Modeling Operations of a Call Center Using ARENA Simulation Software

Project Group 47:

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Abstract

In a call center environment, numerous challenges exist, requiring many decisions. Determining proper staffing levels is one of many critical decisions for a business operating a call center. While this is just one element of operating a call center it comes with a great deal of complexity and consideration. For instance, technology, employee training and incentive options, customer satisfaction, business growth and seasonality, macro environment and many other influencers. In this work, a streamlined simulation of a call center was built, using ARENA to model a twenty-four-by-seven, three-hundred-sixty-five-day-a-year call center environment for a Financial Services company to exhibit an approach for Operations management to utilize when staffing its workforce.

Background

Overview

A call center environment is common to the Simulation discipline, and two out of the three members of this project group work within a call center, sparking interest in exploring this topic beyond what was covered during the course. Call centers are vital to the structure of large companies in modern societies. They serve as the primary liaison between businesses and customers in order to further develop business goals, reach and expand client base, facilitate customer interactions, and serve as troubleshooters in the case of customer dissatisfaction. The number of call centers globally has increased in recent decades with the increase of telework and expanding technological capabilities to reach larger client bases. Of these call centers, employees make up roughly 75% of operation costs on average, so there are wide ranges of operations research to optimize expenditures [1]. Much research has been done in the past on queueing systems, trunk lines, and whether cross-trained employees are more effective than single area specialists [2]. When simulating a call center, there are a variety of factors that can be considered which can complicate the project's output. There may not be a definitive output optimization, and it can sometimes be better to focus on a single statistic to optimize depending on the scope of the simulation. In the case of this simulation study, we sought to focus on Schedule Utilization.

Noting all the various complexities and decision points [3], assumptions and constants were applied. The assumptions and constants were created from project member imagination to protect the organizations by which two of the group members are employed. Furthermore, the workflow was created after calling a set of companies with well-established call center operations: Chase, Capital One,

Amazon, and UPS, to piece together a generic and streamlined workflow, focusing on a Financial Services call center environment [4].

In this paper, we will first explain our main goal, and then walk through the workflow, assumptions, and constants. We will then explain the baseline simulation, including who our resources (employee staffers) are, as they each have different attributes that were chosen carefully. From this baseline, we will walk through the few different versions that were run by changing aspects of the resources for optimization. Finally, we will talk through a failure scenario that we tested out, before wrapping up with areas for future exploration, and our conclusions.

Main Project Goals

As mentioned, the idea of this simulation is to determine how best to staff the call center. In other words, if we were consultants, and a company hired this project team to model its call center and achieve three goals (see below), what would we recommend?

1. **Minimize costs:**
    o Optimization comes down to the costs of two similar entities: trunk lines, and human capital. The more trunk lines deployed, the higher percentage of call volume that can be handled by the VRU system, reducing the manual work effort needed.
    o Automation and manual costs should both be considered.
    o Most trunk lines cost companies $15-25 a month [1], sourced from a customer support software company's website.
    o The value of $21.60 was chosen for this simulation for ease of calculation. Following a 30-day month yields a 3 cents per hour trunk line cost.

2. **Optimize utilization**
    o Entities were tracked going through the model, recording Call Handling Time to support Idle Time and Utilization.
    o Utilization is one of the most critical metrics leveraged to evaluate call center specialist performance.
    o Typical utilization ranges from 22% to 76%. Note that for the purposes of this simulation, utilization strictly refers to the time a specialist is directly engaging with a caller. It is important to strike a balance, as a 60%+ utilization can lead to burnout [4].

3. **Minimize lost calls**
    o Even though costs are being minimized, handling demand volume to support our customers is critical. Being able to handle the call volume was determined by whether the student version of ARENA did not crash when we ran the simulation. In other words, there were no more than 150 simultaneous entities in the various portions of our simulation at any given point, then it was successfully handled.

Workflow

Sampling the entities noted previously revealed a common flow – Fig. 1. Calling the customer service centers is always met by a voice response unit (VRU), requesting the customer select how support is

needed. Typically, the selection will be met by another layer of options focusing on the topic selected initially. The options available can bring the customer to self-service VRU or Customer Specialist. At the end of a call, after speaking with a representative, the customer is given the option to complete a survey.

