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Project 4

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Project 4: Green Line Simulation Data Report

This report details the findings of running a simulation of the Twin Cities Green Light Rail Line. The simulation was created with a few assumptions in mind. First of all, it assumes that passengers concurrently board and depart the train, so that the train is waiting only for whichever process takes longer. Next, it assumes that the train takes three minutes to get from one stop to the next, but, the train doesn't actually leave the old stop until the three minutes is up. This means that a stop will be considered full, even if the train's processes have finished, and because of this the maximum amount of trains on the line is 22. Third, trains will only move to the next stop with that exception that trains that arrive at a full station will skip the stop, and continue on to the next empty stop. Only one train is allowed at each stop. This simulation assumes that passengers arrive at the 10 normal (Furthermore referred to as "other") stops at an average rate of one passenger per 30 seconds, with 10% arriving exactly at 30 seconds, 50% arriving within 6 seconds of the average, 80% arriving within 15 seconds of the average, and with 100% arriving within 23 seconds of the average. At the 10 downtown stops, passengers arrive 10 seconds on average faster than the other stops, and at the 3 UMN Campus stops, passengers arrive 5 seconds faster. When passengers arrive at a stop, their destination is five times more likely than the other stops to be a downtown stop, and 3 times more likely to be a campus stop.

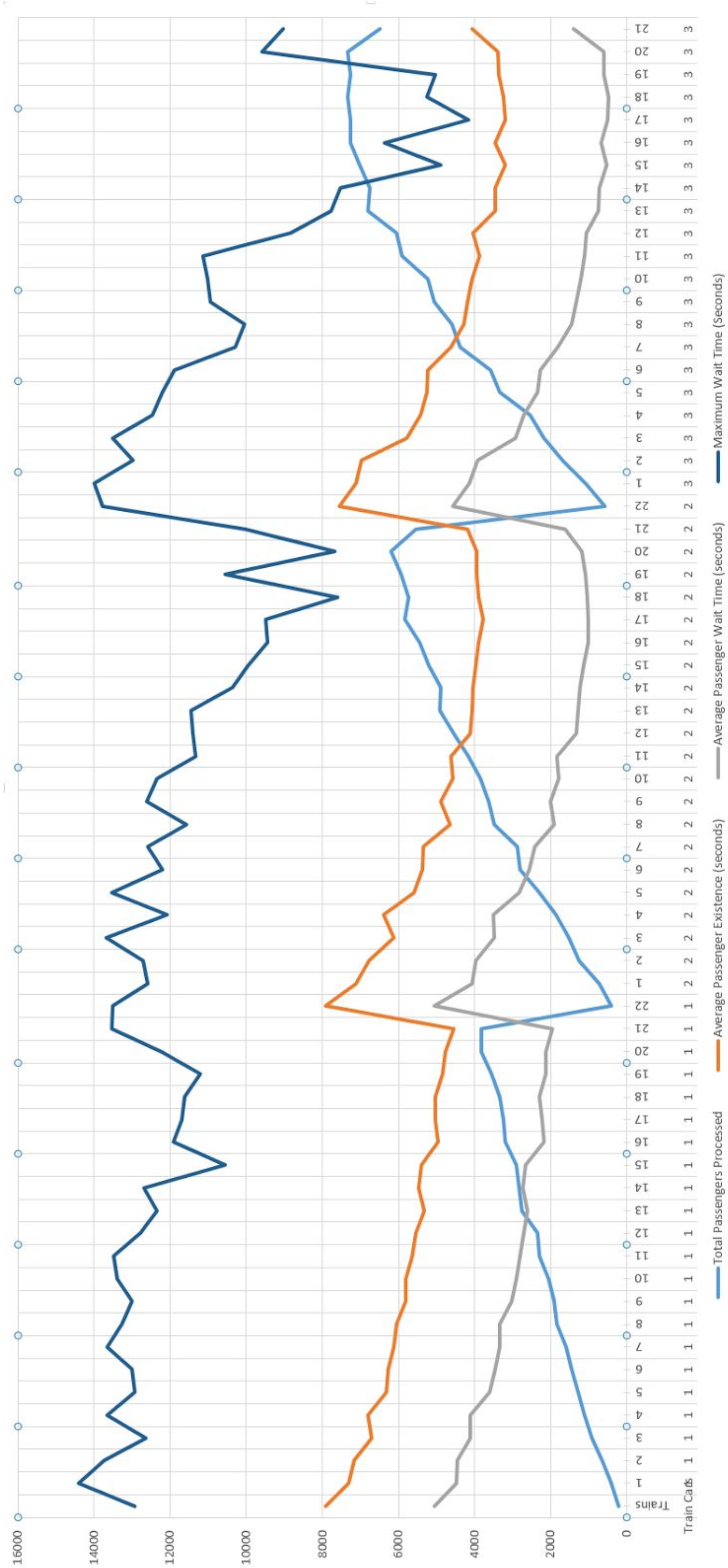
The data recorded here is from the simulation running at 15,000 seconds. The simulation is believed to be in equilibrium, so the graphs should have a similar shape for any amount of time. The raw data collected can be found in the appendix of this report. Figure 1 is a graph depicting the maximum and average passenger wait times, average passenger existence time, and total number of passengers processed. Figure 2 is the table of raw data used to make the graph in figure 1. It also contains columns for the average passengers waiting at the average downtown, campus, and other stops.

