22nd *International Conference on Harbor, Maritime and Multimodal Logistic Modeling & Simulation*
17th International Multidisciplinary Modeling & Simulation Multiconference

ISSN 2724-0339 ISBN 978-88-85741-46-1 © 2020 The Authors.
DOI: 10.46354/i3m.2020.hms.005

Simulation improves amusement park customer service

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Abstract

Over the last half-century or more, simulation has established a splendid record of helping to improve complex systems. This fine record began historically with improvements to manufacturing processes, and in due course expanded to many other fields, including warehousing, transportation systems, health-care systems such as clinics and hospitals, and general customer-service systems such as banks, hotels, retail stores, and other venues where customer service is highly important. In this work, the application of simulation to improvement of customer service at an amusement park in Southeast Asia is documented, along with the contributions it made and indications for further work. The management of the park was justifiably concerned with operating costs, long customer waiting lines, and loss of potential customers via balking. Simulation pointed the way to significant process improvements and hence customer-service improvements with negligible increases in operating costs.

Keywords: discrete-event process simulation, queueing systems, resource utilization, amusement park, customer service

1. Introduction

Historically, discrete-event process simulation was first and very extensively used to improve manufacturing operations; indeed, examples in the literature are numerous. Rather more recently, simulation has been extensively applied to other complex systems, including those in health care (e.g., hospitals and clinics), warehousing operations often essential to efficient and reliable operation of supply chains, transportation systems such as bus lines and subways, and systems directly involving customer interactions, such as hotels, theaters, retail stores, and banks. An excellent survey a decade ago documents the expansion of simulation into service industries (Jahangirian et al. 2010). As a specific example, one may cite the application of simulation to a motor vehicle repair facility (Venkat and Wakeland 2006).

The project described here applied the powers of simulation to improvement of customer service at an amusement park in Southeast Asia. The managers of this amusement park were keenly and justifiably concerned with deficiencies in customer service, such as long waiting lines, vociferous complaints, balking, and the ominous potential, already emerging, of loss of business. The analysts explained to these managers that "yes, there is a precedent – Walt Disney, arguably the most famous amusement park worldwide, has used simulation in published studies (Nirenberg, Daw, and Pender 2018). Since the most immediately obvious possibilities of improvement, such as purchase of more machines and/or the hiring of additional personnel, entailed significant costs, the managers sought the help and guidance of simulation analysis.

In the following sections, we (1) present an overview of the amusement park operations most relevant to customer service, (2) describe the collection and analysis of input data, (3) discuss the building, verification, and validation of the simulation model, (4) highlight key results from this model obtained by output analysis, and (5) present conclusions, recommendations to the amusement park's management, and the directions in which likely future work may proceed.

2. Overview of amusement park operations

The amusement park under study for service improvements comprises three sections:

1. The section catering to children, and featuring attractions such as high-thrill rides and a large Ferris wheel;
2. The section catering to adults, with a cultural park under current expansion to "cultural views" of ten countries and which will focus on traditional architecture and horticulture;
3. The central (in terms of both physical location and general nature of facilities) zone, the interface between the other two sections, containing shops, toilet and washroom facilities, concession stands, and places for visitors to relax.

Customers who come to this amusement park may be conveniently divided into three groups; rarely, a particular customer was a member of group 3 in addition to being a member of the mutually exclusive groups 1 and 2:

1. Those who made reservations, via Internet or postal mail, prior to arrival, and therefore must print tickets at a kiosk machine;
2. Those who need to queue to obtain entry tickets from a ticket clerk;
3. Those who wish to consult with a park manager to arrange reservations for a future date, as is often the case for customers planning graduation or wedding celebrations.

Relative to group #2, two skill levels of ticket clerks can be hired, exclusively or jointly. The more experienced and skilled clerks ("type A") earn about half again as much as the lesser ("type B"), and concomitantly can serve more customers per hour; their typical service times are about one minute faster. The ticket clerks work in relatively short time blocks amenable to hiring part-time workers (highly desirable in context); these time blocks being 9am-noon, noon-3pm, 3pm-6pm, and 6pm-9:30pm. A ticket clerk about to go off-shift will finish the current transaction; a manager about to go off-shift (late afternoon) will likewise complete the current conversation (e.g., concerning a future group reservation).

The park is open daily for thirteen hours, from 9am to 10pm. Customers who purchased tickets prior to arrival (group #1 above) are admitted until 10pm, but no would-be customer in group #2 can purchase a ticket from a clerk after 9:30pm, and customers in group #3 can speak with a manager only until 5:30pm.

