Evaluation report.

Executive Summary

We discuss the overall design of our elevator simulation, in addition we critically analyse behaviour of the simulation, regarding the effects of inputting different probabilities of clients arriving and developers/employees changing floors. The results of our study demonstrate that, an increase in p value is directly proportional to an increase in average waiting time. In contrast, results suggest Q values have a negative linear relationship in relation to the average wait time.

Behaviour of the simulation

This section briefly discusses the behaviour of the system, in relation to how it was made to ensure that results are repeatable. To achieve this, a single instance of Random is reused throughout the simulation: a user inputted seed is used to create a random inside the building class, which is shared between each person through their constructor methods, when they are initialised.

Study Findings

This section investigates the impact of all 25 combinations P and Q values in relation to average waiting times and number of complaints made in a day. To achieve the results of this study, 5 different P values (0.001, 0.002, 0.003, 0.004, or 0.005) and 5 different Q values (0.002, 0.004, 0.006, 0.008, or 0.01), along with a consistent spawn value of 10 for employees and developers on tick 0, were used. Anomalies were detected in every seed regarding the total number of people in the simulation, these were still included in our study as they did not affect the general trend of the data.

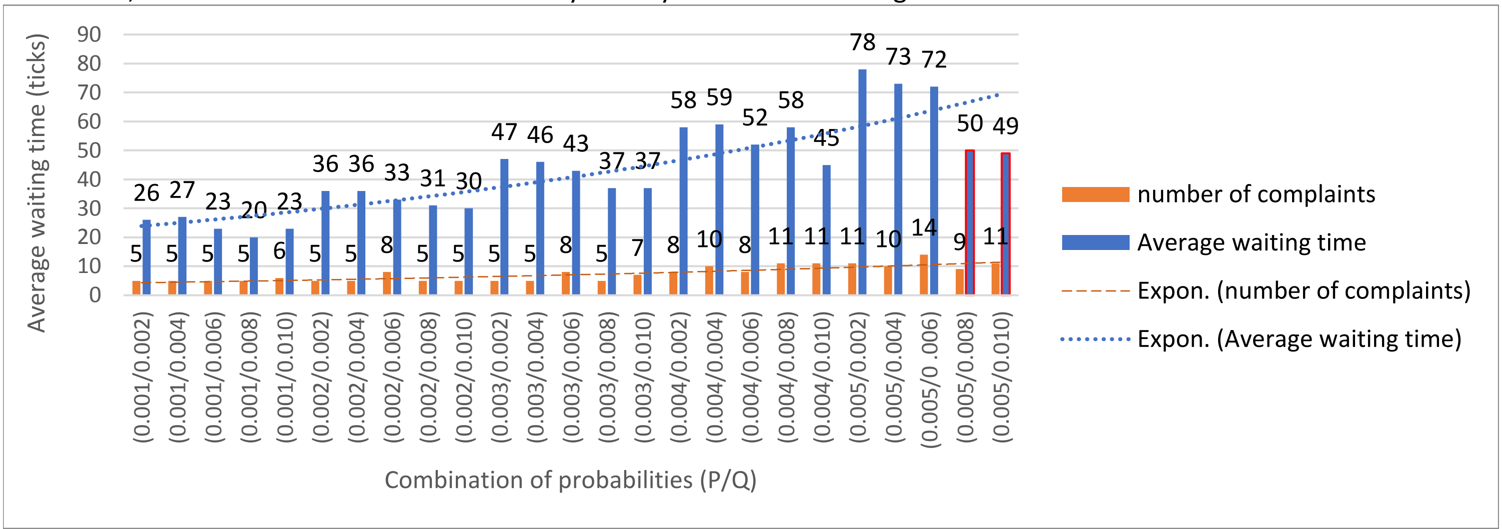

Figure 1. Seed 1, Average waiting times and number of complaints across all 25 test combinations of P and Q values.

Figure 1 demonstrates a positive linear relationship between combinations of P and Q and the average waiting time of people. The graph implies an increasing probability of changing floors (P value) has the largest impact towards the average wait time of people waiting for the elevator in the simulation. On the contrary, the results also highlight the positive impact from increasing the probability of client spawn (Q value) past 0.004: the total average wait time decreases with each increment of Q above 0.004.

This occurs because the total average wait time is averaged over a larger population of people, when higher Q values are used. This larger population greatly undermines the impact of an increasing P value to the point where drastic decreases in average total wait times can occur, as shown with the red outlined bars at the end of the chart.

We speculate that the average waiting time would continue and may even further exaggerate the drastic impact of shown in figure 1, if higher Q values were continued to be used. However, at some given point where a P value is high enough, it may outweigh the impact of Q, thus foreshadowing results that illustrate a more stable increase of average waiting times as both P and Q are increased in conjunction of each other.

In addition to this, figure 1 also illustrates the number of complaints made in all test combinations for seed 1. The results suggest a steady constant increase in the number of complaints made, with respect to each increment of P. However, there are some instances where the number of complaints suddenly spikes. We hypothesize this could be due to the nature of rival developers refusing to board the lift when their rival exists in the elevator already, for seed 1 as this trend of "spiking" complaints is not consistent across all seeds. Other seeds demonstrate a steady and consistent increase in the number of complaints for each increment of P and Q.