The data found has some interesting points. The general shape of each line are either very similar or are very close to the inverse. Each line can be divided into three distinct sections, one for each number of train cars. For one and two train cars, the data reaches a clear maximum/minimum at 22 trains. For three cars, however, the data seems to flatline starting at around 14 trains until 21 trains. The raw numbers themselves are within a few hundred between each of them. This means that 14 trains with three cars performs about the same as 21 trains with three cars. It is also interesting to note the dip in performance at 22 trains with three cars each. A possible cause of this is because at this point only one train can move at a time.

Performance-wise, it can be seen that 22 trains with one car each (22 cars) is similar to 10 trains with two cars each (20 cars), or 6 trains with three cars each (18 cars). Likewise, 22 trains with two cars each (44 cars) is similar in performance to 12 trains with three cars each (36 cars). Three train cars on 14-21 trains outperforms and other combination of train, based when comparing based on the data collected here.

Referring to the average waiting passengers at stops in figure 2, there is another point of interest. It can be seen that, on average, campus stops have the largest amount of waiting passengers, with downtown stops having the next largest, and other stops having the smallest. What is interesting here is that downtown stops have the high rate of passenger arrival, higher than the campus stops, and both are higher than the other stops. A possible reason for this trend is the spread of the downtown stops. Downtown stops are grouped up and located at the beginning and the end of the line, and there are a large number of them. 10 out of every 23 stops that the average train will make will be downtown stops, Downtown stops are usually right next to each other, and the most common destination will be a downtown stop. It is likely for a passenger to be getting on the train to go to a downtown stop, even starting from a downtown stop, meaning that the train will be more likely to be empty at these stops and will pick up passengers.

The average amount of passengers waiting at a stop seems to be more heavily affected by the number of trains rather than the number of cars, but the number of cars does seem to help some. This is because train cars, on average, aren't completely full all of the time. Trains, however, are coming and going, and going in different directions. Passengers only want to get on the train that is going in the same direction as they are. The more trains there are, the more likely that a train that has space that is going in the direction that the passenger is will arrive at the stop.



Appendix

Figure 1 (graph to the right): A graph of the simulation results. Along the x-axis is the parameters of the simulation. It is divided by train and by train car. The y-axis counts both the seconds recorded by passengers and the total amount of passengers. The orange line represents the average time of existence for the passengers. The grey line represents the average waiting time for the passengers. The light blue line represents the total amount of passengers processed in each run. The dark blue line represents the maximum wait time in seconds for the passengers under those parameters. All data should be assumed to be an estimate with a small margin of error. These results were gathered under a run time of 15000 seconds.

