# Modeling and Simulation of a Pacing Engine for Proactive Campaigns in Contact Center Environment

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**Abstract**

Proactive contact campaigns play a growing role in modern contact centers. Their traditional usage as a telemarketing tool now is widely extended to different types of service notifications. In this paper we describe the most common model of a proactive telephone contact campaign, suggest several methods of its pacing algorithm and present simulation results.

## 1 INTRODUCTION

Telephony call centers and their successors, known as contact centers (CC), play a very important role in contemporary business. According to some estimation [1-3] 70% of all business interactions are handled in contact centers. In the U.S., the number of all contact center workers is about 4 million or 2.5-3% of the U.S. workforce.

Contact centers perform a wide spectrum of services such as reservations, sales, customer service, and technical support.

There are two types of call processing in contact centers: inbound and outbound. Inbound calls are originated outside the call center by customers, and then reach the call center where they are routed to operators, called *agents*. Outbound calls, conversely, are originated inside the call center, reach customers, and then are processed by agents. A typical application of outbound calls is a campaign in which customers are called with the aid of specialized call center equipment such as dialers, call progress detectors, answering machine detectors, etc.

There are several approaches to outbound dialing [6] such as manual, preview, progressive, predictive, and power dialing. Two of them are considered to be the optimal ones: progressive dialing (where calls are generated only when agents become available and the number of calls is equal to the number of available agents) and predictive dialing (where the number of generated calls is based on prediction of how many agents will be available at the time when calls pass the dialer and on the estimated success rate of reaching the called party).

It should be noted that literature devoted to outbound dialing is very rare. We can only mention a paper [4] that presents only the problem statement but lacks a description of a solution. The reason might be that the subject was considered to be a no-no in the operation research society. Indeed, for a long time outbound dialing activity done by contact center agents was thought of as annoying and hated by most customers. Calls were generated blindly to consumers who were not very happy to be distracted from everyday activities. Nowadays, the outbound services have changed dramatically. As a rule the calls have become more targeted and friendly, end users have the possibility to enlist in Do-Not-Call lists to prevent themselves from receiving unsolicited calls and there are regulation regarding the maximum time a called party is allowed to be kept waiting for an agent. For example, outbound campaigns are used as reminders of appointments and payments in a friendly manner, notification on the status of orders, useful up-sell offers, etc. Moreover, targeted outbound calls play the role of proactive notifications and therefore can reduce the number of inbound calls.

This paper addresses the problem of calculating outgoing telephony calls for predictive and progressive dialing regimes. Roughly speaking, the problem is how to define when to launch another outbound call so that agents will have enough work and customers are not left waiting long in a queue for an available agent. This task belongs to the area of queuing system theory in which there are two main approaches: analytical and simulation. This paper is devoted to modeling and simulation of analytical dialing methods for outbound telephone calls. It can also be applied to other real-time media such as outbound chat interactions.

## 2 OUTBOUND ENVIRONMENT

In this section we explore the typical outbound environment in a contact center. The general environment of CC is depicted in Figure 1.

