*Proceedings of the 2001 Winter Simulation Conference*
*B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, eds.*

# CALL CENTER SCHEDULING TECHNOLOGY EVALUATION USING SIMULATION

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## ABSTRACT

Telemarketers, direct marketing agencies, collection agencies and others whose primary means of customer contact is via the telephone invest considerable sums of money to make the calling operation efficient and productive. Investments are required in human resources, infrastructure and technology. Having invested the dollars, businesses want to ensure that value is maximized. Call scheduling algorithms provide an efficient method to maximize customer contact. However, management at a large, national credit-card bank was not convinced that the software used to schedule calls was providing an adequate level of service. Simulation studies showed that management was justified in this assumption. The study also revealed that process improvement opportunities exist, which if implemented would likely produce the desired performance improvements.

## 1 INTRODUCTION

Call centers are used by marketers, collection agencies and fund raising organizations to make contact with customers in an efficient manner. Resources to manage the call center should be allocated so returns to the enterprise are maximized. To achieve this goal, considerable expenditures are made to develop or procure software that efficiently schedules calls. Since competitive systems exist, a technique is needed to select from the best alternative. Choosing between competing scheduling alternatives requires consideration of overall system goals.

The measure of effectiveness used for comparison depends on the business goal. For example the measure of effectiveness for a collection agency might be the number of customers actually contacted or the number of dollars at risk, depending on how the collection unit is evaluated. Figure 1 depicts a stylized relationship between probability of contacting a particular customer and the availability of customer service representatives over the course of the day. The diagram shows the potential mismatch between available resources and the probability of contact – when there is minimum probability of contact, the maximum amount of resources are available and vice-versa. Scheduling algorithms are designed so that calling resources are efficiently utilized and call effectiveness is maximized.

The use of simulation to support business decision making is well established (Stanford and Graham 1998, Schrage and Peters 1999). Simulation has been increasingly used to model various aspects of call center operations, with recent applications to call center and workforce management (Chokshi 1999, Klungle 1999) and call routing (Miller and Bapat 1999). This paper uses simulation to model the call center process to compare the performance of three different scheduling approaches. The paper begins with a brief description of call scheduling algorithms, followed by a description of the calling process and model used to simulate the call center. Simulation results are used to assess the relative performance of the competing systems, and further consequences to call center operations are discussed.

## 2 CALL SCHEDULING

On a given day there may be thousands of calls to make to customers. Ideally, customers will be contacted and accounts resolved on the first call. However, mismatches in resources and inability to contact customers combine to make a complicated resource allocation problem.

There are many approaches to design a call scheduling system. Heuristic methods based on rules derived from management experience are straightforward to implement. Methods are often based on mathematical programming techniques (such as integer and linear programming), logistic modeling or expert system techniques. Linear programming (LP) methods are widely used because of the availability of commercial LP solvers and the ease of for-

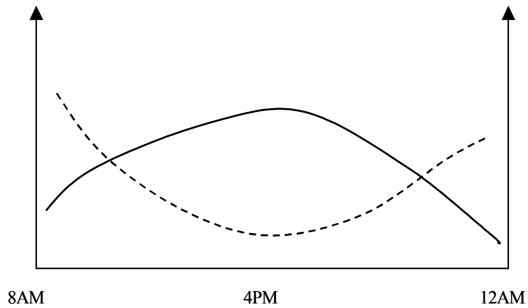


Figure 1: Probability of Coverage (Dashed Line) and Resource Availability (Solid Line) over Time

mulation. A general integer programming (IP) scheduling model can be written as follows:

$$\text{Maximize performance} = \sum\sum x_{ij} * \text{performance measure}$$

Subject to:

$$\sum x_{ij} * r_{ij} < R_j \quad \forall j$$
$$x_{ij} = \{0, 1\} \quad \forall i, j$$

where $i$ is the call and $j$ is the time period, $x_{ij}$ is a binary scheduling variable determining whether call $i$ will be scheduled in period $j$, $r_{ij}$ is the (expected) resource consumed by call $i$ if call is made in time $j$, and $R_j$ is the resource availability in period $j$. Management chooses the performance measure, which may be expressed as dollars at risk, outstanding account balance, or number of successful customer contacts. Resource availability is typically measured in FTE hours.

Because the number of variables in a typical IP formulation can be very large, the problem is often solved using heuristic techniques. In the heuristic approach considered for this study, calls are prioritized according to the customer's outstanding balance. Calls are then made in rank order throughout the day. Ranking rules based on complex functions of customer attributes could also be used. While simple to implement, heuristic approaches may result in a sub-optimal call schedule. Both heuristic and LP methods for scheduling have the weakness that the uncertainty of customer contact and variation of call duration are not explicitly considered, factors that both have an impact on the effectiveness of the collection process.

