# Operational Research 2 - Simul8

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October 2019

## 1 Introduction

The main objective of the simulation is to model a call centre and minimise the staffing cost among the feasible solutions. The constraints on the solutions are the trivial points that the numbers of workers must be positive integers as well as having a Quality of Service of greater than 70% and an Abandonment Rate of less than 5%. The Quality of Service is defined to be the fraction of calls whose waiting time in queue is no larger than 30 seconds, and the Abandonment Rate is the percentage of calls which are abandoned before they start being served by a Call Agent. The software used for the simulation was Simul8.

# 2 Simulation

## 2.1 Implementation

The two varieties of day, heavy-1 and heavy-2, were modelled using two concurrent sims, each with the entry point data distributions adjusted to fit the day as per the specification. Three agent types were modelled using three resources per sim, each of which acts as the sole constraint on the activities for processing of calls. Two call types were modelled using two entry points per sim. The two events of a call either being successfully processed or being abandoned due to excessive wait times were modelled using four exit points per sim. The random variable of a customer's patience for queuing was modelled using the 'Shelf-Life' feature, with the values being assigned as per the distribution given on the specification. The call intake was modelled as per spec, according to day type, at the entry points - using an exponential distribution with average reciprocal of given inter-arrival time.

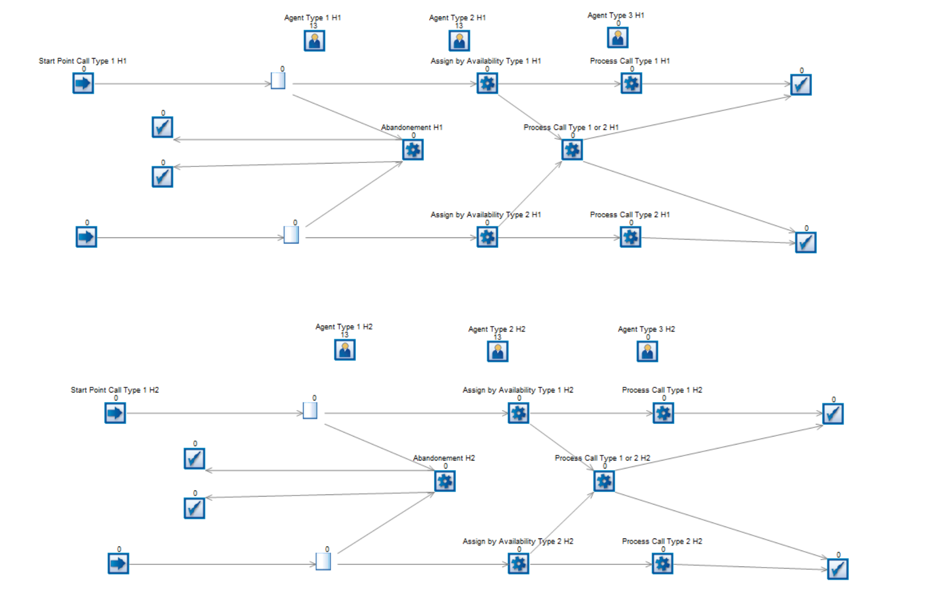


Figure 1: The Simulation

## 2.2 Design Decisions

The routing policy was designed to prioritise the usage of agents of types one and two over agents of type three to minimise cost. This was achieved as below, with the routing policy from the sorts giving preference to specialist-handling over generalist-handling. Entrance points were split as seen to enable data to be measured separately by call type. Exit points were separated as seen to enable abandonment-rates to be measured separately per call type. Queues were separated as seen to enable waiting times within the queue to be measured separately by call type. Concurrent sims were chosen as this would expedite the testing process and enable more precise comparisons between the results per day-type, as results are now measured per day type across the board to be averaged as appropriate later. Agents as resources were chosen to act as the measurement for the optimal solution and as a natural constraint on the simulation. The inter arrival times were modelled accurately to correctly simulate the pauses between calls incoming at each entry point given the nature of the exponential distribution.

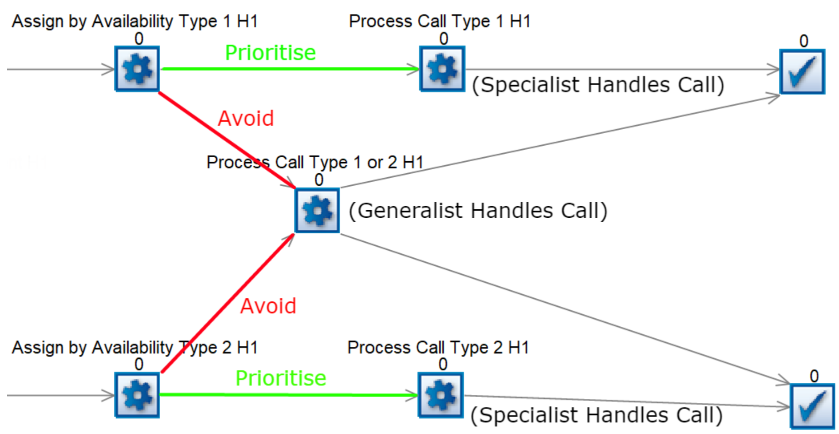


Figure 2: Routing Policy

## 3 Analysis

Here we will discuss the methodology we used in testing, the results that were output and what information we were able to glean from them.