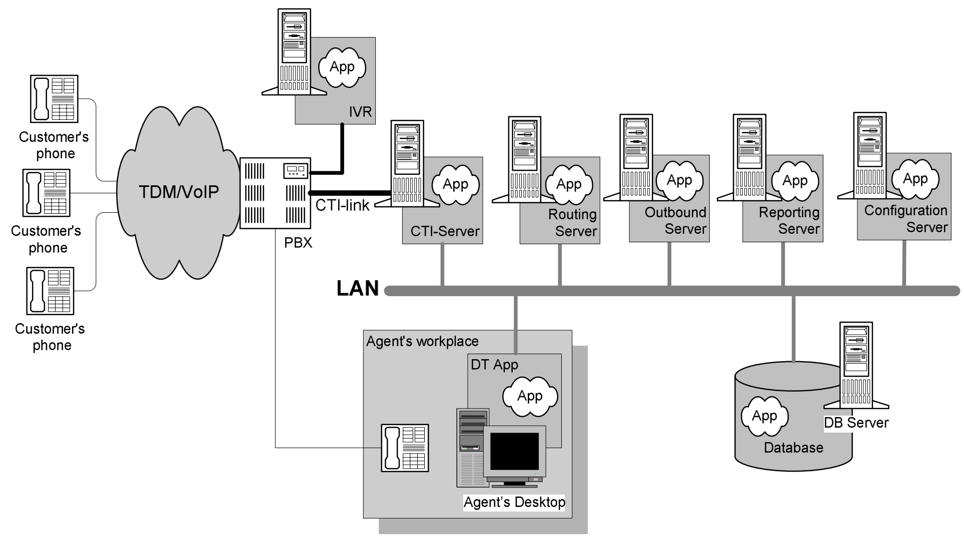


**Figure 1. Contact Center environment.**

Traditionally, for Time-Division Multiplexing (TDM) networks telephony call centers are based on technology known as Computer Telephony Integration (CTI) [5]. A typical contact center is comprised of a Private Branch Exchange (PBX) (or Soft PBX in case of IP network) having a CTI Server connected to it via a CTI link. There are components (servers) responsible for routing and processing customer calls interconnected by Local Area Network (LAN). For example, an Interactive Voice Response (IVR) System usually starts the processing of a call by performing an automatic dialog with a customer collecting all information needed for appropriate future processing. The routing server is responsible for determining the most appropriate and available agent and for routing the call to his/her workplace. For example, the decision can be made based upon exploring agents' skills - a policy called skill-based routing. When the call is transferred to the agent's telephone, his/her desktop receives data associated with the call such as information about the customer, type of service requested, etc. Based on this information the agent talks with the customer serving his/her needs. All relevant information about processing of the call and the agent behavior can be captured, collected, stored and reported by the reporting module.

The above components and call processing logic are typical for inbound calls that are originated outside of the contact center. Outbound calls are originated within a contact center with the aid of an outbound server. Integrated parts of the outbound server are a dialer and a Call Progress Detector (CPD) that generates calls and tracks their progress (see Figure 2). Please note that some calls do not reach customers due to busy signals, no answer, fax or answering machines.

The outbound dialing operates as follows. The outbound server generates a call to customers in accordance to a calling list. The progress of the call is monitored by a Call Progress Detector. If the call is answered by a live person – i.e. a successful call - then it is placed into a queue to wait for an available agent. When an agent becomes available the call is transferred to his/her workplace. It may happen that while the call is queued the customer is hanging up. Such call is referred to as abandoned.

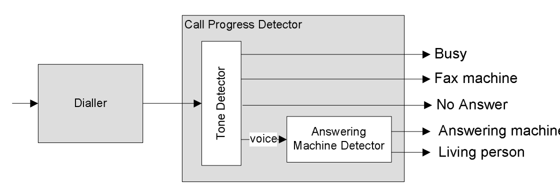


**Figure 2. Call progress detecting**

## 3 STATEMENT OF THE PROBLEM

In this section, we consider the model of a Campaign Manager that will be referred to hereafter as the System (see Figure 3). This model is represented in terms of queuing systems. It is comprised of the following elements: a call generator, a dialer, the CPD, a queue, and a set of agents. Typically agents may also process inbound calls, which should be taken into consideration.

The problem is to define a strategy for call generation by the call generator in such a way that the following conditions are met:

1. All agents should have enough work, i.e., agent utilization should reach at least some pre-specified rate $u_{\min}$. In the remainder of the paper this rate will be referred to as *busy factor*.

2. The rate of customers who have not waited for processing and have left the queue should not be higher than some specified value $A_{\max}$, called the abandonment rate.

