DISCRETE EVENT SIMULATION FOR OVADIA LAW GROUP CALL CENTER

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1 INTRODUCTION

According to (Poster, 2007) on the U.S Bureau of Labor Statistics report, 1.55 million people are working in the call center industry. Moreover, it is expected that this number will keep growing for the years to come. With the recent events of the pandemic and the intrinsic changes it has brought to the actual society, many companies have changed their physical business to online sales. This is why many of them have been obligated to create call centers, increasing the number of the ones that existed before the pandemic to help their customers with their inquiries.

As stated by (Munoz and Bastian, 2016) one of the most important aspects considered by call center managers is the optimization of its operators, which implies covering the highly variable demand and finding an efficient way to assign people to certain shifts to achieve a desired service level and abandonment rate. This highlights the importance of the simulation process because it allows experimenting in the system without suffering the consequences in real life, Furthermore, simulation is

also important because it enables the business or the manager to distribute their resources (time, money, workers) most appropriately.

The main concepts used in this paper are the clients or events that refer to the incoming calls of the call center, also the activities that refer to the action of the agents speaking to the clients and transferring them to either the Ovadia Law group or the other allied law companies and the word agents refers to the employees of the call center that take the calls.

This paper provides a discrete event model and its description for the Ovadia Law Group call center system in order to examine possible reasons for delays in their service and possible improvements to their waiting times. The processes included in the model will be call arrivals, waiting time or ring time, and duration of the communication with the respective agent or talking time. Discrete event simulation is used because of its great accuracy and easy implementation in systems, including queues like the ones formed by the incoming calls of this call center. Discrete Event Simulation (DES) was chosen to do the model of this company's call center model because the incoming calls are not continuous and the individual's characteristics do not change the system, while the individuals flow within a defined system.

2 CONCEPTUAL MODELING

2.1 PROBLEM DEFINITION

By understanding the system and the close evaluation of the call center work, issues that affect waiting time or occupation percentage of the workers were noticed.

In this system, there are two different start points: the new clients and the old ones. The latter are the ones that have had cases with the company in the past but are calling to open a new case regarding a different matter. This is important because the type of client affects the talking time directly. If it is a new client, the agents have to ask them several questions in order to send this information to the corresponding attorney, but if the caller is a preexisting client, they only have to update the details of the case, but not the basic information.

There are eight agents in the call center; all speak Spanish, three speak English, and the rest speak Portuguese. Most of the agents work from Monday to Friday, but they work in three different schedules that are 7 am to 4 pm, 8 am to 5 pm, and 1 pm to 10 pm, but two agents work on the weekends from 9 am to 6 pm US ET.

Most of the missed calls in the system are because the clients call outside business hours, all the agents are busy, that all the agents that speak the client's language are busy or the waiting time is too long and they decide to hang up.

2.2 OBJECTIVES OF THE MODEL

2.2.1 MODEL'S PURPOSE

The purpose of this model and simulation is to find possible issues regarding the ring time and the occupation percentages of the employees and provide some possible solutions for this problems. Ovadia Law Group's agents usually have a relatively low occupation percentage, so it is expected to find a solution for this problem without firing employees or using much more money.

2.2.2 SPECIFIC OBJECTIVES OF THE MODEL

Perform a sensibility analysis to find the influence of the parameters in the variables when they experience changes.

Understand how different sources of calls affect the model.

Understand how the subsystems correlate and interact with each other and how those interactions affect the model's performance.

2.2.3 PROJECT'S OBJECTIVES

Model the call center's system as faithful to reality as possible in order to obtain applicable results using the software Simul8.

Analyze and obtain the probability distribution that explains and adjusts to the call center's data.

Make a sensitivity analysis to identify the parameters that directly affect the call center's performance to suggest improvements to the company.

2.3 ENTRANCES AND EXITS

The entrances to the model are the calls from either Customers that have already called or new clients that speak one of three languages, Spanish, English and Portuguese, the existing exits are the calls that finish all the call center process and are redirected to either Ovadia Law Group or one of the allied companies and the other exit is the calls lost because of no agent from that language attending at that time. The inputs the model uses are the number of agents working on each shift, this are also known as the experimental factors and the outputs relevant to the accomplishment of the objectives are the utilization percentage of each agent, the number of calls lost, the amount of calls completely processed and the average time in system.