Financial Services are heavily regulated [6], and, while Financial Institutions aim to provide service that meets all regulatory standards, customers will have an opportunity to share details where regulatory standards are not being met in the form of a complaint.
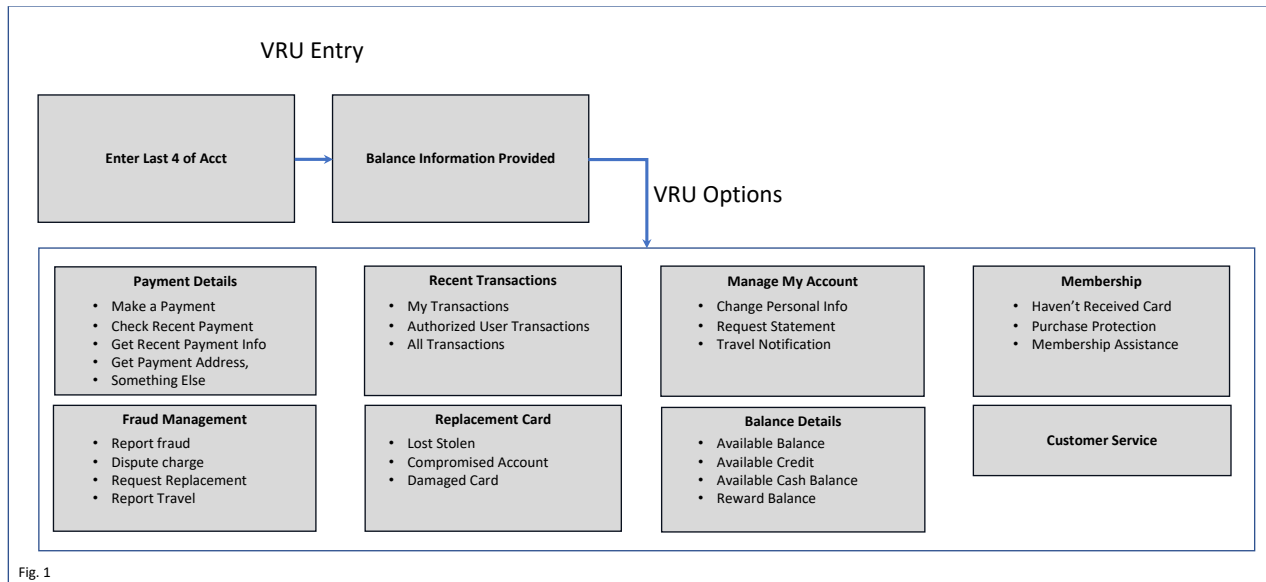

Figure 1. Options taken when greeted by VRU.

Assumptions

It was mentioned above that assumptions and constants were devised in order to run this simulation without giving away company proprietary data of multiple project team members. The constants themselves were devised similarly, but in this section, we will first review the non-constant assumptions followed by those that are constant.

Assumptions About the VRU and Process Flow

Numerous assumptions were made to account for the complexity that exists within a call center:

- Operations cover 24 hours daily for 365 days – no downtime.
- All customers are immediately directed to an automated system that attempts to resolve customer issues via a series of button pushes and automated readouts, and commands, to avoid human capital requirements.
- Customers can either press a button, choosing to be redirected to a person, or, if the automated system is unable to resolve the issue the customer can then be warm transferred.

They are given the option of handling multiple issues with the automated system, so at the end, they can either press another button to go back to the main menu or to exit the call [5].

- Prior to call termination, the customer is given an option to take a survey. This option is available regardless of whether they only used the automated system or spoke to a human representative.
- In some instances, the customer believes the representative or company failed to meet regulatory standards [6]. This complaint is filed via phone to another human representative, after which they still have the option to take the survey before hanging up.

