Bussim Report

assignment 2

Introduction:

The Bussim project simulates the operation of a non-linear bus system. It shows the boarding and alighting action of passengers, the arrival and turns of buses, and changes between buses of a passenger due to individual needs. Each action will be vividly described and printed on the terminal screen.
Two simulations will be made, the first one would have six buses in operation where the second only has four. Comparisons between those two animations will be made to create graph which helps us analyzing the difference in two simulations.

Extensions made:

- **Added six more stops (Centre St, Queens St, Abbey St, Steph St, Harr St and Kenn St) and applied non-linear bus system:**
  Originally there were only four stops, which are East, West, South and North St. Six more stops have been added. Centre St, North St and Queens St act as transfer stations which allow people on the different lines to travel to stations that is on other lines. North St and South St were on the x-axes at the beginning, those two stops were then moved to y-axes and their original position was replaced by Queens St and Abbey St. Harr St, Steph St and Kenn St was named after the three students in this group, and is positioned on another line which has an inclined line. The travelling route of the passenger is designed in a way so that least number of stops is needed to pass. For example, a passenger from Steph St who wants to go to Abbey St, instead of going to all the way to Queens St and change, he will first take an inclined bus of direction -1, get off and change at North St, and get on a vertical bus of direction -1, get off and change at Centre St, and get on a horizontal bus of direction -1.

- **Buses picks up and drop off passengers in both directions:**
  Originally the buses only pick up and drop off passengers in direction 1, which is from left to right. Now buses can pick up and drop off passengers in both directions.

- **Passengers have different destinations:**
  Passengers can have different destinations instead of only going to West St. However, passengers will not have destinations which is same as it's source station.

- **Buses travel either vertically, horizontally or inclined:**
  Since there are stops that are three lines, there will be buses that are responsible

for each one of the lines. Four buses operate how horizontal line, two bus operates on vertical line and three buses operate on inclined line.

- **Different type of buses available, they have different speeds, routes and capacities:**
  There are three type of bus now available, Express, Rapid and Local. Express are the fastest bus, with capacity of 4 and only stops and pick up at stations that are on the ends, such as West St and East St, or South St and North St. They ignore passengers on any other stops and passengers who has destination other than its arranged stops. Rapid bus has medium speed, have a capacity of 6, and it only stops and pick up at West St, Centre St, Queens St and East St. If a passenger is at West St, however his destination is on the vertical line, it will also get on the rapid bus but will be dropped off at Centre St for change. Local bus is the slowest bus, but have the highest capacity (10), and it stops and pick up passengers in every single stop, if the destination of the passenger is not on the same axes as the bus, the local bus will drop them off at Centre St for change.

- **Passengers only get on buses if the direction of the bus is same as its own travelling direction:**
  For example, if the passengers are at Queens St and wants to go to East St, his travelling direction will be from left to right. So, he will only boards if the bus approaching is also going from left to right. This function also applies to situations that occurs on other lines.

- **Longer time needed to board and alight according to the number of passengers that are boarding and alighting.**
  The bus will now stop at a station if passengers are getting on and off, it is now showing passengers leaving and boarding graphically. Longer time will be needed to board and alight if there are more passengers getting on and off.

- **Use of impatient passengers:**

  Passengers become impatient and changes color from blue to purple after 7 seconds, and they will leave the station after waiting for more than 12 seconds.

- **Upgraded the message output on the terminal screen:**

  Improved the style of outputting messages on the terminal screen, where it also outputs the name of the passenger's destination, as well as showing the passengers H/V/S direction (horizontal/vertical/inclined). In addition, there will also be message output on terminal if the passenger in a station waited too long and left, and if a passenger got off at a transfer station and waits for change.

- **Simple cost structure shown on figure:**

  On the figure, there is now a label which updates every cycle, showing the number of buses which is in operation, the number of passengers boarded, total revenue earned, fixed cost, oil cost, total cost and net profit. Local bus ticket cost $2, Rapid bus ticket cost $3 and express bus ticket cost $5. Operating a bus adds a fixed cost of $25, and oil cost of $2.5 per turn. Net profit is calculated by subtracting total cost from total revenue

