SIMULATION IMPROVES CALL CENTER DESIGN AT TRAVEL AGENCY OFFICES

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ABSTRACT

Historically, discrete-event process simulation was first, most often, and very profitably applied to manufacturing industries. More recently, simulation applications have broadened significantly to include warehouses, health care (clinics and hospitals), public transport networks, and service industry applications such as retailing and call centers. As simulation becomes more affordable, smaller enterprises use it to good effect. In this paper, the authors describe a successful application of simulation to improve the design and operation of a call center supporting a small, generic travel agency.

INTRODUCTION

Discrete-event process simulation has a commendably broad range of applications in industry. Historically and still very frequently, it has been used to design and improve manufacturing processes (Rohrer 1998). More recently, and increasingly rapidly, simulation analyses have expanded into health care, public transport networks (e.g., buses, trains, airplanes), and service industry applications (hotels, retail stores, and call centers). Such applications, with their complexity, stochasticity, and constraints on often expensive resources, are ideally suited to exploit the powers of simulation analysis (Laughery, Plott, and Scott-Nash 1998). Call centers, with their unpredictable rates of incoming calls, high variability of time needed to completely serve an incoming call, difficulties and expenses of staffing, and various levels of skill and authority needed to handle different customers, are excellent candidates for simulation analysis. In a valuable tutorial, (Mathew and Nambiar 2013) provide a template for successful call center simulation. For example, (Pichitlamken et al. 2003) apply simulation to a telephone call center with both incoming and outgoing calls, and two types of agents. As another example, (Mazzuchi and Wallace 2004) apply simulation to implement and enhance skill-based call routing in a call center. More recently, (Kuncova and Wasserbauer 2007) apply simulation to the analysis and improvement of helpdesk operations. In this paper, we apply simulation to the design of a call center within a travel agency; hence the typical incoming call will undertake to make travel reservations. These reservations may vary from simple to exceedingly complex. Furthermore, customers calling the center will have two different levels of priority and privilege.

CONTEXT OF SYSTEM STUDY

The travel agency modeled and analyzed is in the process of consolidating its current small travel offices into two new locations; these new locations will handle all requests by telephone. At the time of project inception, a severe recession had recently reduced business travel, impacting the travel industry generally and requiring rigorous reductions in operating costs. Of the two new offices, one will be in the United States (handling calls between 7am and 7pm "Eastern Standard Time" (this is, for example, the time in New York City, New York). The other office will be overseas (site yet to be determined) and handle calls between 7pm and 7am EST.

Naturally, the cost of the two call centers is under close scrutiny; the major components of this cost are employees and telephone lines. Intentional overstaffing will certainly provide timely customer service, but at perhaps prohibitive (and certainly profit-eroding) cost. Therefore, the agency fixed upon simulation as an analytical tool to help assess and choose among various call center configurations.

The systems must accommodate incoming calls seeking to make travel reservations. Two types of customers – regular and "cardholders" – use the system. Cardholders, who travel often and generate more income, are to be favored. There are two types of cardholders – "silver" (about ⅔ of cardholders) and "gold" (about ⅓ of cardholders). Cardholders call a different number than do regular customers. The new system will have a limited number (originally planned as 50, more lines can be purchased in blocks of 5) of trunk lines. When the system becomes congested ("congested," from the viewpoint of the client, based on extensive experience, is typically taken to mean "90% of trunk lines are in use;" the appropriateness of this viewpoint to be assessed via the simulation analysis), the remaining open lines become reserved for cardholders (a cardholder's incoming call will succeed, but a regular customer's incoming call will receive a busy signal).

OBSERVATIONAL DATA AND ANALYSIS

Collectively, calls arrive at the rates given in Table 1 (number of calls per hour, either 12-hour period), with interarrival times approximately exponential, as determined by the distribution-fitting software Stat::Fit® (Nelson and Yamnitsky 1998). This software permits use of the chi-square, Kolgomorov-Smirnov, and Anderson-Darling goodness-of-fit tests; all three of these tests recommended an exponential distribution.