In this study, three scheduling methods are compared:

1. Heuristic – call sequence ordered by customer balance,
2. Batch Optimized – daily scheduling (16 hourly lists),
3. Dynamic Optimized – hourly scheduling (reoptimization at the beginning of every hour).

Aside from the differences described above, an important feature that distinguishes the three techniques is how calls that are not completed are handled. The differences are discussed in the next section.

## 3 MODELING AND SIMULATION

To estimate the improvement in productivity associated with the use of batch optimized software and its dynamic version over the baseline practice for outbound call scheduling, a simulation model is developed. Considering a lack of available comparative data for batch and heuristic scheduling methods, and the fact that the dynamic technique has never been implemented, computer simulation models were the only practical means for developing the comparative estimates. Because of distinctions between the how calling lists are maintained throughout the day, a separate model is developed for each of the three scheduling methods.

### 3.1 Calling Process

The processes involved in the dialing operations are characterized as follows. A call (entity) is generated by the scheduler and is sent to the first available customer service representative (CSR), who subsequently makes the call. The number of CSRs may vary by hour. A call will result in one of the following three outcomes:

1. Right party contact (RPC) – the customer was contacted directly.
2. Wrong party contact (WPC) – the phone was answered, but the customer was not home or did not take the call.
3. Non-contact (NC) – there was no answer, or an answering machine was reached.

The call making process is depicted in Figure 2. Each call outcome has an associated contact probability. The contact probability depends on the individual customer, and is a function of factors such as the time of day, historical customer contact rate and customer location. The call duration differs for each outcome and follows a statistical distribution that is determined from the historical database. Call duration statistics for each of the three possible outcomes were collected and probability distributions were estimated. Lognormal distributions were used to model call duration.

If the call results in a RPC, the CSR follows a procedure that seeks to establish a payment commitment from the customer. Calls resulting in a WPC are removed from the list for the day, while calls resulting in a NC are recycled back to the calling list. In each case, the master database is updated with the call outcome for the customer.

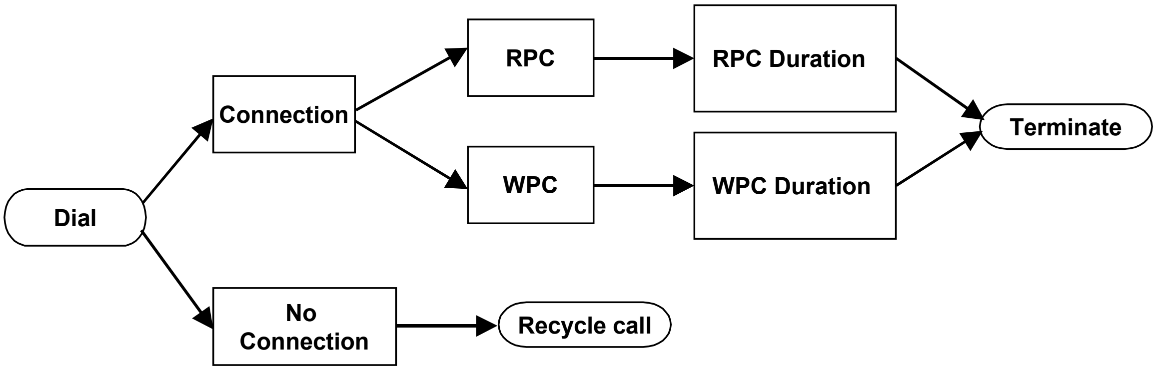


Figure 2: Calling Process

### 3.2 Simulation Model

The complete simulation model consists of two stages. The first stage is the specific scheduling software that generates a list of calls according to the scheduling criteria. The second stage simulates the probabilistic nature of the outcome and duration of each call. Statistics are kept to measure the frequency of right party contacts (RPC). The increase in right party contacts over the baseline case is referred to as the *lift*. RPCs are directly correlated with dollars recovered, so the lift provides a measure of the value for the alternative scheduling systems. The simulation results are used to generate estimates of the lift, as well as to identify opportunities for improvement in overall operation.

In the first stage of the simulation, calls are scheduled as determined by the scheduling method. The baseline scheduling technique is a heuristic method where calls are scheduled based on the customer's outstanding balance. Batch and dynamic scheduling methods are commercial software tools that use linear programming based methods to optimize the calling list with the objective function being to maximize the number of RPCs on a given day.