2.4 MODEL CONTENT

2.4.1 Scope

One of the main difficulties in developing this project is the data given by Ovadia Law Group because, in the categories, Source, Old clients and New clients, they only report the average and not the raw information. This is a difficulty because the data cannot be adjusted correctly to a probability distribution that truly represents it and if the model is developed with the wrong probability distribution, this could lead to simulating the model incorrectly, therefore give the wrong suggestions or insights about the model. Even though the time between calls and the duration of the calls are raw information, not averages they didn't differentiate between old caller and new caller and this could be an issue when adjusting the data to a probability distribution because these variables are directly related to the duration of the call.

In the development of the model the software Simul8 will be the main tool to use because it allows to represent the model, add probability distributions to the variables using the option Statfit, make changes and see how all of that affects the obtained outputs. To make more simple calculations and some graphics the software Excel will also be used.

The main objective in this project is to obtain a model that reflects the real-life call center system because as of this results some improvement suggestions might be done to the company helping them to improve key processes helping them to attend the most number of calls possible using the resources available.

2.4.2 Level of detail

The model describes the calls from old or new clients to Ovadia Law Group call center, these calls can be for one of 11 allied companies and depending on the company they are reaching, one of three languages is related to them, 8 agents are answering the phones from which 3 speak Portuguese, 5 speak English, and all 8 of them speak Spanish as well. Also, depending on the company they are reaching, the call center can just redirect them directly to the company or collect their information for the company and then redirect them. Lastly, some information collecting for some companies takes longer than others due to the information required.

2.4.3 Assumptions

In the implemented model it is assumed that people from all the languages represent the same proportion of the calls at any hour of the day, as well as the clients reaching the different companies. This is because the given data only includes the total of callers for that company and language through the whole day, also human error wont be taken into account and also it is assumed that agents take a similar amount of time for attending the same type of call. Given that the demand of the lawyers seems to be inelastic between weekends and business days, it has been assumed that the only change in the demand is per hours and not per days.

2.4.4 Simplifications

Instead of modeling the entire day, only work hours will be taken into account for the model, agent's time to complete each call is grouped into the language the customer asks for as within the agents that speak the same language no difference in times was significant, lastly the difference between callers that are redirected to other company and the ones redirected to Ovadia Law Group are not going to be differenced as this doesn't affect their time in system significantly.

3 SIMILAR CASES

In the project made by Munoz, D. A., & Bastian, N. D. (2016) their main approach was to generate and analyze discrete-event systems simulation-optimization models to test the behavior of a real-world call center under the actual configuration and under different levels of cross-training. This is similar to our project because they also simulate a call center system and optimize the available resources. Even though this is not the objective in this project, based on the simulations performed, some suggestions can be made to the Ovadia Law Group call center to improve the system's general functioning. This article is also useful because they use different statistical distributions such as the Erlang, Poisson and exponential that can be the same as the Ovadia Law Group call center and in that way the results of their investigation can be used to compare and validate the results obtained with the modeling of this call center.

Another investigation useful as a guideline for the development of this project is Pisaniello, A., da Silva, W. B., Chwif, L., & Pereira, W. I. (2018) because in their project they simulate another call center but also because they receive the calls in two different groups, just as in the Ovadia Law Group call center the calls have divisions by language and type of client. The fact that their model considers this disseverance is very useful to validate the model made to simulate this call center because the results obtained might be similar. On the other hand, using this article as a reference might show a direct comparison between

simulation methods: Validation and Verification (V&V) and Discrete Event Simulation (DES). Based on the results obtained in this project and the ones obtained in that investigation it might be possible to add things from V&V to provide better conclusions once the model is completed.

Finally, the most similar article to this project is the one made by the authors Kuncová, M., Fábry, J., & Klimova, A. M. (2020). They used the program Simul8 to analyze a discrete event in a call center. That investigation is useful for the development of this project because it could be useful as a guide to see how they distribute the resources, the entrances and exits, the agents and the activities. In that way if there is a crossroad during this process solutions might be found and if they chose a different approach for the structure of the model, at the end of the simulation a comparison can be made and draw conclusions and propose improvements. An important thing implemented by the previously mentioned authors is that they performed a sensibility analysis once the DES in Simul8 was completed to see how the change in some parameters could affect the system. This is a clever strategy to implement because it could help the company to sort these changes when they occur.