It was assumed that there are seven primary reasons a customer calls. Most can be handled via the automated system:

- Payment
- Balance
- Fraud
- Credit
- Lost Card
- Stolen Card

The one option requiring a customer specialist is the instance a request is made to close an account. The reason for this treatment is to make reasonable attempts to retain the customer and to determine what the problem may be.

It was also assumed that a sales team exists to sell new offers to customers who calls in. The call center takes advantage of this contact point.

Constants

- **Shifts:**
  Before getting into the constants, first, a definition - the day is divided up into three components for the purposes of this simulation, and because we are also staffing, three 8-hour periods were established:
  - "First Shift": has "normal" business operating hours (9-5, for example, let's say)
  - "Second Shift": evening hours
  - "Third Shift": overnight/early morning hours

- **Arrivals:**
  It was assumed that customers call in a nonhomogeneous Poisson manner, calling with an exponential mean of:
  - 200 per hour during First Shift
  - 100 per hour during Second Shift
  - 50 per hour during Third Shift

- **Trunk Lines:**
  Ten trunk lines are in place to start out for the model – the quantity of trunk lines is ultimately reduced in later iterations of the simulation. At the point which all trunk lines are in use, the call

will be routed to a Customer Specialist. Overflow is most likely during the First Shift when the Call Arrival % is highest, decreasing with each successive shift throughout the day.

- **System Interaction:**
  All automated system interactions followed a uniform distribution.

- **Automated Issue Resolution Time:**
  It was assumed that in the automated system, making a payment or checking your balance takes 2-5 minutes, reporting fraud or a credit issue takes 5-10 minutes, and reporting a lost or stolen card takes 10-20 minutes.

- **Customer Selection Upon VRU Entry:**
  Customer selection leveraging N-way by Chance percentage determines whether a self-service option is chosen or customer service is preferred.
  - Self-service: 85%
    - Payment/Balance: 65%
    - Fraud/Credit: 15%
    - Lost/Stolen Card: 5%
    - Customer Specialist: 15%

  Calls that land with a Customer Specialist will be routed to a resource, consistent with the self-service approach, using N-way by Chance.

  - Specialist: 15%
    - Payment/Balance: 45%
    - Fraud/Credit: 20%
    - Lost/Stolen Card: 15%
    - Account Closure: 5%
    - Sales: 15%

- **Customer Specialist Issue Resolution Time:**
  All phone calls with actual human representatives are assumed to have a triangular distribution in length [2]:
  - Payment/balance calls assumed to have (3,6,12) distribution
  - Closing account assumed to have (15,30,45) distribution
  - All other calls with representatives, including sales calls, assumed to have (6,12,24) distribution

  It was assumed that after speaking with a representative, a customer is allowed the option of being transferred to another department to handle a different issue, which they take with 5% likelihood. They still have the option of going back to take the survey, which they do with 20% likelihood. Half a percent of them choose to make a complaint. Of those who make a complaint, 45% go on to take the survey.

Resources

The following staffing configuration was chosen initially in Table 1 below.

Name	Skill Set 1?	Skill Set 2?	Skill Set 3?	Shift	Wages
Joey	Y			First Shift	$18/hr.
Rachel	Y			First Shift	$18/hr.
Zach	Y			Second Shift	$18/hr.
Gabby	Y			Third Shift	$18/hr.
Clayton	Y	Y		First Shift	$20/hr.
Michelle	Y	Y		First Shift	$20/hr.
Matt	Y	Y		Second Shift	$20/hr.
Katie	Y	Y		Third Shift	$20/hr.
Peter	Y		Y	First Shift	$22/hr.
Clare	Y		Y	First Shift	$22/hr.
Tayshia	Y		Y	Second Shift	$22/hr.
Arie	Y		Y	Third Shift	$22/hr.
Colton	Y	Y	Y	First Shift	$25/hr.
Becca	Y	Y	Y	First Shift	$25/hr.
Hannah	Y	Y	Y	First Shift	$25/hr.

Table 1. List of employees in the simulated call center and their skill set, shift, and wage. Notice that certain skill sets granted more desirable wages and having multiple skill sets resulted in increased wages.