Time period	Regular Arrival Rates	Cardholder Arrival Rates
7 – 8	87	89
8 – 9	165	243
9 – 10	236	221
10 - 11	323	180
11 – 12	277	301
12 - 1	440	490
1 – 2	269	394
2 – 3	342	347
3 – 4	175	240
4 – 5	273	269
5 – 6	115	145
6 – 7	56	69

Table 1. Incoming Call Arrival Rates Over 12 Hours

These calls fall into three categories: requesting information (16%), making a reservation (76%), and changing a reservation (8%). Cardholders are asked to input their card number (7 to 16 seconds, uniformly distributed). Calls that must wait for service from a representative join a priority queue (gold cardholders first, silver cardholders second, regular customers third; first-come-first-served [FIFO] within these priorities).

There are three categories of operators: gold-card, the most skilled, who serve only gold cardholders; silver-card, who serve either silver cardholders or regular customers (preferentially the former), and regular, who serve only regular customers. Relative to regular operators (the lowest skill level), silver-card operators reduce service time by 5% and gold-card operators reduce it by 12% After taking a call, an operator must do follow-up work before being available to take another call. Distribution-fitting analysis supported use of triangular distributions to take calls and uniform distributions to do the follow-up work, as shown in Table 2.

Call Type	Service (min.)	After (min.)
Information	T (1.2, 2.05,3.75)	U (0.05, 0.1)
Reservation	T (2.25, 2.95,8.6)	U (0.5, 0.8)
Change	T (1.2, 1.9, 5.8)	U (0.4, 0.6)

Table 2. Regular Operator Time Requirements

Silver-card operators earn 20% more than regular operators; gold-card operators earn 15% more than silver-card operators. Operators work an eight-hour shift (7am-3pm local time, 8am – 4pm, 9am to 5pm, 10am to 6pm, or 11am – 7pm). Roving part-time operators (not to be included separately in the analysis) relieve these operators for breaks and lunch. With five possible shifts and three operator skill levels, there are fifteen possible staffing levels. The system starts empty of calls at 7am local time.

The client tasked the simulation analysis with meeting all five of the following performance metrics at minimum cost (staffing and trunk lines):

1. 98% gold-card callers wait ≤ 1½ minutes
2. 95% silver-card callers wait ≤ 3 minutes
3. 85% regular callers wait ≤ 15 minutes
4. ≤ 2% of cardholders receive busy signal
5. ≤ 20% regular customers receive busy signal

MODEL CONSTRUCTION, VERIFICATION, AND VALIDATION

Convenient and efficient construction of the simulation model required software capable of representing multiple resource pools, time-varying arrival rates, a complex queuing discipline (FIFO within priority classes), and the customer behaviors of balking and reneging. Additional desired niceties were animation concurrent with model building (although three-dimensional animation was of minor importance), the ability of the software to define and draw from easily updated data tables, and the ability to conduct analyses of multiple actual or proposed scenarios within one simulation experiment. Considering these requirements, the simulation analysts chose the Simio® software package, which also has excellent documentation (Kelton, Smith, and Sturrock 2013). Additionally, Simio® provides a convenient drag-&-drop interface (as contrasted with the writing of code) for the writing of process logic (such as that required for callers who renege, or for the operators doing post-call paperwork before becoming available to the next caller). As one example of such a process, Figure 1 and Table 1 in the Appendix diagram and explain the flow of the B_Resource process. This process holds responsibility for seizing and releasing of resources, calculating the average waiting time for callers who must wait for assistance, and counts the number of callers whose service promptness meets the specified performance levels.

Construction, verification, and validation of the model proceeded smoothly. As one important aid to verification was building the model piecemeal, verifying each portion before adding more segments of the model. Therefore, errors were easily and promptly isolated and corrected. Additional verification measures undertaken included informal walkthroughs, running the model with constants (instead of probability distributions), running the model with extreme and implausible values, and checking results against spreadsheet computations, and running the model with only one (or very few) entities (callers) entering it to check the process logic flow. Validation methods used included inviting the client to view the animation, and checking the results of the base model (representing the current system) against current system performance metrics such as queue lengths and times various types of callers spent in the system. These measures resulted in routine correction of errors, culminating in successful verification and validation (Balci 1998) and hence a highly credible model.