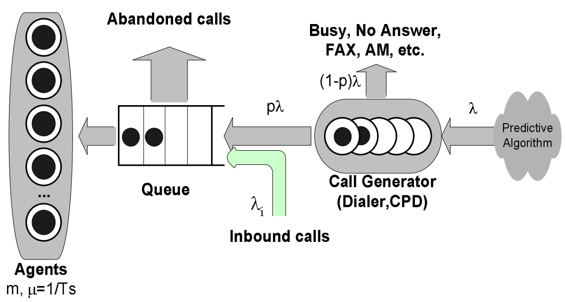


**Figure 3. Outbound model**

It has been shown that these two requirements might not always be satisfied simultaneously. Therefore we will treat these requirements as two separate problems:

1. The abandonment rate should be maintained at an admissible level $A_{\max}$, while maximizing the agent's busy factor.

2. The agents' busy factor is maintained at an admissible level $u_{\min}$ while the abandonment ratio is as low as possible.

The generator has access to all system parameters which include the total number of agents $m$ in the System (note that the number may vary), arrival rate of inbound calls $\lambda_i$, average handling time $T_s$, and a hit rate $p$ that is a probability of a dialed telephone call being answered by a live person.

## 4 DIALING METHODS

### 4.1 Predictive Dialing Methods

We assume the outbound call flow to be a Poisson process with parameter λ. The service time (duration of a conversation) in our model has a general distribution with parameter $\mu=1/T_s$. We also suppose that all customers are impatient and will hang up if they have to wait because all agents are busy. Note that for outbound calls this is quite close to the reality. This results in zero queue length. Thus we have a M/G/m/m queuing system in terms of queuing theory.

Let $\rho=\lambda/\mu$ denote a traffic offer. Then the Erlang-*B* formula (e.g. see [7]) that is known as Erlang loss formula gives us a probability of finding all agents busy:

$$E_B(m,\rho) = \frac{\rho^m / m!}{\sum_{i=0}^{m} \rho^i / i!} \tag{1}$$

The main idea of the predictive method considered in this paper is to obtain a dialing rate $\lambda_m$ which is used by the outbound dialer to generate an outbound call flow and reach one of the optimization goals, i.e. either abandonment rate or busy factor.

#### 4.1.1 Optimization of Abandonment Rate

Suppose that we want to maintain the abandon rate at or below $A_{\max}$. For a given $m$, we can determine $\rho_m$ as a maximal $\rho$ that satisfies the inequality:

$$E_B(m,\rho) \le A_{\max} \tag{2}$$

We describe in detail the method of calculating the optimal λ by solving the inequality (2) and taking into consideration inbound call flow and hit rate. The value $\rho_m$ can be represented in the following way:

$$\rho_m = \frac{p\lambda_m + \lambda_i}{\mu}, \tag{3}$$

where $p$ is a hit rate introduced in section 3.

Equation (3) gives us the opportunity to calculate $\lambda_m$ that tells the dialer how frequently it should dial the outbound calls in order to achieve abandonment rate $A_{\max}$. Basically, the predictive algorithm includes the following steps:

1. Estimate values of the parameters – $p$, $\lambda_i$, $\mu$. These values are usually calculated using the current data of the most recent processed calls.

2. Obtain $\rho_m$ from (2) by solving the corresponding nonlinear equation using any iterative procedure appropriate for our case.

3. Obtain $\lambda_m$ from (3): $\lambda_m = (\rho_m \mu - \lambda_i)/p$.

4. Dialer generates outbound calls with intensity $\lambda_m$. Here we omit the technical details of defining the precise time moments when dialer the actually sends the calls.

Figure 4 shows the interdependency between abandonment rate and number of agents for different busy factor values.

#### 4.1.2 Optimization of Busy Factor

The busy factor $u_{\min}$ can be obtained as a minimal u that satisfies the equation:

$$u = \frac{\rho}{m}\left[1 - E_B(m,\rho)\right] \tag{4}$$

which can be applied for both M/M/m/m and M/G/m/m models [8,9].