4 DATA OF THE MODEL

While analyzing the time between calls and considering that the frequency tends to depend on the hour, it was expected that different hours had different means of the time between calls. Thus an independence analysis with the mean of the time between calls in each hour, because of the memory loss property of the exponential distribution (which was expected as the appropriate distribution for this parameter) indicated independence between different hours. And ever so more noticeable was the fact that the fitted density of the time between calls in a day, rejected the exponential distribution, and erlang distribution, but when the analysis was done per hour it did not reject these, see below.

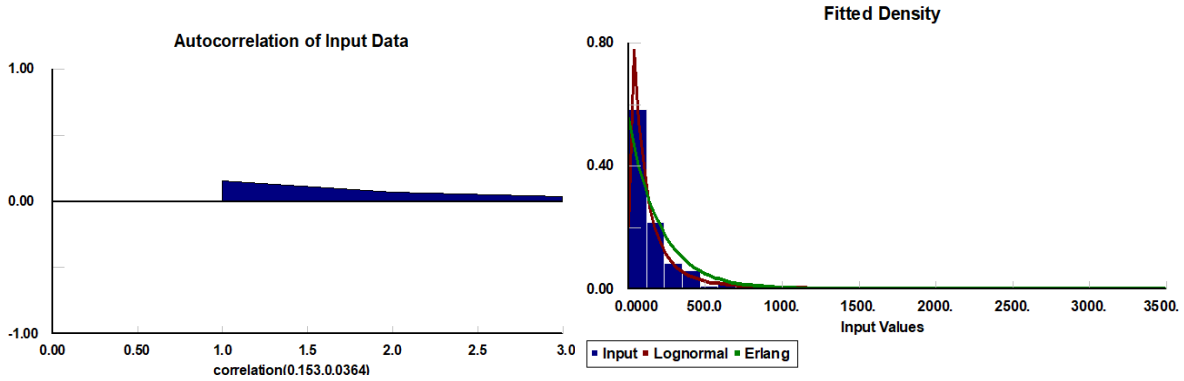


Figure 1: Autocorrelation and Fitted Density of the time between calls in a day

When analyzing the time between calls there were some distributions like the Gamma or the Weibull that fit better than the exponential distribution, however given the literature, specifically the author Aguir, Karaesmen (2004) and the fact that the exponential distribution was not rejected when fitted, the exponential distribution was chosen as the appropriate distribution for the model. It is also worth noting that that there is no correlation in the time between calls, this is due to the memory loss property of the exponential distribution.

autofit of distributions

distribution	rank	acceptance	aicc prob
Weibull(0.268, 0.925, 133)	98.8	do not reject	0.216
Exponential(0.268, 138)	74.6	do not reject	1
Gamma(0.268, 1, 138)	74.6	do not reject	0.343
Erlang(0.268, 1, 138)	74.6	do not reject	0.343
Pearson 6(0.268, 507, 1.18, 5.19)	63.2	do not reject	0.0935
Lognormal(-5.39, 4.46, 1.09)	63.1	do not reject	0.0924
Beta(0.268, 835, 0.836, 3.93)	43.1	do not reject	0.0565
Pearson 5(-27, 1.8, 158)	39.8	do not reject	0.0132
Rayleigh(-76.5, 183)	0.0378	reject	0
Power Function(0.222, 681, 0.442)	0.00648	reject	0
Triangular(0.199, 672, 0.25)	0	reject	0
Uniform(0.268, 655)	0	reject	0
Chi Squared	no fit	reject	0

autofit of distributions

distribution	rank	acceptance	aicc prob
Gamma(-0.501, 1.25, 93.1)	100	do not reject	1
Weibull(-0.138, 1.13, 122)	99.9	do not reject	0.883
Pearson 6(0.232, 274, 1.81, 5.12)	95.4	do not reject	0.393
Lognormal(-13.2, 4.56, 0.806)	86.6	do not reject	0.488
Pearson 5(-42.1, 3.16, 353)	80.8	do not reject	0.198
Erlang(-0.501, 1, 117)	63.2	do not reject	0.127
Beta(0.232, 624, 1.12, 4.65)	62.8	do not reject	0.332
Exponential(0.232, 116)	46.5	do not reject	0.54
Rayleigh(-42.4, 133)	0.974	do not reject	0.00226
Power Function(0.135, 468, 0.531)	0.00609	reject	0
Triangular(-4.71, 478, 7.1)	0.000371	reject	0.00353
Uniform(0.232, 463)	0	reject	0
Chi Squared	no fit	reject	0

Figure 2: Fitting of the time between calls in two different hours.