Note: "Skill Set 1" is the ability to handle a customer payment or balance check, and all representatives are able to do this. "Skill Set 2" is the ability to handle the reporting of fraud or a credit issue. "Skill Set 3" is the ability to handle a lost or stolen card or close an account. These were handled via resource sets in ARENA.

Explanation for Configuration

Three employees, Colton, Becca, and Hannah, were chosen as "jack of all trades" who have all skill sets, and they only work First Shift because this is when the highest demand happens. For the remaining 12 employees, 50% of them are on First Shift, 25% on Second Shift, and 25% on Third Shift, with an even distribution amongst all three shifts, of all skill sets. Of those who have only skill Set 1, they have this 50/25/25 distribution, of those who have Skill Sets 1 and 2, they also have this 50/25/25 distribution, and of those who have Skill Sets 1 and 3, they also have this 50/25/25 distribution. This distribution is based on the highest call volume coming during First Shift.

Those who only have Skill Set 1 are paid $18/hr., those who have Skill Sets 1 and 2 are paid $20/hr., those who have Skill Sets 1 and 3 are paid $22/hr., and the "jack of all trades" are paid $25/hr. These wages are based on those with more skills, and those will more difficult skills (i.e., closing an account) being paid more.

Experimentation for Optimization

To begin with, we ran the simulation in a non-batch format, to watch the customers flowing through, and to determine the steady state simultaneous number of customers in the self-service area, which allowed us to determine how many trunk lines to install. This steady state during First Shift (the highest volume, hence the shift we looked at this for) was around 10 simultaneous customers using self-service, so our first iteration used 10 trunk lines.

We chose to run the simulation for 30 days as the costs used for trunk lines was listed per month, and it allowed us to look at some long-term data of simulation.

An output of the cost ratio for the cost per busy time and cost per idle time, for all the 15 specialists, is below. The report from which these numbers came is also in the zip file, titled "Readout from 10-trunk line version."

Name	Busy Cost	Idle Cost
Joey	$1,888.10	$2,446.10
Rachel	$973.35	$3,351.50
Zach	$1,435.40	$2,888.50
Gabby	$593	$3,726.90
Clayton	$2,085.10	$2,739.10
Michelle	$1,225.90	$3,588.10
Matt	$2,263	$2,546.90
Katie	$774.24	$4,025.70
Peter	$2,475.60	$2,869.30
Clare	$1,656.30	$3,636.10
Tayshia	$2,614.60	$2,696.30
Arie	$864.14	$4,415.80
Colton	$612.67	$5,417.40
Becca	$390.04	$5,609.90
Hannah	$902.46	$5,102.90

Table 2. The comparison of busy vs. idle costs for the fifteen company representatives using ten trunk lines. Note that the best utilization of an employee in this scenario is just about a 50-50 split between busy and idle time.

Quite horribly, not a single employee is being utilized more than 50% of the time, and therefore more than half the cost of employee wages is being wasted. For the next iteration, the decision was made to drop the number of trunk lines in half, to 5 trunk lines, to see whether there is higher utilization of the resources that we are paying. This results in all trunk lines being full more frequently, which would redirect customers to specialists. Also, dropping the number of trunk lines drops the trunk line cost in half as well, resulting in a reduction of costs by $108.

After dropping the number of trunk lines to 5, the next output can be seen in Table 3. The report from which these numbers came is also in the zip file, titled "Readout from 5-trunk line version".

Name	Busy Cost	Idle Cost
Joey	$2,899.90	$1,436.30
Rachel	$2,427	$1,909.90
Zach	$2,266.10	$2,064.10
Gabby	$791.97	$3,528
Clayton	$3,504.80	$1,318.90
Michelle	$2,964.70	$1,871.90
Matt	$3,441.80	$1,387.30
Katie	$1,134.60	$3,665.30
Peter	$3,804	$1,541.70
Clare	$3,380.90	$1,948.60
Tayshia	$4,040.60	$1,275.40
Arie	$1,724.50	$3,555.40
Colton	$3,462	$2,575.50
Becca	$3,298.80	$2,731.70
Hannah	$3,630	$2,399.40

Table 3. Busy vs. idle cost for the fifteen employees using only five trunk lines. Compared to Table 2, it is immediately evident that using only five trunk lines results in much better employee utilization across the board.