The second stage simulates the handling of calls by the customer service representatives (CSR). In any given hour, there are a fixed number of CSRs available to make calls. Each call occupies the CSR resource for a random duration before releasing the resource for the next call. For each of the three scheduling methods if the call results in a RPC or WPC the call is disposed of. Calls that result in a non-contact are recycled back onto the call list. The manner the call is recycled depends on the scheduling method. Under the heuristic and batch optimized method, these calls are placed on the bottom of the list. If sufficient resources are available these calls will be made again on the same day, however the number of calls to a customer on a given day is limited to some predetermined number. With the dynamic scheduling method, non-contact calls are returned to the general pool of calls for reoptimization in the following hour.

To run the simulation, the following data are required. Daily calling lists that consist of customers to be called with attributes describing the hourly probabilities of contact, probability distributions for the call duration of each outcome, and the number of customer service representatives available for each hour of simulation are needed. The simulation model was created using in ARENA 4.0 with a Visio interface. The models were validated through discussions with call center managers and in the case of the batch scheduler, through comparison with actual data. The technical staff initially pointed out some questionable results, and upon examination identified some input parameters that required correction. The final outputs all were reviewed by senior management to assess validity of the final model.

The logical sequence of the simulation model is now described. One of the three call scheduling techniques are used to generate a list of calls for the given day. While the initial call list is independent of the simulation model, the call list may be modified by the simulation model depending on the outcome of calls and the scheduling method used. In the case of a non-contact more than one attempt is made. The number of times a non-contact can be re-called is predetermined and is monitored by a variable. The model is divided into fifteen submodels, each representing one hour of the day starting from 8 AM and ending at 11 PM. At the end of each hour, the call list is updated according the rule appropriate to the scheduling method, and subsequently the calling for the next hour is initiated. The simulation results are directly exported to spreadsheet for further analysis.

## 4 SIMULATION RESULTS

The output results were directly exported to spreadsheet for further analysis. Two hundred replications for 15 hour days of operation were simulated.

Table 1 shows the summary output for the simulation runs. Both the batch and dynamic methods produced more RPCs with fewer total calls than the heuristic method. The heuristic method required making far more calls then either scheduling alternative, even though the resources available for calling are equal for all methods. There are two reasons for this. One, since the call list is not optimized with respect to probability of contact, many no-contact calls are generated. Second, the time needed to complete an RPC call is longer than NC and WPC calls. Both alternative methods increase the calling efficiency of the CSRs.

Table 1: Summary Simulation Results

| | Calls | RPC | WPC |
|---|---|---|---|
| Heuristic | 264980 | 11132 | 32238 |
| Batch | 187541 | 11738 | 27004 |
| Dynamic | 202298 | 12120 | 28758 |

While there is overall improvement in efficiency and effectiveness of calling resources by using the alternative scheduling methods, the gains are not uniform throughout the day. Figure 3 shows, by hour, the improvement in RPCs of the two alternative scheduling methods over the heuristic method. The dynamic method provides a considerable increase in RPCs, although the greatest gains are seen at the beginning of the day. The advantage declines as the day progresses. The batch scheduling method outperforms the heuristic method during the hours when calling resources are most constrained.

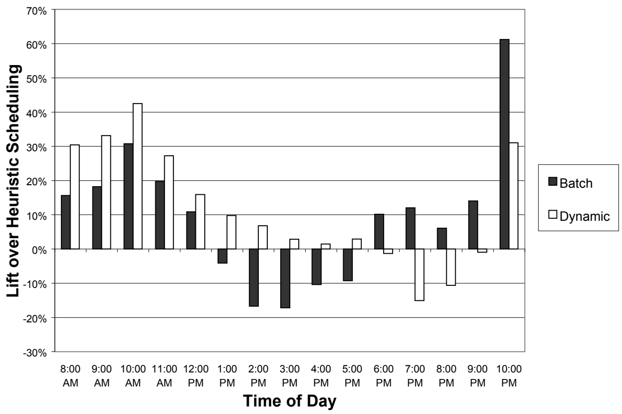


Figure 3: Lifts Improvements by Time of Day for Alternative Schedulers over Heuristic Scheduler

The improved performance of the two alternatives at the beginning of the day is not surprising, since the schedules are designed to account for probability of contact, thus maximizing the efficiency of the limited calling resources. It is likely that the higher level of resources in the middle of the day mask the differences in the three methods, resulting in smaller differences. The apparent decrease in performance for the batch scheduling is not well understood.