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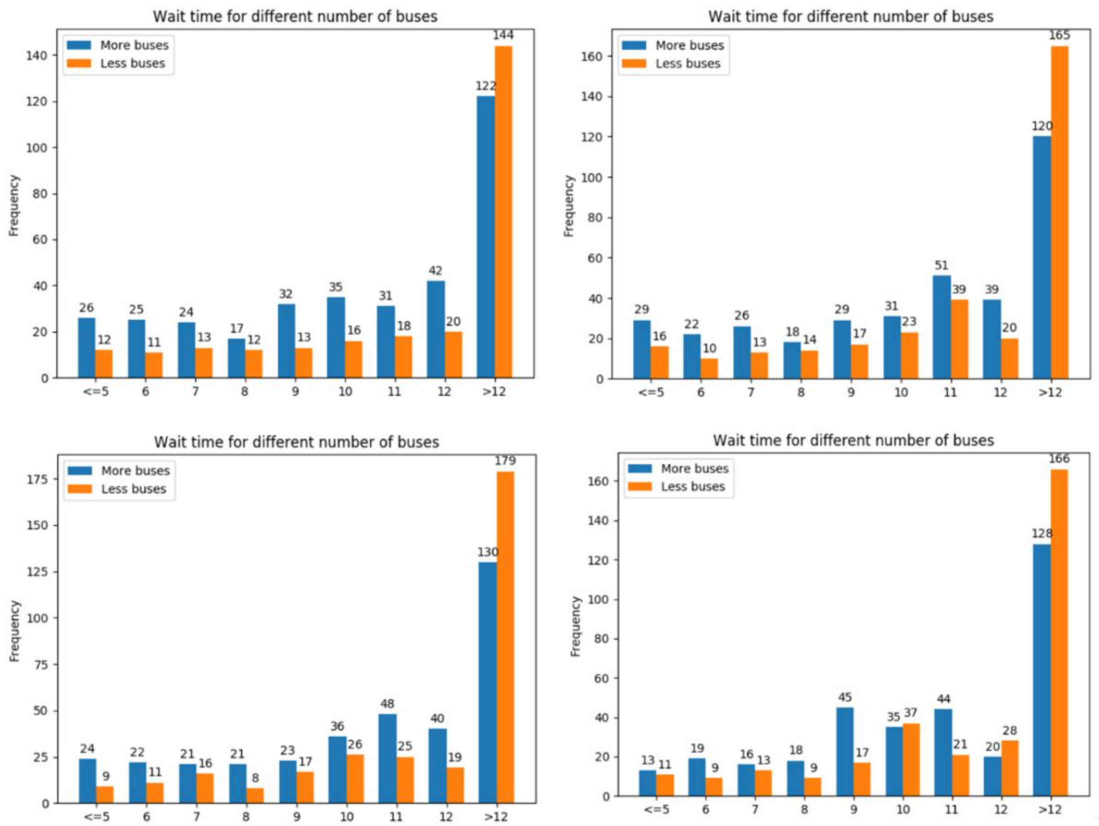
Analysis:

The plot_demo file in busstop folder calls the plotting_function file which actually generate the graphs.

Question 1: How does different number of buses affects the average wait time of passengers at stops?

Two models were simulated in order to compare, the first model have 9 buses in operation (4/2/4 in horizontal/vertical/inclined) and second model only have 6 (3/1/3 in horizontal/vertical/inclined). A bar graph which shows the number of passengers having different waiting times in station in the two model is plotted. Graph is plotted four times, and each simulation lasted for a duration of three minutes in order to obtain reliable results.



According to the four graphs above, using less buses results in an increase in the number of passengers leaving (wait time > 12s). However, for waiting times, in the range of 10-12 seconds, seems to have a larger number of passengers compared to other times regardless of more or less buses. By using statistical calculations, average waiting time can be calculated by this formula:

$$\frac{\sum(n \cdot t)}{N}$$

Where n is the number of passengers at a particular waiting time, t is the waiting time and N is the total number of passengers.

After calculation, the average waiting time for using more buses is 8.78 seconds and average waiting time for using less buses are 9.13 seconds.

As a result, using three more buses doesn't affect average waiting time a lot, with only a difference of 0.35 seconds. However, it does increase the number of boarded passengers a lot.

Question 2: How does removing buses affect the amount of net profit earned within a fixed period of time?

Three models were simulated for this question, the first, second and third models contains nine, seven and five buses respectively. Each model was simulated for five minutes, and a line graph is plotted to obtain the relationship between time and net profit. The graph obtained is shown below.