EXPERIMENTATION AND OUTPUT ANALYSIS

Experimentation with this model was conducted with terminating runs (zero warm-up time), since each of the two offices started each twelve-hour shift empty and idle. Likewise, replication lengths were fixed at twelve hours. Preliminary investigation soon confirmed that 100 replications per scenario yielded sufficiently narrow 95% confidence intervals for performance metrics – "sufficiently narrow" being interpreted as having readily distinguishable performances relative to the five performance metrics listed earlier. These eleven scenarios were distinguished on the basis of:

1. Number of lines reserved for cardholders during periods of congestion, x
2. Number of additional lines, y
3. Number of gold-card operators working 7am-11am
4. Number of gold-card operators working 11am-3pm
5. Number of gold-card operators working 3pm-7pm
6. Number of silver-card operators working 7am-11am
7. Number of silver-card operators working 11am-3pm
8. Number of silver-card operators working 3pm-7pm
9. Number of regular-card operators working 7am-11am
10. Number of regular-card operators working 11am-3pm
11. Number of regular-card operators working 3pm-7pm

We remark that (a) $x + y = 50 + 5z$, where z is a non-negative integer (trunk lines can be added only in groups of five) and (b) the third through eleventh items above represent a simplification, since operators have five, not three, choices of shift. Experimentation soon revealed that meeting all five of the customer-service performance metrics was clearly impossible with $z = 0$, but possible with $z = 1$; i.e., one group of five trunk lines must be added.

Therefore, thirty-three plausible scenarios were constructed and run, all with $x + y = 50 + 5 * 1 = 55$. Among these scenarios, eleven met all five performance objectives; twenty-two failed at least one performance objective (some failed as many as three). The scenario meeting all five performance objective metrics at minimal cost was scenario 26, specifying 35 regular operators working 7am – 11am, 50 regular operators working 11am – 3pm, and 38 regular operators working 3pm – 7pm, with 36 of the 55 lines unreserved and the remaining 19 lines reserved. Quite surprisingly, this scenario specified zero gold-card operators and zero silver-card operators, inasmuch as their faster service capabilities (coupled with the lesser flexibility of the gold-card operators) failed to justify their higher costs.

SUMMARY AND CONCLUSION

This allocation of operators, in conjunction with purchase of five additional telephone lines, proved highly effective. Furthermore, as the regular operators acquire additional experience, the service metrics continue gradual, and slight but noticeable, improvement. The model will be revised to analyze various other customer-service scenarios, such as office visits and organized consultations.

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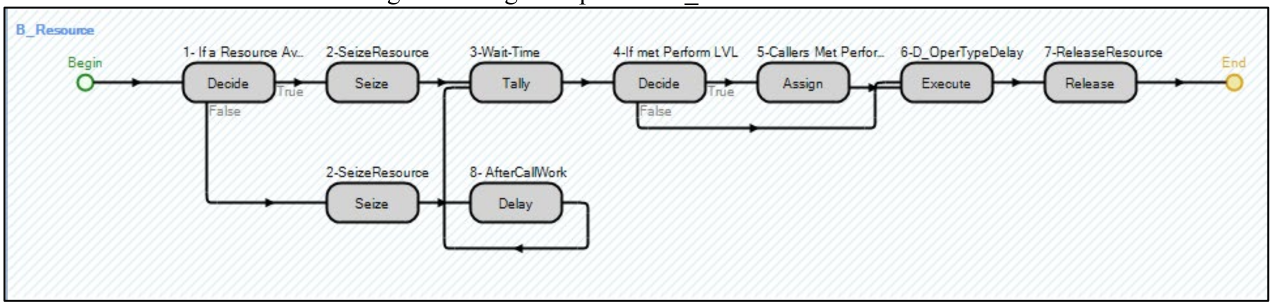
APPENDIX

Figure 1. Logic Map of the B_Resource Process



	Step	Expression	Purpose
1	Decide	CallersTable.AfterCallExp	To see if there an available resource
2	Seize	CallersTable.ResOperators	To seize an available operator from the lists identified
3	Tally	CallersTable.TallyStatistic (TimeNow-ModelEntity.TimeCreated-CallersTable.Matching)	To update the tally statistics in the table for each type of caller. The time is calculated as shown in expression cell
4	Decide	TimeNow-ModelEntity.TimeCreated-CallersTable.Matching<=CallersTable.CallersPerformanceLvl	To check whether the service to the caller meets the specified performance level or not
5	Assign	CallersTable.CallersWaitState+1	To count the number of callers whose service meets the performance level
6	Execute	D_OperTypeDelay	To execute the delay-of-operator process
7	Release	CallersTable.ResOperators	To release the operator that seized by the entity after finishing the delay-of-operator process
8	Delay	CallersTable.AfterCallWork	To delay the entity the after call-work time

Table 1. Stepwise Explanation of B_Resource Process Logic