Figure 2 (data table below): A data table reporting the data gathered for each train/train car combination. It contains data columns for the total passengers processed, average passenger existence time, average passenger wait time, maximum passenger wait time, and the average passengers waiting at the average downtown, campus, and other stops.

rain (	Train	Total Passengers I	Average Passenger Existen	Average Passenger Wait Tim	Maximum Wait Time (S	Average Downtown Passen	Average Campus Passen	Average Other Passeng
1	1	202	7923	5061	12924	231	281	228
1	2	395	7315	4470	14420	223.2	259	238.9
1	3	644	7175	4449	13728	216.3	269	225.3
1	4	923	6701	4118	12651	203.9	249.7	227.3
1	5	1097	6798	4101	13658	194.2	258.3	220.9
1	6	1286	6323	3615	12926	181.7	241.7	224.2
1	7	1451	6270	3461	13014	275.4	230.7	222.2
1	8	1593	6135	3335	13659	166.5	234.7	218
1	9	1842	6050	3343	13282	158.1	233.7	210.6
1	10	1920	5807	3029	13012	153.1	215.3	212
1	11	2060	5801	2897	13396	152.4	228.7	202.7
1	12	2297	5638	2815	13496	144.4	200.3	201.9
1	13	2347	5546	2714	12798	145.4	205	190.5
1	14	2758	5319	2621	12340	127.9	189.7	196.1
1	15	2836	5475	2721	12678	135.7	168.3	191.4
1	16	2909	5397	2662	10557	146.1	186.7	161.4
1	17	3197	4950	2166	11918	114	184.3	174.8
1	18	3240	5038	2227	11699	116.9	165.7	172.6
1	19	3326	5035	2288	11611	119.7	146	169.3
1	20	3549	4844	2116	11203	115.1	161.7	151.4
1	21	3823	4774	2137	12217	118.3	169.7	135.3
1	22	3822	4561	1950	13527	141.5	158.7	120.3
2	1	401	7924	5055	13523	223.2	260	236.2
2	2	715	7105	4069	12595	212	251.7	228.1
2	3	1264	6779	3957	12703	193.7	243.3	219
2	4	1532	6127	3484	13687	177.3	220.3	214.4
2	5	1870	6382	3510	12093	169.2	214.7	206.5
2	6	2294	5599	2823	13525	146	204	205.2
2	7	2798	5380	2565	12193	131.1	208.3	187
2	8	2881	5337	2425	12604	128	193.7	182.9
2	9	3494	4640	1902	11567	107.7	152.7	178.8
2	10	3617	4882	2002	12608	101.7	169	171
2	11	3857	4562	1780	12351	89.8	116.3	179.5
2	12	4171	4632	1825	11344	94.3	124.3	156.9
2	13	4555	4110	1329	11408	73	109.7	153.5
2	14	4917	4062	1279	11463	68.7	79	142.5
2	15	4884	4043	1241	10364	68.4	90.3	129
2	16	5208	3966	1133	9961	65.3	78.3	118.9
2	17	5447	3888	1016	9435	62.8	73.7	107.2
2	18	5840	3763	1023	9484	65	62.3	91.9
2	19	5734	3892	1026	7612	71.8	50.3	82.9
2	20	5918	3945	1086	10564	97.3	48	58
2	21	6207	3940	1179	7680	86	77	46.8
2	22	5553	4187	1624	10027	130.5	83.3	60.1
3	1	578	7556	4567	13780	220.5	259.3	233
3	2	1073	7122	4134	13991	204.8	243	221.5
3	3	1693	6970	3926	12980	188.5	229.7	205.8
3	4	2166	5787	2920	13521	156.6	220	203.1
3	5	2541	5416	2700	12461	139	191.7	192
3	6	3330	5263	2349	12210	123.6	200	168.2
3	7	3580	5229	2263	11887	112	143	172.1
3	8	4387	4610	1804	10283	91.7	139.3	156
3	9	4603	4271	1448	10056	74.5	140.3	145
3	10	5062	4178	1339	10956	67.5	98.7	132.9
3	11	5223	4075	1213	11013	65.7	74	127
3	12	5912	3882	1116	11133	64.5	57.3	98.9
3	13	6052	4046	1055	8834	65.5	47.3	89.8
3	14	6801	3455	740	7781	58.9	30.3	53.7
3	15	6745	3467	729	7521	59.2	32	49.2
3	16	7011	3187	526	4900	58.1	23.3	30
3	17	7258	3449	670	6355	61.1	28.7	28.7
3	18	7273	3192	515	4172	60.3	17.7	17.1
3	19	7341	3244	487	5261	76.6	15.7	12.1
3	20	7254	3354	593	5041	69.7	21.7	13.1
3	21	7336	3375	610	9582	76.9	24.7	12
3	22	6482	4067	1409	9039	91.8	66.3	42.4