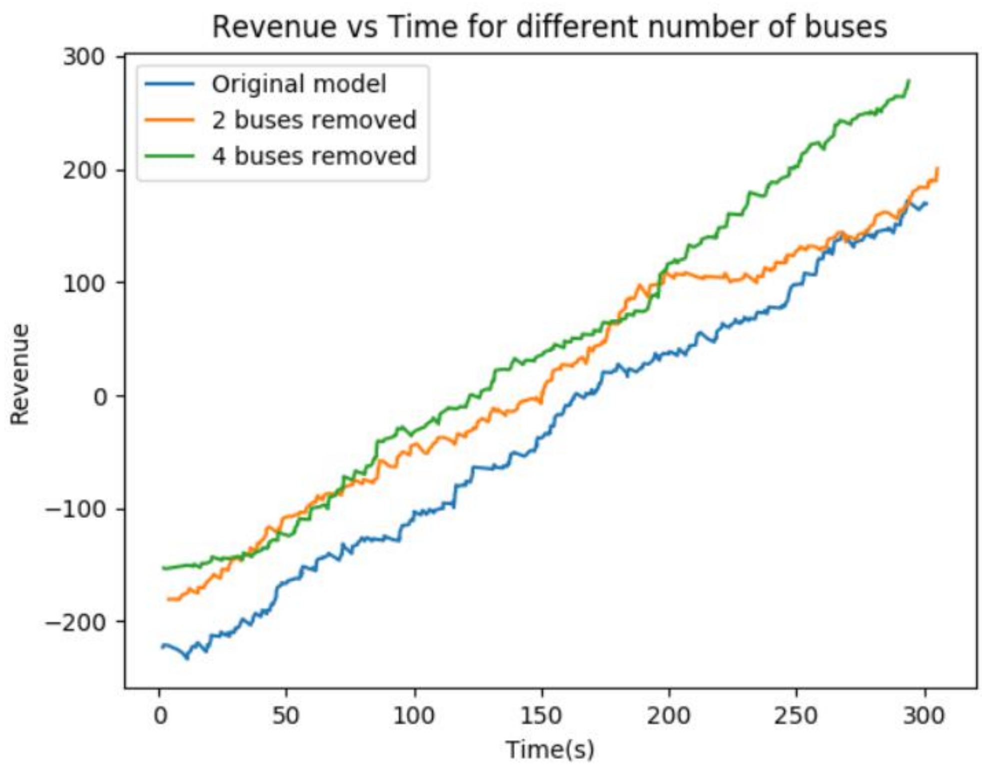
Operation of buses requires costs, including fixed costs (cost of running a bus) and oil cost. Each bus has a fixed cost of $25 regardless what type of bus it is, and the oil cost for each bus is also the same, it is calculated as $2.5 per turn. That is, after each turn, a cost of $2.5 will be added to total cost.

According to the graph, it appears to be that amount of net profit earned increases as the number of buses removed increases. This may be because of fixed cost drops significantly as less bus is in operation, which makes the deficit at the beginning smaller, therefore results in an upward shift of the entire line.

On the other hand, this may also occur due to a reduction in oil cost. During the simulation, multiple local bus's position tends to overlap each other, which becomes extremely inefficient because it basically then only acts as a single bus. In order to solve this problem, we think that it would be better if local buses have slightly different speeds, such as 1.25, 1.5 and 1.75. Varying local buses speed a little might have a large impact on net profit.

Just out of interest, the three models were simulated again for five minutes to look at the difference in net profit gained, after varying the local bus speeds.

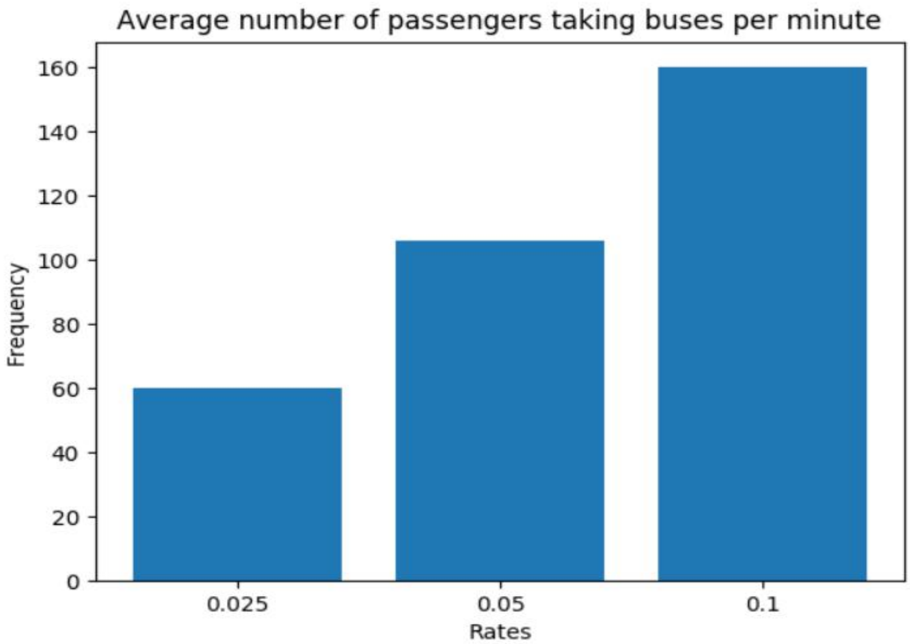
On the graph below, shows the relationship between time and net profit after varying the bus speeds. The green and orange line's net profit have increased from approximately \$250 to \$280 and \$140 to \$190 respectively, while the original model's net profit appears to stay the same. As a result, varying the bus speeds do have an impact on net profit gained mainly because this can help to prevent situations where local buses on a same line overlap each other.