### 3.1 Methodology

The first problem presented was deciding on how to choose the number of each type of specialist or generalist. To do this we used the symmetry of the problem to assume the same number of Agent Type-1 and Agent Type-2, or for them to differ by 1. For each value of Agent Type-3, the critical number of Agents Type-1 and Type-2 were found so that the boundary of the feasible solution was found, as well as checking the value when Agent Type-1 and Type-2 differed by 1. This was calculated for all values of Agent Type-3 until Agent Type-1 and Agent Type-2 were no longer needed to fulfil the constraints. By the linearity of the cost function this means the optimal solution for each value of Agent Type-3 was found. The minimal Unit Cost of the feasible solutions collected was taken to give the optimal unit cost for the simulation. Each trial lasted for 5 days and was run 15 times per trial. It was decided to run this many trials, as for each day in Simul8 two days of data were recorded, with 5 Simul8 days being run 50 times this leads to each trial being an average of 150 days worth of data. Due to the Central Limit Theorem using 150 days, we are sufficiently close to infinity to assume a high probability of any non simulated day falling within a normal range.

| Agent Type 1 | Agent Type 2 | Agent Type 3 | Average QOS | Average Abandonment | Unit Cost | Unit Cost Of Successful Trials |
|---|---|---|---|---|---|---|
| 12 | 12 | 0 | 88.13% | 3.63% | 24 | 24 |
| 12 | 11 | 0 | 84.94% | 4.75% | 23 | 23 |
| 11 | 12 | 0 | 84.83% | 4.73% | 23 | 23 |
| 11 | 11 | 0 | 81.63% | 5.85% | 22 | Fail |
| 11 | 11 | 1 | 86.84% | 3.98% | 23.1 | 23.1 |
| 11 | 10 | 1 | 82.93% | 5.23% | 22.1 | Fail |
| 10 | 11 | 1 | 82.92% | 5.27% | 22.1 | Fail |
| 10 | 10 | 1 | 79.06% | 6.58% | 21.1 | Fail |
| 10 | 10 | 2 | 84.77% | 4.51% | 22.2 | 22.2 |
| 10 | 9 | 2 | 80.19% | 6.12% | 21.2 | Fail |
| 9 | 10 | 2 | 80.42% | 6.06% | 21.2 | Fail |
| 9 | 9 | 2 | 75.45% | 7.79% | 20.2 | Fail |
| 9 | 9 | 3 | 81.68% | 5.52% | 21.3 | Fail |
| 9 | 9 | 4 | 87.02% | 3.78% | 22.4 | 22.4 |
| 9 | 8 | 4 | 82.46% | 5.22% | 21.4 | Fail |
| 8 | 9 | 4 | 82.62% | 5.17% | 21.4 | Fail |
| 8 | 8 | 4 | 77.71% | 6.76% | 20.4 | Fail |
| 8 | 8 | 5 | 83.84% | 4.72% | 21.5 | 21.5 |
| 8 | 7 | 5 | 78.60% | 6.47% | 20.5 | Fail |
| 7 | 8 | 5 | 78.45% | 6.47% | 20.5 | Fail |
| 7 | 7 | 5 | 72.71% | 8.39% | 19.5 | Fail |
| 7 | 7 | 6 | 79.20% | 6.16% | 20.6 | Fail |
| 7 | 7 | 7 | 84.87% | 4.29% | 21.7 | 21.7 |
| 7 | 6 | 7 | 79.89% | 5.95% | 20.7 | Fail |
| 6 | 7 | 7 | 79.74% | 5.98% | 20.7 | Fail |
| 6 | 6 | 7 | 74.23% | 7.93% | 19.7 | Fail |
| 6 | 6 | 8 | 80.49% | 5.71% | 20.8 | Fail |
| 6 | 6 | 9 | 85.79% | 4.03% | 21.9 | 21.9 |
| 6 | 5 | 9 | 80.87% | 5.55% | 20.9 | Fail |