5 MODEL IMPLEMENTATION IN SIMUL8

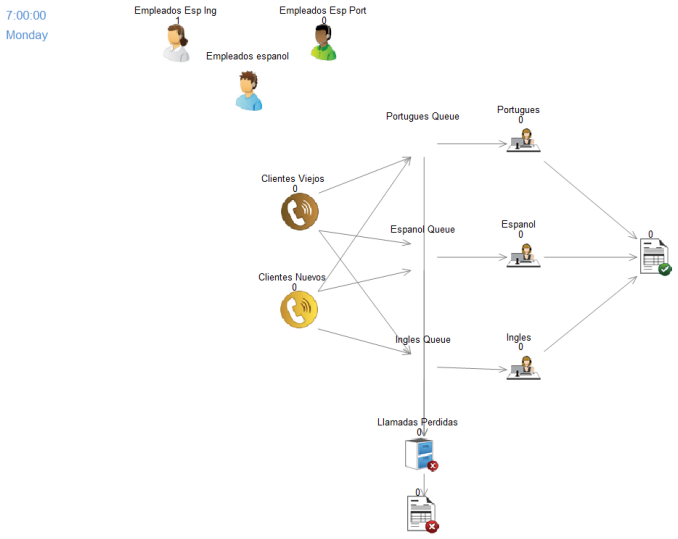


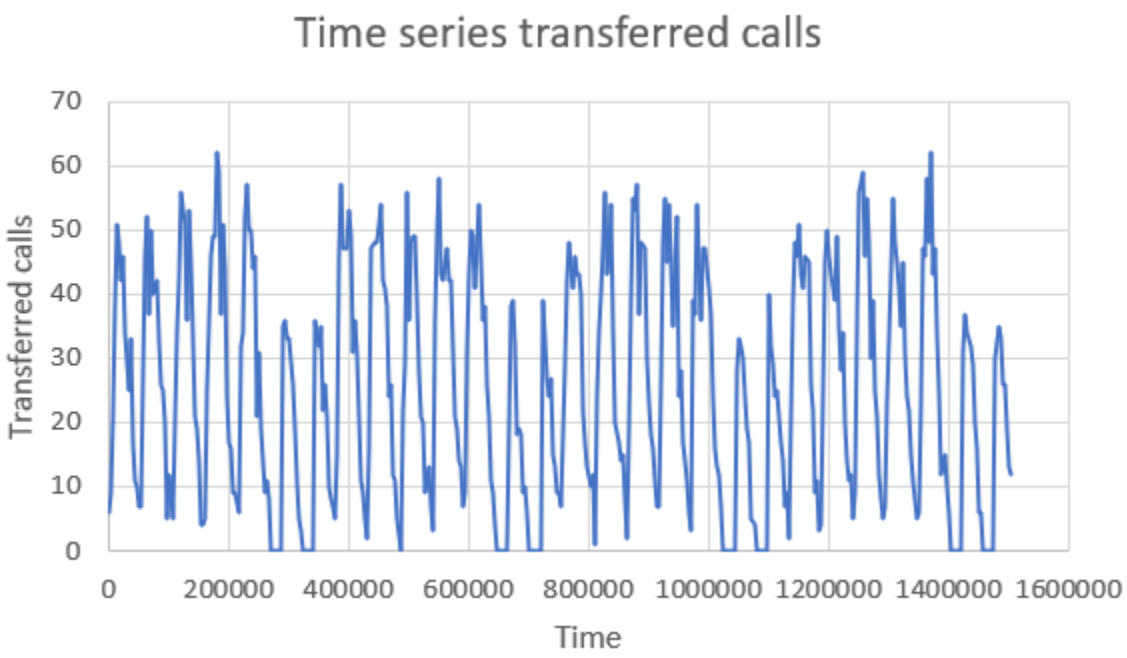
Figure 3: Simul8 model of Ovadia's Call Center

The model describes the calls from old or new clients to Ovadia Law Group call center, these calls can be for one of 11 allied companies and depending on the company they are reaching, one of three languages is related to them, there are 8 agents answering the phones from which 3 speak Portuguese, 5 speak English and all 8 of them speak Spanish as well. Also depending on the company, they are reaching, the call center can just redirect them directly to the company or collect their information for the company and then redirect them, lastly some information collecting for some companies takes longer than others due to the information required.

6 RESULTS GATHERING

6.1 Nature of the model

The model has a terminating nature in a window of time of a week as the employees' schedules repeat every week, also the idea of the model is to look how to improve the regular weekly behavior of the call center every week.