Question 3: How does the rate of randomly created passengers affect the number of passengers boarded per minute?

Three models were simulated for five minutes to examine the relationship between rate of randomly created passengers and number of passengers boarded per minute. The bar graph below is plotted to show the correlation between those two variables.

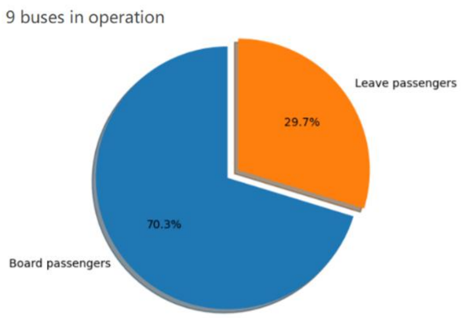
According to the graph above, when rate is raised from 0.025 to 0.05, 0.025 to 0.1,

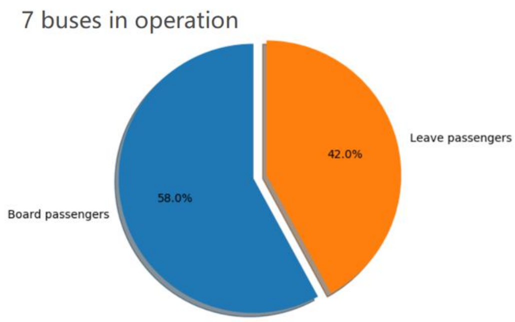


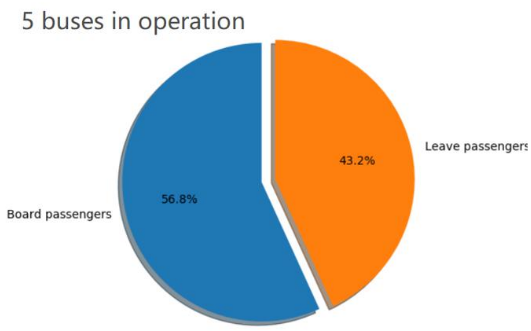
and 0.05 to 0.1, 75%, 167% and 52% increase in number of passengers boarded per minute is obtained respectively. By looking at the simulation we then know this is because each bus has higher average passengers on bus after stopping at a station. Which leads to a large number of passengers boarded per minute.

Question 4: How does the number of buses affect the percentage of successfully boarded and percentage of leaving passengers.

Three models were simulated for a duration of five minutes to examine the relationship between number of buses and percentage of boarded and leaving passenger. The first, second, and third models contains nine, seven and five buses respectively. A pie chart is plotted to observe the percentage of two type of passengers clearly.







We can vividly observe that when more buses are in operation, percentage of boarded passengers is higher and percentage of leaving passengers is lower.

When lowering number of buses in operation from nine to seven, a large increase in percentage of successfully boarded passengers is obtained. However, when reducing number of buses from 7 to 5, the change is not significant.

<u>Conclusion:</u>

On the first attempt in non-linear bus system, we only created two bus lines, one vertical and one horizontal which shares a common stop is the center. After we finished other tasks, we thought it would be a good idea to develop a more complexed non-linear bus system, as a result we came up with this new three-line bus system. Since the passenger's route is designed in a way that least number of stops will needed to be passed, we have considered every possible situation, in order to reach highest efficiency in the operation of the bus system.

In addition, we added an interesting feature, that is, when buses alight or boards passengers, the animation will show passengers will boarding and alighting one after another graphically.

At the end, we only created a simple cost structure because we are running out of time.

In conclusion, we had a really clear distribution of tasks, everyone knows what they are responsible for. Meanwhile, helping each other to add some comment if they forgot to do so.