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4/26/2019

Summary of Findings from our Transit System Simulation

Introduction:

Minneapolis public transit has enlisted the help of talented computer science students from the world renowned computer science department at UMN Twin Cities. I have been tasked with coming up with recommendations on how to alleviate rider complaints with regards to Route 3, popular with students such as myself who are stuck living in Como. To do so, I have designed a simulation program that mimics Route 3 with regards to buses, riders, and a variety of statistics simulated in a time sensitive environment. I will test a variety of different cases, altering the number of express and regular buses along with the rate of rider arrivals at different stops to simulate different real world situations that the drivers on Route 3 face.

Note: The README file for this project contains information such as credits, my program/class structure, and specific methodologies. The classes themselves are also commented.

Test Cases and Analysis:

Note: the given arrival rates were ~60 seconds and ~120 seconds for downtown and non downtown spots, respectively. However, these relatively high arrival rates put the simulation out of equilibrium with the suggested range of buses(with regards to queue lengths at bus stops), so I modified arrival rates as follows:

Given situation : ~60,~120

Peak situation: ~150, ~300

Off Peak situation: ~300,~600

I have listed my test cases and gathered statistics below, and will analyze them now.

Case 1: Given rider arrival intervals

Traffic Type: given situation

Regular Buses: 5

Express Buses: 4

total bus departures from a bus stop: 244

total rider arrivals at a destination: 230

total people who boarded a bus: 347

Average Transit Time: 59.916666666666664 minutes

Average Wait Time: 18.989710144927535 minutes

total people who got in line: 2962

How full each bus is on average: 41.545081967213115

Max queue length at a stop: 149
Max wait time for a rider: 112.05 minutes

Case 2: Peak traffic with average buses

Traffic Type: peak
Downtown stop arrival rate:
Regular Buses: 5
Express Buses: 4
total bus departures from a bus stop: 244
total rider arrivals at a destination: 190
total people who boarded a bus: 327
Average Transit Time: 58.855438596491226 minutes
Average Wait Time: 17.782412280701752 minutes
total people who got in line: 1216
How full each bus is on average: 36.15573770491803
Max queue length at a stop: 58
Max wait time for a rider: 89.625 minutes

Case 3: peak traffic with more regular buses

Stats:
Traffic Type: peak
Regular Buses: 9
Express Buses: 3
total bus departures from a bus stop: 393
total rider arrivals at a destination: 205
total people who boarded a bus: 307
Average Transit Time: 49.68 minutes
Average Wait Time: 14.002642276422764 minutes
total people who got in line: 1228
How full each bus is on average: 41.104325699745544
Max queue length at a stop: 51
Max wait time for a rider: 92.95 minutes

Case 4: peak traffic with more express buses

Stats:
Traffic Type: peak
Regular Buses: 2
Express Buses: 12
total bus departures from a bus stop: 212
total rider arrivals at a destination: 124
total people who boarded a bus: 256
Average Transit Time: 65.2361559139785 minutes
Average Wait Time: 23.346438172043012 minutes
total people who got in line: 1179
How full each bus is on average: 22.42452830188679
Max queue length at a stop: 63
Max wait time for a rider: 134.85 minutes

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Case 5: off peak with even buses

Stats:

Traffic Type: Off peak situation

Regular Buses: 6

Express Buses: 6

total bus departures from a bus stop: 306

total rider arrivals at a destination: 164

total people who boarded a bus: 296

Average Transit Time: 52.546239837398375 minutes

Average Wait Time: 18.34918699186992 minutes

total people who got in line: 630

How full each bus is on average: 27.415032679738562

Max queue length at a stop: 25

Max wait time for a rider: 131.5 minutes

Case 6: off peak with more regular buses

Traffic Type: Off peak situation

Regular Buses: 9

Express Buses: 3

total bus departures from a bus stop: 393

total rider arrivals at a destination: 175

total people who boarded a bus: 285

Average Transit Time: 44.43657142857143 minutes

Average Wait Time: 13.63904761904762 minutes

total people who got in line: 605

How full each bus is on average: 35.38931297709924

Max queue length at a stop: 21

Max wait time for a rider: 127.75 minutes

Case 7: larger intervals between rider arrivals (600,1200) and slightly more regular buses

Stats:

Traffic Type: less frequent intervals

Regular Buses: 6

Express Buses: 3

total bus departures from a bus stop: 273

total rider arrivals at a destination: 97

total people who boarded a bus: 174

Average Transit Time: 48.28659793814433 minutes

Average Wait Time: 14.816494845360825 minutes

total people who got in line: 309

How full each bus is on average: 19.706959706959708

Max queue length at a stop: 12

Max wait time for a rider: 51.35 minutes

Case 8: Even more buses with (600,1200) rider Intervals

Stats:

Traffic Type: less frequent intervals

Regular Buses: 12

Express Buses: 12

total bus departures from a bus stop: 612

total rider arrivals at a destination: 109

total people who boarded a bus: 184

Average Transit Time: 38.98868501529052 minutes
Average Wait Time: 8.842201834862385 minutes
total people who got in line: 313
How full each bus is on average: 22.34640522875817
Max queue length at a stop: 11
Max wait time for a rider: 93.01666666666667 minutes

Analysis & Recommendations

Since I designed the program to have express riders only board express buses and regular riders board regular buses, there is a inefficiency in the simulation that can be adjusted for with less frequent rider arrivals. In the later cases, average wait time is significantly lower and an even mix led to lower wait times in the (600,1200) intervals. In all cases, it's interesting to note that having more express buses increased average wait times, while more regular buses decreased wait times. This is because more stops are serviced by the regular buses than the express buses.

Bus utilization is highest in peak and when we have less buses. This makes sense, since buses will fill up a lot faster. This is beneficial to the bus company but will lead to lots of rider complaints, which was the problem in the first place.

However, bus utilization is lower when we deploy lots of buses to a larger rider arrival interval. I would recommend that slightly more regular buses are used in all situations. In a peak situation, I recommend 9 regular buses and 5 express buses since that's where the trends point to, in the case that express riders only take express. I say this since 9 & 5 is less buses than our later cases which had less wait time but much less bus utilization. Since the goal is to maximize PMPG, we should be closer to our earlier cases.