3. Data collection and analysis

Average arrival rates per hour, for all thirteen hours of the operational day, were collected for each of the three types of customers. Similarly, travel times were collected from the amusement park entrance to the automatic ticket machine, the ticket clerks' windows, and the manager's kiosk. Occasionally, a customer had to walk from the automatic ticket machine to a ticket clerk's window (a problem with the previously made reservation) or even to the manager's kiosk (a decline of a credit card or a question pertaining to payment in a foreign currency). Since all these travel times were observed to be less than ½ minute, they were treated as constants, ignoring for the present work differences in walking speeds. Also, data were collected on the distributions of service times of the automatic ticket machine, the ticket salesclerks (at each of the two levels of experience and efficiency), and the manager's consultations. Observations noted that the hourly arrival rates at both the ticket machine and the ticket salesclerks increased slowly and steadily from opening time to mid-afternoon, and then declined quite rapidly. At the queue to purchase tickets from an agent, potential customers were observed to have a 30% probability of balking whenever there were more than five customers already in the waiting line.

Having been collected, these raw data were examined with the Stat::Fit® software (Benneyan 1998). After doing so, and with the precaution of showing the amusement park managers and supervisors the characteristic histogram of distributions, arrivals were modeled as exponential, and service times as triangular for the automatic ticket machine (with very slight positive skewness) and the ticket salesclerks (with no skewness). The manager's service times (relative to customers in group #3) were exponential, as befits a situation where many such transactions are rather canonical, but a minority are unexpectedly complex. As is often the case in practical simulation work, the value added by using distribution-fitting software was not so much advice on the best distribution to use (if indeed there existed a single "best" distribution), but rather cautionary advice on conspicuously inappropriate distributions to avoid (in these cases, the normal, gamma, and lognormal distributions.

4. Model development, verification, and validation

First, a completely conceptual, diagrammatic model was built and discussed with the client managers – a flow chart of all paths taken from the actual amusement park physical entrance to passage to the park's attractions (or departure, in the case of customers in group #3 above). This model was built in Microsoft Visio®, representing service points (e.g., the ticket clerks, the kiosks, and the manager's office) with circles and customer flow by lines. The thickness of each line roughly corresponded to the volume of customer flow along that line. Use of such highly intuitively understandable diagrammatic models has long been recognized in manufacturing industries, as documented by (Prasad and Strand 1993). More recently, (Heher and Chen 2017) document the value of such charts in "service environments," such as the study described here. Thorough discussion of this diagram by the park management and the simulation analysts, with the diagram on a conference table between them, ensured that the analysts' understanding of the process flows exactly matched the expert knowledge of the amusement park managers and supervisors.

Next, the members of the project team, using methods outlined in (Vasudevan et al. 2009), and many of the considerations of simulation software choice documented in (Abu-Taieh and El-Sheikh 2009) concurred in the choice of the Simio® software, Version 11 [SIMulation with Intelligent Objects] (Prochaska and Thiesing 2017), (Smith, Sturrock, and Kelton 2018) to construct a model of the amusement park's operations. Simio® provides constructs such as the Server (to model, for example, the ticket vending kiosk and the ticket sales agents), the Entity (a different Entity was used to represent each of the three types of customers), a Worker (e.g., a customer buying a ticket in person might be served by an experienced or an inexperienced ticket agent), and a Resource (to represent the actual machine at the ticket-printing kiosk, which might fail (e.g., jam)). These Simio® constructs were used to model the key steps of entering the park, joining the correct queue, and using the ticket-printing kiosk, buying a ticket from an agent, or speaking with a manager. Additionally, Simio® makes it relatively easy to specify workers' schedules, and establish specifications such as "A customer in group #1 can enter the park until 10pm, but a customer in group #2 can enter only until 9:30pm." After doing these tasks, a customer entity exited the model; conceptually, for groups #1 and #2, by going to enjoy the park's attractions, or for group #3, leaving the park with arrangements for a subsequent celebratory event presumably fixed.

The first iteration of the Simio® model deliberately contained only the Simio® default values for parameters such as interarrival times and cycle times. Only after verification of correct entity flow in the animation were the values obtained from data collection and analysis (previous section) inserted. A partial two-dimensional screen shot of this model, as completed, is shown in Figure 1, Appendix A. From this screen, a three-dimensional animation (if desired; relatively unimportant in this simulation study) is only two clicks away.

Verification and validation of the model used the following traditional and time-tested techniques (Sturrock 2018):

1. Structured walkthroughs conducted among the members of the analyst team
2. Sending one entity (an arriving customer) through the model and tracking every physical step taken by that entity; in this step, first a customer from group #1 entered; then a customer from group #2; and then a customer from group #3
3. Temporary removal of all stochastic variation of the model, followed by arithmetic checks using Microsoft Excel®
4. Combining #2 and #3 to check that a single customer of each type spent the expected time in the model
5. Ensuring that every routing path placed in the model had non-zero traffic over a sufficiently long test run length
6. Directional variation (e.g., do queue lengths and waiting times increase when, for example, the service times of ticket salesclerks is increased, and decrease when the number of ticket salesclerks working in parallel is increased?)