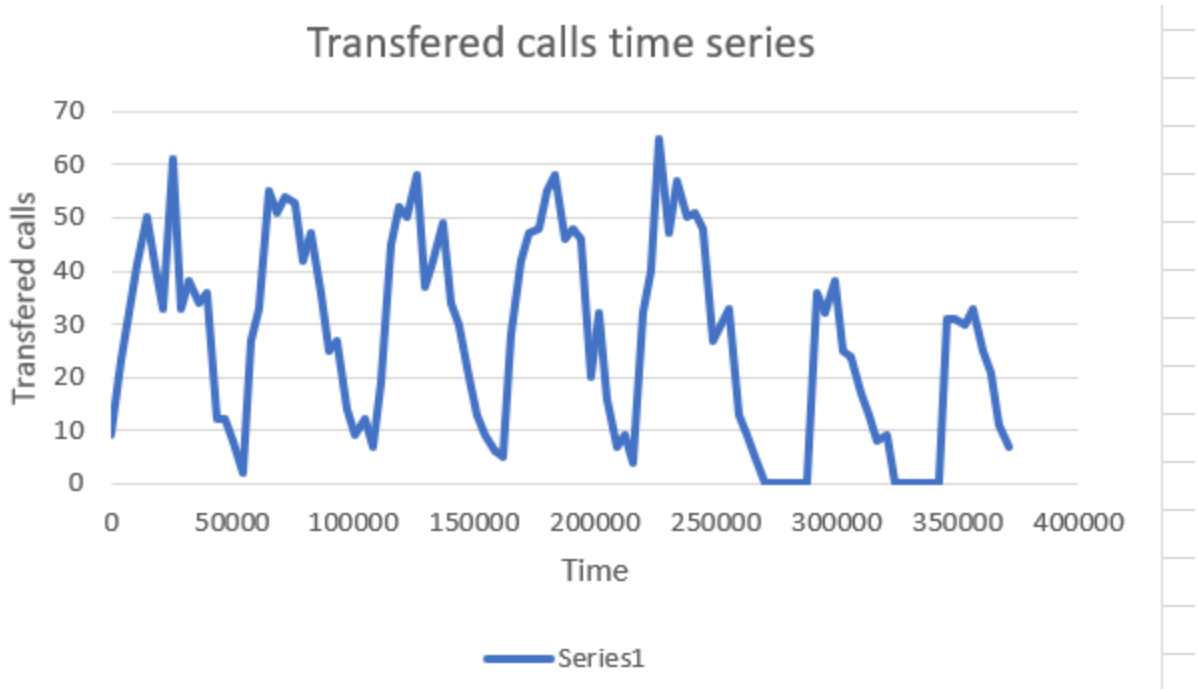
The time series above describe the transferred calls per hour during one month on the Ovadia Law Group call center, it is evident it has a cyclic or restarting behavior every week, this means the process is terminating in a lapse of a week.

6.2 Nature of the output of the model

The model's output is transient as the distributions involved in the time calls can take and how often a new client arrives generate numbers, this causes the output of processed calls to be different each time, the average time in system and the amount of calls lost are the most important resulting outputs that change according to the random numbers dependent on the distributions used in both the duration of the activity and the time between arrivals.

6.3 Management of Initialization Bias

The model does not require an initialization bias management as the system itself restarts every day just like the model does, this means there is no need for a warm up period as seen in the next window of time.



As it is seen in the graph above, the queues restart every day and as the simulation starts at the beginning of the workday on Monday, there is not a initial Bias and no need for it's management.

6.4 Number of runs

The next table shows how many runs are recommended to have a good calculation of each of the different output variables:

(Recommended runs for 5% precision)	
transferidos: Average Time in System	11
transferidos: Number Completed	4
Perdidas: Number Completed	9
transferidos: Maximum Time in System	4

Therefore, the number of runs has been decided to be 11 to have a more precise approximation of the average time in system.