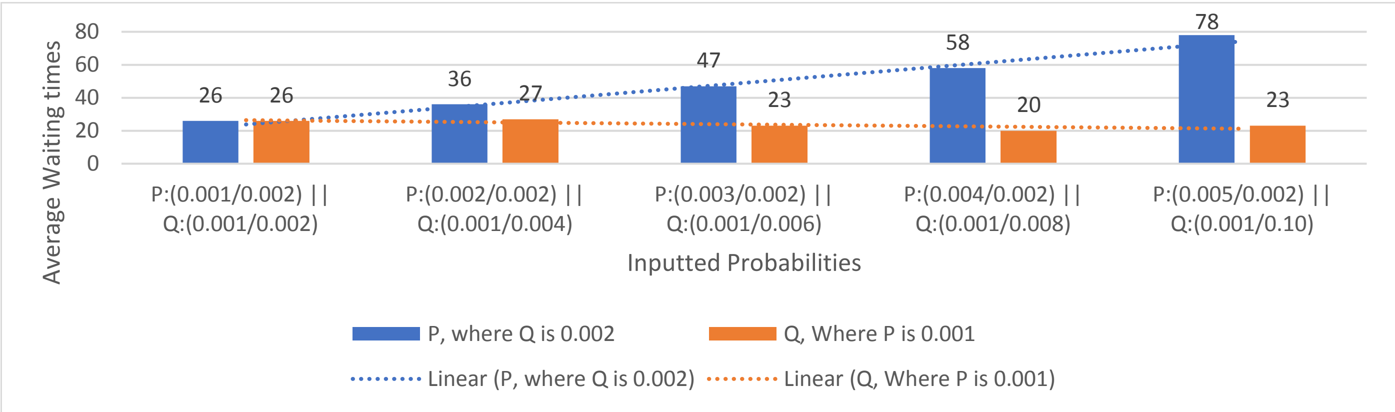

Figure 2: Seed 1, bar chart illustrating the individual effects of P & Q on average waiting times

Figure 2 illustrates the relationship between Q values and average waiting time: A strong negative linear relationship is produced. This is due to the increased population of clients added into the simulation. As consequence to this, the total population of people is also increased with each increment of Q, which results in a decreased average waiting time. While demand for the lift would increase due to an increased population of people, the average waiting time does not. This is because the total waiting time of the population is averaged using a larger population size. Hence, a lower average waiting time is produced. The results in figure 2 also illustrates the relationship between P values and average waiting time, which in contrast suggests a strong positive linear relationship between the two variables. This is directly due to an increased demand to use the lift at higher P values.

An efficiently working elevator is defined through an average waiting time below 60 ticks and no more than 5 complaints from the clients in a day. An average waiting time of under 60 ticks was not met by any seed tests for this study, however, every seed tested had 0 client complaints for every combination of P and Q.
Results show when P values of 0.005 is used the lift becomes overwhelmed to manage these requests, however this impact is undermined when Q values of 0.004 or higher are used.
Interestingly, there was a consistent modal average of 5 complaints for all seeds. This is due to the nature of rival developers, refusing to board the lift if their rival is already present in the elevator, in addition to the unorthodox method used to order the arrival of people at tick 0. For example, in every seed we tested, people would arrive in the same order on tick 0: 10 employees followed by 5 Goggle and then 5 Mugtome developers. Due to the consistent order of this arrival, the Mugtome developers always refused to board the lift together with Goggle developers, which caused a peak in average wait time and a modal average of 5 complaints made in a day.

Improvements

Due to the nature of rival developers, the number of complaints was consistently a minimum of 5 throughout the simulation, across all seeds. To improve this, we would shuffle the order at which people arrive in the building at the start of the simulated day. This would decrease the number of complaints made in each seed as the rival developers would have a reduced the possibility to see other and move to the end of the queue, thus waiting longer to board the lift.

Interestingly, a similar lift simulation project (Hamdi and Mulvaney, 1998) which models the passenger arrival throughout the day using real world data suggests the implementation of a method where people have a randomly generated arrival time to spawn in the building, to more accurately represent the real-world, as people do not always arrive to work in time. To better represent this environment in our oversimplified simulation of a lift, we should implement a method where employees and developers would each have a randomly generated arrival time to spawn in the building. For example, instead of spawning people on tick 0, they would randomly arrive in the building between tick 0 and 60 ticks.

Conclusion

In conclusion, our study demonstrates that increasing the probability of client spawn (Q) decreases the average waiting time but has a very small influence over the number of complaints made in a day. In contrast, increasing the probability of changing floors (P value) demonstrates a drastic increase of average waiting time for the elevator and a steady influence towards increasing the number of complaints made in a day. However, our simulation has successfully represented working lift, however the simulation is currently inefficient in regards of handling a higher demand of lift requests. Finally, we also suggest some potential improvements to decrease the number of complaints made in a day and more accurately simulate a real-world elevator.

References

Hamdi, M. and Mulvaney, D, 1998. Simulation of Lift Passenger Systems and Modelling of Passenger Movements. [online] 2 (1029 6646.), p.11. Available at: <https://www.academia.edu/11549282/The_simulation_of_lift_systems_and_the_modelling_passenger_movements> [Accessed 5 May 2020].