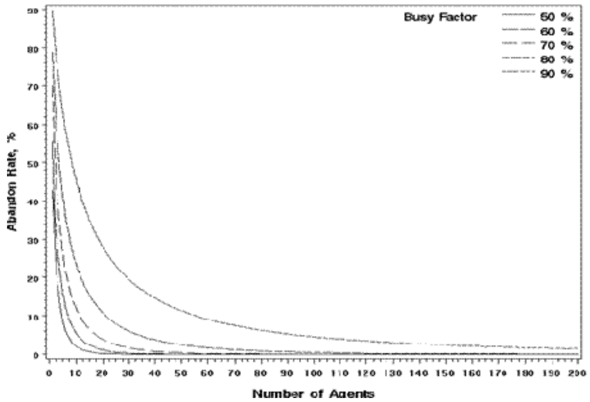


**Figure 4. Abandonment rate.**

The predictive algorithm which optimizes the busy factor works in a similar way as for abandonment rate. We use the same three steps to obtain the dialing rate $\lambda_m$, where $\rho_m$ is a maximal $\rho$ that satisfies (4) for given $u_{\min}$.

Figure 5 shows the busy factor as a function of the number of agents for different abandonment rate values.

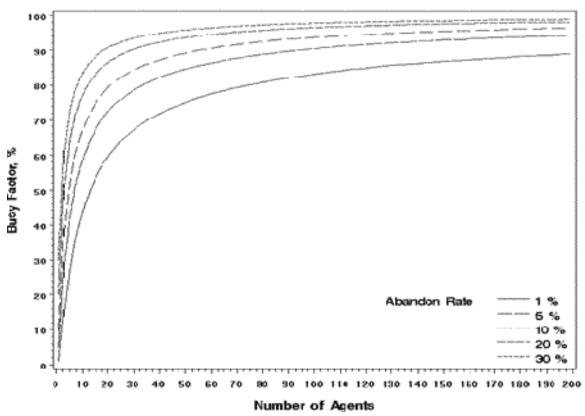


**Figure 5. Busy Factor.**

Both predictive methods described above work very well only for large agent groups - when the number of agents is above 50. The methods' performance degrades very rapidly for small groups with less than 20 agents. This small-group problem is well known among practical users of predictive dialers. We will present some suggestions on how to resolve or at least mitigate the issue.

Another limitation of the predictive method is that it does not take into consideration the current agent statuses. For instance, if suddenly all agents become busy for unusually long time, the campaign will continue generating outbound calls with the same rate. It may lead to increasing an abandonment rate until these long calls will be counted and the average handling time $T_s$ will be recalculated.

### 4.2 Progressive Dialing Method

Usually the progressive dialing method works for pure outbound scenario with no inbound traffic. It includes the following two main steps:

1. Each time when the system changes its state (an agent switches the status from ready to busy or vice versa, or a new outbound call is generated) the preliminary number $N$ of new outbound calls to be dialed is calculated by the formula:

$$N = N_r - N_d \quad (5)$$

where $N_r$ - number of agents ready to take a call, $N_d$ - number of already dialed outbound calls which are still in the dialer in the status of call progress detection.

2. If (5) gives a positive value, dial $N$ outbound calls.

This method is one of simplest because it does not need sophisticated mathematical theory for its implementation. In some situations it looks rather conservative and gives relatively low agent occupancy. Most frequently it is used during a start-up phase of an outbound campaign in order to collect all necessary data to prepare dialing in more advanced modes.

The predictive method is considered to be more efficient than the progressive one. However, for small agent groups (5-20 agents) this may not be the case. Indeed, as we will show below that our progressive method gives a constant agent busy factor while the abandonment rate is zero. With the predictive method, if we try to decrease abandonment rate, the agent occupancy will be also decreased turning to zero. At this point, the agent busy factor in predictive dialing will be less than the agent busy factor in progressive dialing. Thus for certain number of agents and certain values of abandonment rate, the progressive method is better than the predictive one. This phenomenon could be explained as following: The progressive method takes into consideration the current state of agents while the predictive method does not. Obviously this state becomes relevant for a small number of agents.

