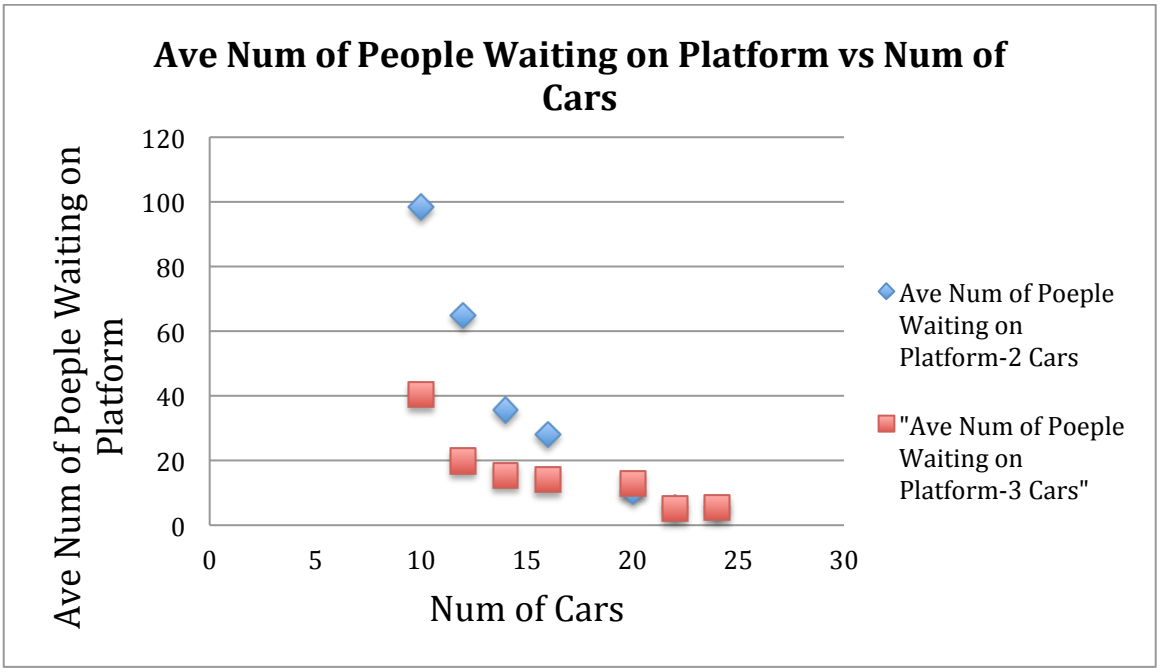

Figure 4 Average Numbers of People Waiting on Platform vs. Number of Cars

Analysis and recommendation

According to the figures, average waiting time for each passenger decreases when more trains are scheduled into service. It remains at constant if more than 22 trains in service. The time spent by passenger who didn't finish the trip was not included in the calculation. But this is reflected by Figure 2, 3, and 4.

Usually the downtown station is more crowded than normal stations. Adding more trains could provide enough spots for passengers. And by concluding the Figure 1, 2, 3 and 4, an arrangement with 22 to 24 trains and 2 cars in each train is recommended. Less than 20 trains could cause the passenger accumulation in stations and adding a third car might ease the traffic pressure as well as there are more than 16 trains in service. The data in table 2 shows that there would be about 650(2 cars) and 330 (3 cars) passengers waiting for trains if only 16 trains in service and passenger will aggregates on the stations in middle of the route because the capacity is filled by passenger who get into the train at downtown stations.

If there are not enough trains on the railway, adding the third car could be a solution. As we can see from Figure 3 and 4, adding a third car can significantly evacuate the platforms. But if there are more than 20 trains, there should be enough spaces for passengers on platforms. According to Figure 2, if there are more than 22 trains in service, there would be no passenger accumulation on each station. There should be no more than 130 passengers waiting for transportation, which is, there are about 5 passengers in each station. The passengers could always find a seat in next coming train.