6.5 Solution space

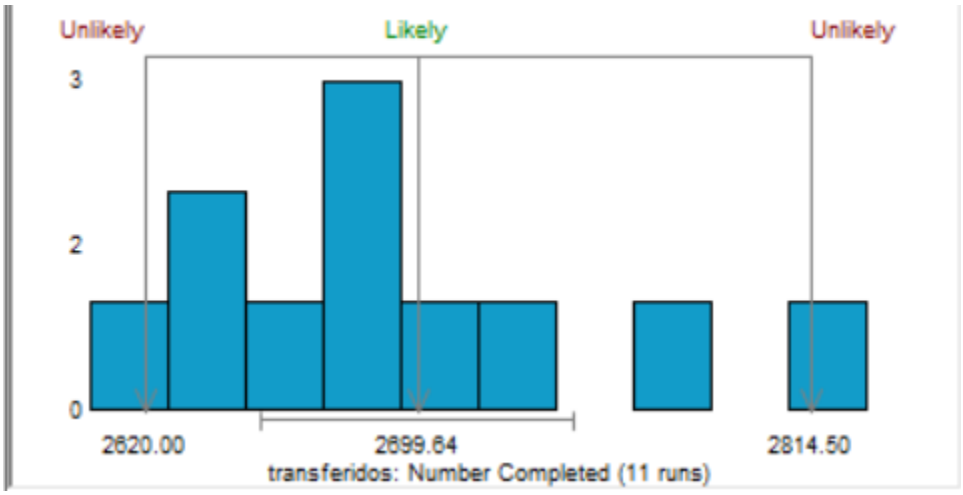
The solution space is defined by how many agents there can be available in each existing shift. The minimum number of agents on each schedule its one as the call center wants to keep providing its services in the same hours, and the maximum of agents that speak the same language in the same shift is three as there is no more physical space in the call center for more employees. The parameters of each of the distribution that influence in the model shouldn't be changed in a significant way as it would mess up completely how the model functions. The average of time between arrivals cannot go lower than the one defined at 3 pm and cannot be higher than the one assigned to 12 m.

7 VERIFICATION AND VALIDATION

A table with confidence intervals and average values of every output value, a black box validation will be done next.

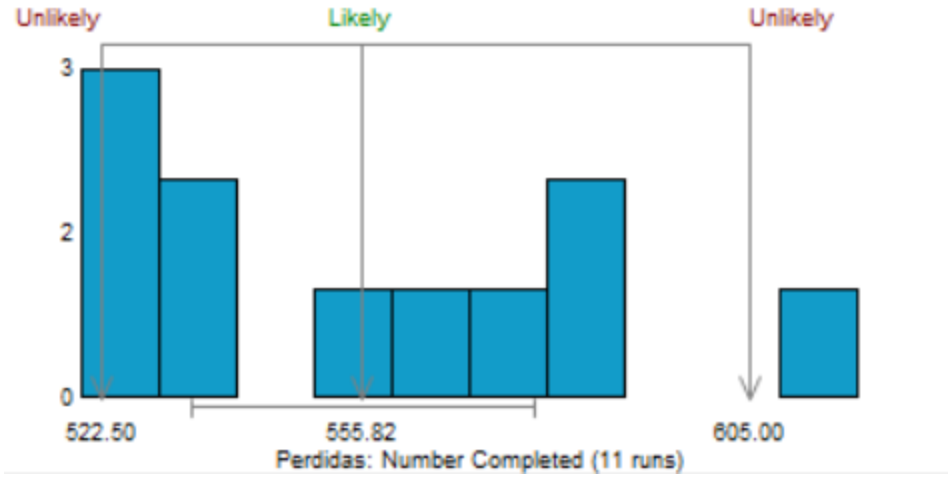
		Low 95% Range	Average Result	High 95% Range	Risk
Esp Ing dia	Utilization %	52.43	53.70	54.97	
Esp Ing tarde	Utilization %	23.67	24.65	25.62	
Esp Ing temprano	Utilization %	35.81	37.33	38.84	
Esp Ing weeknd1	Utilization %	31.91	32.83	33.75	
Esp Ing weeknd2	Utilization %	25.12	26.36	27.60	
Esp Por dia	Utilization %	65.48	66.68	67.88	
Esp Por tarde	Utilization %	42.71	44.08	45.44	
transferidos	Number Completed	2653.83	2699.64	2745.44	
	Average Time in System	301.36	316.48	331.60	
	Maximum Time in System	21898.63	21959.96	22021.28	
Perdidas	Average Time in System	300.72	300.72	300.72	
	Maximum Time in System	300.72	300.72	300.72	
	Number Completed	533.94	555.82	577.70	

The next is a histogram showing the results of transferred calls for each of 11 different runs and the confidence interval found.