As is well-nigh inevitable in simulation model development, verification, and validation, errors were detected and corrected. Indeed, one error resulted in customers transiting the model in zero time! Another error, a routing logic error, was exposed by noticing that one of the routes in the model was never used. After correcting these errors, comparison of model results, pertaining to the current system, with data actually observed during production yielded agreement of performance metrics within 3½%, helping the model achieve credibility with the managers of the amusement park.

5. Experimentation and results

Since the amusement park opens afresh every day, the simulation model was run as a terminating system, hence with zero warmup time. For each of the situations to be studied, 100 replications of the model were run. Interestingly, it was at this phase of the project that the amusement park managers came to realize one of the significant benefits of simulation: Not the slightest need to suspend, or even disrupt in the slightest, the operation of the park while the simulation study proceeded through the phases of model construction, verification, and validation through the comparative analysis of scenarios to be examined for comparative merit.

Midway through the project, due to managerial policy changes at the park, a request was made that "the staffing level of type A and of type B ticket agents must remain the same throughout the workday (i.e., across all four time blocks)." Relative to the current situation, and acceding to that new directive, nine scenarios, with reference to different staffing levels of the type A and type B ticket agents during the day, were run, as shown in Table 1 (below).

Table 1: The Nine Scheduling Scenarios Compared

Scenario #	# Type A Clerks	# Type B Clerks
1	2	1
2	1	2
3	**0**	**3**
4	3	0
5	2	2
6	3	1
7	1	3
8	4	0
9	0	4

The Simio® "Experiment" feature provides a convenient interface for running all scenarios consecutively on a "one-click" basis, and provides easily interpreted box-&-whisker plots for performance metrics of interest, as shown in Figure 2, Appendix A.

On viewing and examining the results of the nine alternative scenarios and comparing their results with the base case (the current situation, which was used early to verify and validate the model), management chose Scenario 3 (boldface in Table 1). This scenario produced the best combination of lowest operating cost and relatively high customer satisfaction. Relative to the current ad hoc procedures and policies, this scenario reduces daily operating costs by more than 50% (from more than $14,500 per day to less than $7,000 per day). Furthermore, this scenario reduces the percent of dissatisfied customers (defined as potential customers who balk) from slightly more than 16% to slightly less than 7%.

6. Conclusions and future work

Management eagerly and almost immediately replaced the current operating policy (which, in a casual private conversation about the project, one client manager sardonically characterized by the rhetorical question "What policy?") with Scenario #3. The predicted improvements were observed in 1½ weeks and lasted nicely – until the pandemic under way now. In addition to the quantitative improvements predicted and realized relative to traditional operations research queuing system performance metrics (e.g., reduced time-in-system, time-in-queue, average and maximum length of queues), morale of employees improved. This uptick in morale was especially noticeable among the ticket clerks serving customers in group #2, and these clerks happily made remarks such as "The customers aren't already so irritable by the time they step up to the ticket window." Also, all employees expressed optimism that work schedules, due to smoother customer flow, would become more predictable and reliable – an issue of contention and worker resentment in many retail and service industries in many countries, as documented by (Henly and Lambert 2014). The park is planning to reopen as this paper is written, under this policy. Further work planned for that eagerly awaited time includes examination of more finely detailed schedules, since the current restriction "number of salesclerks of either type must remain constant across all four time blocks" will probably be lifted. Also, further studies are planned to assess local queuing excesses at specific park attractions, such as popular rides or the canteen.

Funding

This paper is the result of a study (one of the course requirements) by a team of supervised graduate students in a second-year master's-level process simulation class, DS 632. External funding was neither needed nor received.

Acknowledgements

The author gratefully acknowledges the industrious, diligent, and highly competent work undertaken by the three master's-level Business Analytics students on this simulation study; these students have respectfully requested anonymity. Likewise, our collective gratitude extends to the management of this amusement park, who made themselves and park employees available for observation, data collection, and answering of questions.

Additionally, the author gratefully acknowledges the valuable and insightful suggestions two anonymous referees made to help improve this paper.

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Appendix A.