This is immediately much better, as the vast majority of employees now have a higher busy cost than idle cost, i.e. they are being utilized more than half the time. There are 3 employees who still have a higher idle than busy cost: Gabby, Katie, and Arie. What do these three employees have in common? They are all Third Shift employees. Clearly, even though we only have 3 Third Shift employees, only 1 may be needed. However, if only one employee is manning the phones on Third Shift, we must choose a "jack of all trades" at that time. This may force us to change our stratagem of putting all the "jack of all trades" in the daytime.

Another thing we did in this iteration is add record modules to check how many callers are being kicked out of the self-service queue because all the trunk lines are full. These are the lines at the very top of the readout. We were able to implement this by using an expression to track all callers passing through and count them in different sets depending on whether they called during First, Second, or Third Shift [8]. From this, we can see that in First Shift, approximately 4,500 callers concerned about issue 1 (payment/balance) were kicked to a specialist, while only 480 about issue 2 (fraud) and 48 about issue 3 (lost/stolen). This confirms our suspicion that issue 1 requires the most staffing, which it already has since every specialist is capable of handling issue 1. Had we found a different result here, we might have had to change the distribution of skill sets for the specialists accordingly.

Okay, so the decision has been made to reduce Third Shift to one staffer. What other reductions, if any, should happen in other shifts, to further increase utilization?

Looking at the above costs for the 12 employees who are on First and Second Shifts, 63% of their cost is busy. Hypothetically, it should be possible to reduce these 12 employees to 9, and have a much higher utilization while not increasing customer wait times.

Hence the following schedule was created:

Name	Skill Set 1?	Skill Set 2?	Skill Set 3?	Shift	Wages
Joey	Y			First Shift	$18/hr.
Rachel	Y			First Shift	$18/hr.
Zach	Y			Second Shift	$18/hr.
Clayton	Y	Y		First Shift	$20/hr.
Michelle	Y	Y		First Shift	$20/hr.
Matt	Y	Y		Second Shift	$20/hr.
Peter	Y		Y	First Shift	$22/hr.
Clare	Y		Y	First Shift	$22/hr.
Tayshia	Y		Y	Second Shift	$22/hr.
Colton	Y	Y	Y	Third Shift	$25/hr.

Table 4. Similar to Table 1, this shows the employees, skill sets, and wages on what is considered the "Reduced Resources" schedule.

This schedule can be seen in the second ARENA file in the zip file, called [Reduced Resources].

Below are the busy and idle costs of the Reduced Resource schedule, and the readout is shared in the zip file as the notepad file that contains [Reduced Resources] in the name of the document.

Name	Busy Cost	Idle Cost
Joey	$3,673.90	$663.67
Rachel	$3,418.80	$920.89
Zach	$2,392	$1,936.50
Clayton	$4,403.90	$448.48
Michelle	$4,302.50	$532.22
Matt	$3,360.90	$1,192.80
Peter	$5,067	$292.48
Clare	$5,036.40	$317.56
Tayshia	$4,440.10	$892.22
Colton	$4,613	$1,386.90

Table 5. Busy vs. idle costs for the Reduced Resource schedule. It can be seen that the employees are much better utilized in this scenario compared to having the full schedule of employees.

As can be seen, making this change of decreasing the total number of employees from 15 to 10, as well as moving Colton to third shift, has all employees with >50% utilization, and most of them with under $1,000 idle cost per month. Having some idle cost is fine, because it is physically impossible for an employee to exclusively be on calls for their full shift with no downtime, and having some idle time built in helps create a buffer since this is only a simulation of one month, and not exactly predictive of every future month, some of which might have slightly higher volume while still following the exponential distribution.

There's where we leave off this optimization goal, with the final decision being to reduce the number of staffers to 10, with the above schedule, and to reduce the number of trunk lines to 5. Both of

these reductions decrease our total cost while still maintaining an appropriate level of service for our customers.