Looking at the output in a further disaggregated basis, Figure 4 shows the cumulative distribution of lifts over the 3000 simulated hours. While the dynamic method is more likely to give a higher level of RPCs than the batch method, it is also more likely to produce lower levels.

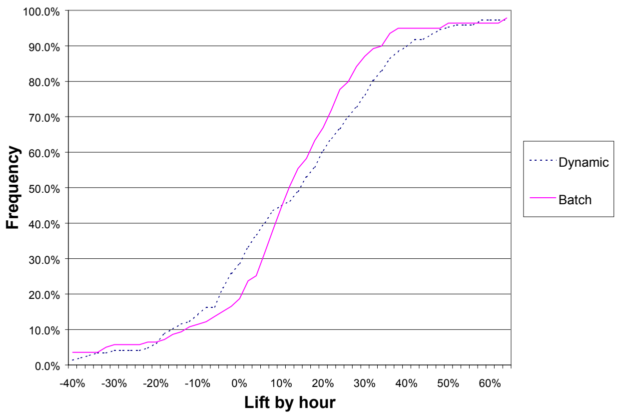


Figure 4: Cumulative Lifts for Batch and Dynamic Schedulers

So far, we have looked at the effectiveness of the call schedulers defined by the number of RPCs produced. To compare the efficiency of the schedulers, measures that account for the productive inputs must be used. One measure that is useful to determine efficiency is the *contact rate*, defined by ratio of RPC to productive FTE work hours. However, the number of productive FTE available is equal in all time periods for each scheduler, and so will vary as RPC varies. A more refined measure of efficiency would be to evaluate the ability of a call to produce an RPC. This measure, referred to as the *intensity*, is defined as the total number of attempts per call scheduled on a given day, also called the intensity. If every call resulted in an RPC, then the intensity would be equal to one. If more calls are required because of WPC and NC outcomes, the intensity will increase, with the result that productive resources are being used without a desirable conclusion.

Figure 5 shows how the intensity varies throughout the course of the day for the three cases. Intensity remains fairly constant throughout the day for the heuristic scheduler at around 21 calls per successful contact for all hours except for the last. Because of the way the call list is recycled, most of the calls made by the CSRs in the last hour are to customers that have been called unsuccessfully at earlier times of day, and so the intensity is considerably higher. The dynamic scheduler produces a slightly improved intensity over the batch scheduler in the early to middle part of the day, but the batch scheduler has better performance later in the day.

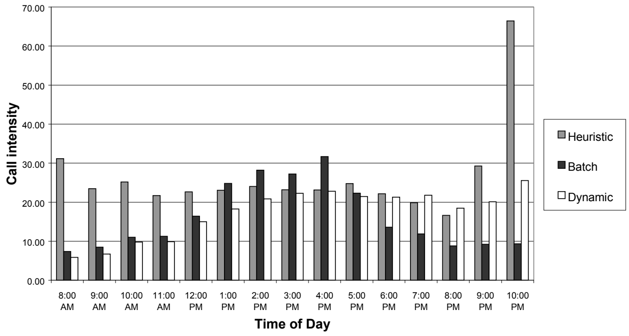


Figure 5: Call Intensity over Time

## 5 CONCLUSIONS

Improvements in call scheduling help to increase productivity. Telemarketers, call-centers, and sales-support use call scheduling to contact customers. These scheduling systems are costly and companies want to know whether or not they are getting their money's worth. Because implementation of any scheduling method involves considerable investment of money, effort and time before performance can measured, simulation was identified as the ideal approach to evaluate the alternatives.

Three types of call scheduling algorithms have been compared using the simulation-based methodology described here. The simulation model mimics the process by which calls are made from a call list produced by each of these scheduling algorithms. The output from the model provides a way to assess the performance of the system against management's goals.

The batch and dynamic scheduling algorithms have been found to be generally superior to the existing heuristic method for effective call scheduling. These methods, however, do not produce superior results all the time. One factor that is likely to affect performance is that the calling resources are not optimized in conjunction with the call list. Joint optimization of CSR scheduling and call scheduling would likely result in further performance improvements over the batch and dynamic methods described in this paper.

The simulation model in its present state can be further used to test sensitivities to changes in size and composition of the call list, available FTE hours and call duration. It can also be used as a forecasting tool for predicting productivity improvements for a given level of resources. As a possible future development, the model might be integrated with standard spreadsheet packages to be used as an MIS for call center managers to improve resource efficiency and effectiveness.

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