| Agent Type 1 | Agent Type 2 | Agent Type 3 | Average QOS | Average Abandonment | Unit Cost | Unit Cost Of Successful Trials |
|---|---|---|---|---|---|---|
| 5 | 6 | 9 | 81.00% | 5.51% | 20.9 | Fail |
| 5 | 5 | 9 | 74.99% | 7.42% | 19.9 | Fail |
| 5 | 5 | 10 | 81.29% | 5.35% | 21 | Fail |
| 5 | 5 | 11 | 86.62% | 3.79% | 22.1 | 22.1 |
| 5 | 4 | 11 | 81.65% | 5.23% | 21.1 | Fail |
| 4 | 5 | 11 | 81.63% | 5.26% | 21.1 | Fail |
| 4 | 4 | 11 | 75.61% | 7.20% | 20.1 | Fail |
| 4 | 4 | 12 | 81.88% | 5.20% | 21.2 | Fail |
| 4 | 4 | 13 | 86.98% | 3.66% | 22.3 | 22.3 |
| 4 | 3 | 13 | 82.06% | 5.16% | 21.3 | Fail |
| 3 | 4 | 13 | 82.28% | 5.07% | 21.3 | Fail |
| 3 | 3 | 13 | 76.25% | 7.03% | 20.3 | Fail |
| 3 | 3 | 14 | 82.50% | 5.01% | 21.4 | Fail |
| 3 | 3 | 15 | 87.40% | 3.57% | 22.5 | 22.5 |
| 3 | 2 | 15 | 82.85% | 4.89% | 21.5 | 21.5 |
| 2 | 3 | 15 | 82.62% | 4.95% | 21.5 | 21.5 |
| 2 | 2 | 15 | 76.86% | 6.82% | 20.5 | Fail |
| 2 | 2 | 16 | 82.90% | 4.93% | 21.6 | 21.6 |
| 2 | 1 | 16 | 77.07% | 6.75% | 20.6 | Fail |
| 1 | 2 | 16 | 77.12% | 6.74% | 20.6 | Fail |
| 1 | 1 | 16 | 70.06% | 8.96% | 19.6 | Fail |
| 1 | 1 | 17 | 77.10% | 6.64% | 20.7 | Fail |
| 1 | 1 | 18 | 83.24% | 4.80% | 21.8 | 21.8 |
| 1 | 0 | 18 | 77.49% | 6.58% | 20.8 | Fail |
| 0 | 1 | 18 | 77.29% | 6.63% | 20.8 | Fail |
| 0 | 0 | 18 | 70.55% | 8.95% | 19.8 | Fail |
| 0 | 0 | 19 | 77.67% | 6.52% | 20.9 | Fail |
| 0 | 0 | 20 | 83.57% | 4.64% | 22 | 22 |

Figure 3: The Spreadsheet

The results from the trials run are shown above. This shows the number of each of the Agent types as well as the value of the constraints for each trial. The Unit Cost of the trial is directly proportional to the cost of hiring the Agents and, therefore, the minimising solution for Unit Cost will also minimise the Hiring Cost of the Agents. This spreadsheet enabled the guarding against some avoidable errors by displaying the values changed for each run and automatically exporting the data from Simul8 from each run meaning no potential errors from copying results across. This meant that human input was reduced to a minimum and therefore human error.

## 3.2 Resultant Findings

It can be clearly seen that the feasible region of the proposed problem is not convex, as we have distinct and non-adjacent solutions. The algorithm used to choose the values to test found the integer values closest to the boundary of the feasible solution and found that the solutions

$$\begin{bmatrix} AgentType1 \\ AgentType2 \\ AgentType3 \end{bmatrix} = \begin{bmatrix} 8 \\ 8 \\ 5 \end{bmatrix}, \begin{bmatrix} 3 \\ 2 \\ 15 \end{bmatrix} or \begin{bmatrix} 2 \\ 3 \\ 15 \end{bmatrix} \tag{1}$$

gave an optimal cost across all values of Agent Type-1, Type-2 and Type-3. Although all of these solutions are of optimal cost they have different values for Quality of Service and for Abandonment Rate. The solution (8 8 5) had better performance for both of these constraints and therefore is the most productive of the feasible solutions of optimal cost. The QoS of our solution is 83.84% and the Abandonment Rate is 4.72%, this makes sense as the Abandonment rate is a much harsher constraint. The Abandonment Rate is close to the 5% boundary on feasibility but given how many runs were taken the variance of the parameter is very small.

# 4 Conclusion

By creating a model of the call centre in Simul8 it was possible to find an optimal solution by running several simulations to minimise unit cost while satisfying the performance constraints which are mentioned in the methodology section of the report.

The feasible solution suggested to the firm is to hire 8 specialist workers and 5 generalist works. This solution gives an average quality service of 83.84 with an abandonment rate of 4.72. Both of these results satisfy the performance constraints given by the firm, with a unit cost of 21.5. Looking at figure 3 which shows the spread sheet of results from the simulation it is clear this is the optimal solution for the firm.

As Seen in the Resultant Findings Section, two other optimal solutions were calculated. Although these solutions were feasible and of optimal cost, both of them had a lower Quality of Service and a higher Abandonment Rate, which clearly shows that the solution given has optimal performance of the feasible solutions of optimal cost.