As a final step to this simulation report, we wanted to observe what happens when the simulation is under stress – namely, a major failure. Due to the use of the student version of ARENA, these observations were somewhat limited and required some trial and error as runtime errors occurred frequently. The final idea chosen was seeing what happens when the self-service system goes down, whether it is due to some system update, or a failure in the system. This would require all callers to automatically be routed away from the self-service system, and straight to the specialists. To put the most strain on the system, we chose to add this system failure to the Reduced Resource schedule, and it is set to go down after a set number of customers and take two hours to fix. Ideally, the up time – or amount of customers served before failure - and down time would be left to a more probabilistic expression, but the limitations of the student version of ARENA made it difficult to get reasonable outcomes, or anything at all that was not a runtime error.

However, the final result that worked (failure after 2000 customers with a down time of two hours) yielded interesting results:

Name	Schedule Utilization	Busy Cost	Idle Cost
Joey	91%	$3,918.10	$432.17
Rachel	87%	$3,759	$585.11
Zach	72%	$3,093.70	$1,241.20
Clayton	96%	$4,594.40	$261.72
Michelle	95%	$4,536.30	$313.98
Matt	84%	$4,018.50	$817.93
Peter	101%	$5,336.50	$64.55
Clare	101%	$5,313.90	$76.96
Tayshia	93%	$4,908.20	$437.19
Colton	87%	$5,088.20	$910.13

Table 6. Busy vs. idle costs for the Reduced Resources schedule, along with their utilization during the same period, when a catastrophic failure is implemented.

Interestingly, the simulation runs to completion, and the schedule utilization, while not optimal for long-term, could be manageable in the short term. In this scenario, Peter and Clare even picked up some overtime with 101% of schedule utilization due to having to stay overtime to complete calls at a shift change. Part of what makes this scenario interesting is that these ten employees scheduled for the purpose of this simulation can potentially be interchangeable with one of the other five that were included in the schedule from Table 1. This would be the more realistic scenario if you consider the schedule over the course of the entire month - and switching Peter and Clare out with one of the other five employees not on the Reduced Resource schedule, or even just switching them to different shifts on a different week - should reduce their schedule utilization and lighten their workload. Additionally, some of the five employees could also be brought in to work as an extra employee on the high stress shifts to even out the schedule utilization. While costing more to the call center due to the extra wages to be paid in the latter suggestion, it would likely improve general worker morale and prevent burnout. The

best option is likely a mix of them both – shift schedules around during this high stress period and also call in reinforcements, if able.

Areas for Future Research

Evaluating the model results and interrogating for 'logical' flow raised opportunities to refine the model to better accomplish the goals referenced in the Background section. Some areas to consider for future work include:

- Optimize customer waiting times – in this project we ensured waiting times would not cause ARENA to crash but do suggest focusing on optimizing waiting time.
- Capture the customer's input from the original menu when they get sent to a specialist, so that the specialist doesn't have to ask them all their info again.
- Modify the model to allow one resource to help a customer with multiple things instead of sending the customer back to the menu to seize another resource.
- While not specifically a cost, simulating sales revenue and items sold can offset OPEX. This analysis can measure the utilization cost for each item to understand the profitability of each item for each resource. Given some resources may generate better profitability for specific products it may be worthwhile to have the customer choose the product of interest in the VRU and then, based on specialist availability prioritize whom will receive the call.
- Identify the optimal combination of resources based on customer wait time, profitability and utilization [5].
- Tracking the amount of complaints made against a particular specialist by tracking pathways and other customer statistics. In this case, if a particular specialist received a disproportionate amount of complaints, repercussions could be implemented.

Conclusions

For the two group members who implement call centers at their companies, this was great research to demonstrate how balancing trunk lines and staffers is important – self-service is useful for customers who prefer dealing with their issue quickly, and don't want to have to explain it in a conversation to a human, and can also help the company by not needing to allocate a resource to deal with those customers. At the same time, customer feedback is of the utmost import, and we don't want all our customers to be frustrated with an automated system that doesn't work, hence we want to maintain a level of staffing that both helps our customers in a timely manner, and in a way that leaves them feeling positive about our company.

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