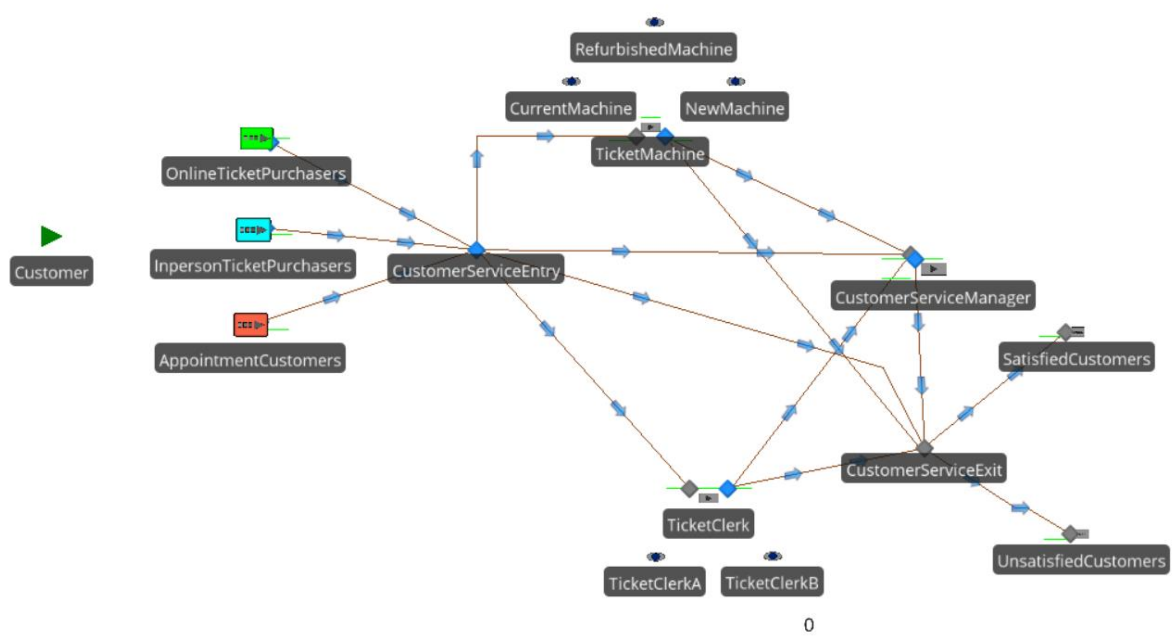

Figure A.1: Screen of the Simio® Model Layout

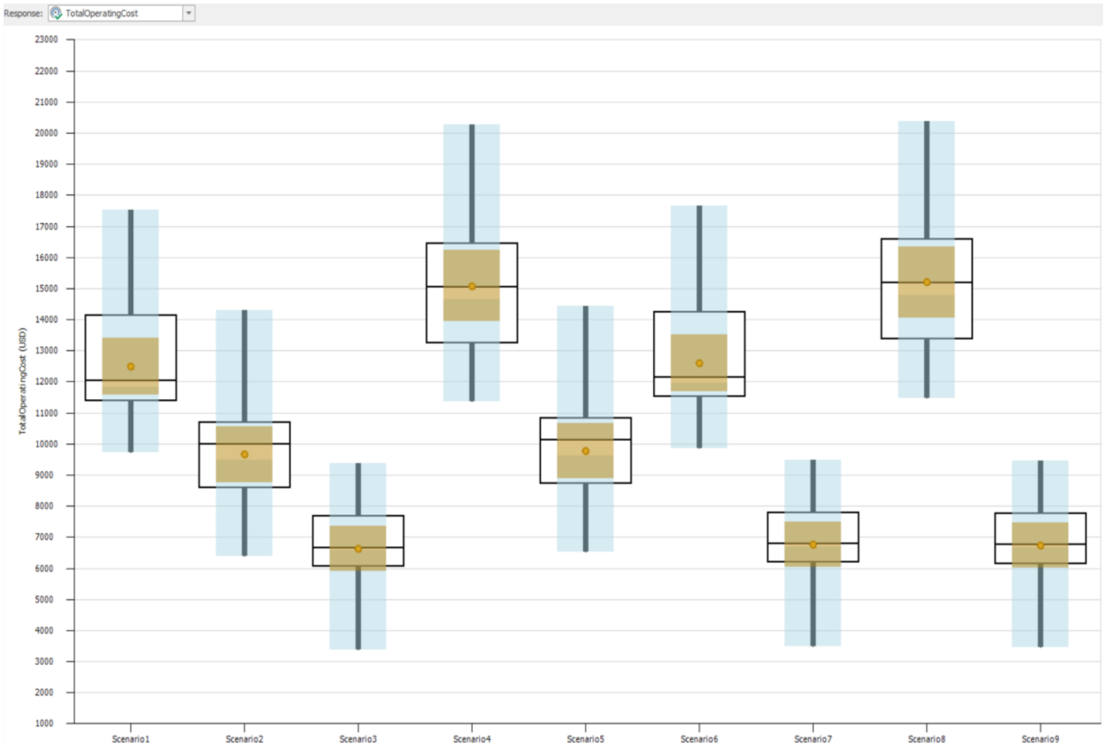

Figure A.2: Example of Simio® Graphical Output Across Scenarios