The real data gave a result inside the confidence interval (2800 total transferred calls) found in the simulation; this depicts a good behavior of the model compared to the real-life system considering the number of transferred calls. The results and outputs of the model and the model itself have been revised and checked by the call center manager who was able to verify that it is consistent with the actual call center behavior.

The next is a histogram showing the results of lost calls for each of 11 different runs and the confidence interval found.



The real data shows a total number of lost calls inside the given confidence interval (577 lost calls in real data) this means the way lost calls are handled is consistent with its management in real life.

8 SENSITIVITY ANALYSIS AND EXPERIMENTATION

8.1 Sensitivity analysis

		transferidos: Number Completed	transferidos: Average Time in System	transferidos: Maximum Time in System	Perdidas: Number Completed
Normal Trial	Low 95% confidence	2653,829644	301,3667371	21898,64241	533,9350224
	Average	2699,636364	316,4869729	21959,96568	555,8181818
	High 95% confidence	2745,443083	331,6072088	22021,28894	577,7013412
Old Callers	-10%	2795,727273	317,5255959	21945,65838	595,4545455
	10%	2618,363636	320,3539916	21987,11517	531,8181818
	Sensitivity	1,936000214	0,093530144	0,338018416	1,454003111
	Beyond Confidence	1	0	0	1
New Callers	-10%	2867,818182	315,9857052	21975,57094	628,5454545
	10%	2552,909091	325,6653227	31778,91912	518,7272727
	Sensitivity	3,437367884	0,320088178	79,93172002	2,509193939
	Beyond Confidence	1	0	1	1
Equipo Legal	-10%	2711	300,3909532	21957,89102	544,5454545
	10%	2685,454545	329,3526878	21960,5975	569,7272727
	Sensitivity	0,2788396	0,957714377	0,022067365	0,575369802
	Beyond Confidence	0	1	0	0
Group 1	-10%	0	0	0	0
	10%	2677,272727	328,02685	21970,90861	578
	Sensitivity	29,22358088	10,84727954	179,1400737	13,20650254
	Beyond Confidence	1	1	1	1
Group 2	-10%	2701,363636	315,9636213	21960,00098	554,0909091
	10%	2697,636364	318,6845782	21959,26352	557,8181818
	Sensitivity	0,040684782	0,089977331	0,006012903	0,085163039
	Beyond Confidence	0	0	0	0
Group 3	-10%	2700	314,2218375	21925,98194	555,4545455
	10%	2697,818182	317,8852053	21974,33765	557,7272727
	Sensitivity	0,023815482	0,121141226	0,394268823	0,051928683
	Beyond Confidence	0	0	0	0
Google Organic	-10%	2699,545455	316,4648801	21959,96568	555,9090909
	10%	2699,636364	316,5091774	21959,96568	555,8181818
	Sensitivity	0,000992312	0,001464836	0	0,002077147
	Beyond Confidence	0	0	0	0

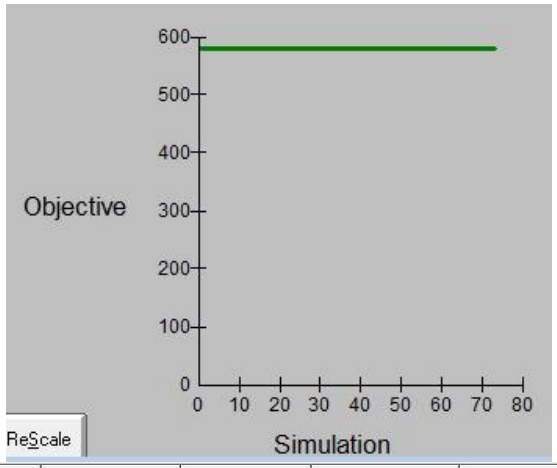
The chart above depicts how much a change on a distribution of each of the input variables changes the different outputs, a number close or higher than one means the input variable is very important or sensible in the result of the output named on every column. The number of calls coming from old callers affects importantly the amount of completed calls and the number of lost calls but not much the time in system as old callers don't need to be processed the same way as new callers. In a similar way new callers are important on both lost calls and completed calls but as well on the maximum time in system because most new callers process is short but some clients of this group take much longer to process.

The number of clients reaching for group one of allied companies are the ones that most affect completed calls, lost calls and both average and maximum time in system, this is because the process of these clients is much longer compared to the others because some clients' information is obtained and the time for the allied companies to answer the calls are longer as well.

8.2 Simulation and optimization

Given one of the major problems that was displayed during simulation was the number of lost calls, optimizing the system to minimize this number was the main priority, first we considered the minimization taking into account the different shifts that were already set and the restrictions that no more than the amount of employees that were already hired (8 employees), could be set throughout all the different turns, next the number of employees who were English and Spanish speakers could not be set in a shift for a Portuguese and Spanish speaking shift. Vice versa, the restrictions for English were made.
The minimization problem thus looked like:

Minimize(lost calls)
s.t. Sum of all shifts = 8
Sum of English-Spanish speaking shifts = 5
Sum of Portuguese-Spanish speaking shifts = 3

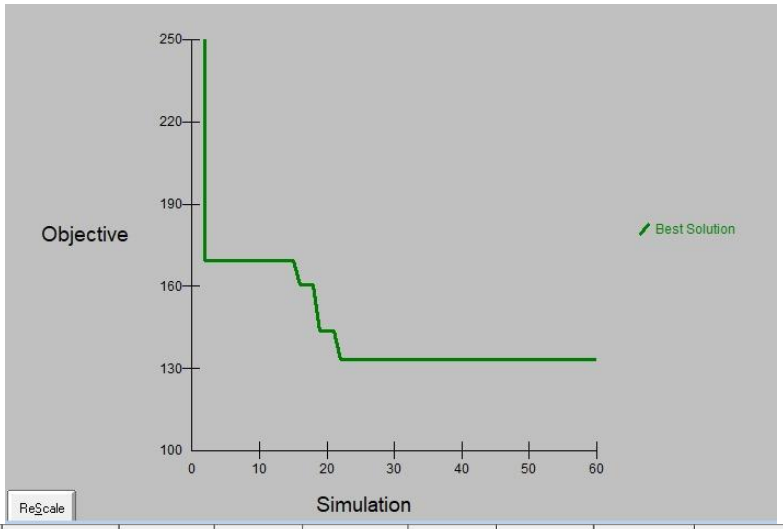


	Simulation	Minimize Perdidas.Number Completed	Var_Esp_Ing_temprano.Content	Var_Esp_Ing_tarde.Content	Var_Esp_Ing_Dia.Content	Var)_Esp_Ing_wknd1.Content	Var_Esp_Por_dia.Content	Var_Esp_Por_tarde.Content	Var_esp_Ing_wknd2.Content
▸	Best: 1	578.667	1	1	1	1	2	1	1

Running the optimization with these considerations it was returned that the best available combination of shifts for the minimization of lost calls was the way the system already was working with. This gave around 580 lost calls on average.

However, as it was noted, most of the calls were lost on weekends, because of the lack of Portuguese speaking agents in weekends and the lack of English-speaking agents in the weekend mornings. Three new possible shifts were created, one in the weekend-mornings for English speaking agents, and two for Portuguese-speaking agents, one in the weekend mornings and the other in the weekend afternoons, this system was run with the same restrictions as the previous one.

Running the optimization with these new considerations in shifts, the best alternative found reduced lost calls from 580 calls to 133 calls lost on average. This alternative set is observed below.



	Simulation	Minimize Perdidas.Number Completed	Var_Esp_Ing_temprano.Content	Var_Esp_Ing_tarde.Content	Var_Esp_Ing_Dia.Content	Var)_Esp_Ing_wknd1.Content	Var_Esp_Por_dia.Content	Var_Esp_Por_tarde.Content	Var_esp_Ing_wknd2.Content	Var_Esp_Ing_wknd_temprano.Content	Var_Esp_Por_Wknd_Tarde.Content	Var_Esp_Por_Wknd_Temprano.Content
	1	2127.33	0	0	0	0	0	0	0	0	0	0
	2	169.333	1	0	1	1	0	1	1	1	1	1
	16	160.667	0	0	1	1	0	1	1	2	0	2
	19	143.667	2	1	0	0	0	0	1	1	1	2
▶	Best: 22	133.333	1	1	0	0	0	0	1	2	1	2

9 CONCLUSIONS

The model was successful on representing the real-life system as was concluded with the white box and black box verification of the model, this means the result of the model optimization could actually be implemented in Ovadia call center, despite this, the cost and probability of remaking the contract of the current agents could cause a bigger cost to be created. Arrivals were found to be following a exponential distribution and time of activities were found to be normal distributions, this is concordant with the similar cases studied and mention in this paper, lastly sensibility analysis showed that the most important variable for the system is the amount of agents that speak Portuguese and work on weekends.

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