The abandonment rate for the progressive method is always equal to zero and the busy factor can be calculated using the following formula:

$$u = \frac{T_s}{T_s + (1-p)\tau_1 / p + \tau_a} \quad (6)$$

where $T_s$ is the average call handling time and $p$ is the hit rate. Values $\tau_1$ and $\tau_a$ are average times of staying in the dialer for unsuccessful and successful calls respectively. From (6) we can conclude that the busy factor in the progressive method does not depend on the number of agents. Here we also can see the conditions under which the progressive method - which as appears to be a very primitive one - might be more efficient than the predictive one. The progressive method has an advantage over the predictive method if the agent handling time is much longer than the time an outbound call is typically kept in the dialer under relatively high hit rate.

### 4.3 Super-progressive Method

In this section we suggest an optimization - we call it the super-progressive dialing method. This method is targeted to improve the efficiency of the predictive algorithm for small agent groups. It is a logical enhancement of the progressive method when taking into account not only $N_r$ and $N_d$ from section 4.2 but also hit rate *p* by allowing the dialer to generate more outbound calls than calculated by (5). The number of additional calls depends on the abandonment rate which should not exceed the specified value $A_{\max}$.

The algorithm has the following steps:

1. Wait until the number of calls in dialer $N_d$ is equal to zero.

2. Find a maximal $n_m$ satisfies the inequality:

$$A(n, p, k) \le A_{\max} \quad (7)$$

where *n* is the number of calls to be dialed, *k* is the number of ready agents ($k \le m$) and $A(n, p, k)$ is calculated by the formula:

$$A(n, p, k) = \sum_{i=1}^{n-k} \frac{i}{k+i} \binom{n}{k+i} p^{k+i} (1-p)^{n-k-i} \quad (8)$$

3. Dialer generates $n_m$ outbound calls.

The method suggested in this paper uses only abandonment rate as an optimization parameter. Another limitation is that it does not work properly in a blended environment where some adjustments are necessary to reduce the outbound dialing rate to allow agents also to accept inbound calls. Such improvements are out of the scope of this paper.

It seems that there is no possibility to analytically express the busy factor as a function of the abandonment rate. So, a simulation is one of the most appropriate ways to compare efficiency of all three methods described in this article. The simulation results and their interpretations are presented in the next section.

## 5 SIMULATION RESULTS AND DISCUSSIONS

### 5.1 Small-group case.

The results shown on charts below for both simulation cases were made in the following way:

1. Values of busy factor for predictive and progressive methods were calculated analytically using formulas (4) and (6) correspondently.

2. Each value of busy factor for super-progressive method is an average of 1000 experiments conducted for M/M/m/m queuing system.

3. Results of each experiment are obtained after running a computer program that simulates an outbound campaign working during 10 hours.

The standard error of each plotted busy factor value is less than 0.1%.

Figure 6 shows the results of Monte-Carlo experiments of the super-progressive method and clarifies the relationship between progressive, predictive, and super-progressive methods in a small-group scenario. The data related to predictive and progressive methods are obtained analytically from the formulae (4) and (6) correspondingly.

This simulation clearly proves that in a typical small-group outbound campaign the super-progressive method has significantly higher busy factor than the two other methods. We strongly recommend to use it for such campaigns when an estimate of the hit rate is available with a value much lower than 1. Also, the progressive method shows to have a significant advantage over the predictive one for the given set of parameters and an abandonment rate less than 10%.

Now let us discuss how the busy factor achieved by suggested pacing algorithms depends on the parameters of the outbound model.

It is clear from the Erlang loss formula (1) and the description of the predictive method that the busy factor for this method is insensitive to such parameters as *p*, $\tau_1$ and $\tau_a$ and depends only on the number of agents *m* in a campaign. Moreover, the busy factor can be expressed as a function of just two parameters: *m* and $A_{\max}$. Similarly, the abandonment rate is a function of *m* and $u_{\min}$. Despite the fact that both functions are nonlinear, they can be easily calculated. They are depicted on Figures 4 and 5 correspondently.

On the contrary, the busy factor of the progressive method is the same for any number of agents. As we mentioned above, according to (6), it is very sensitive to the parameters $T_s$, *p*, $\tau_1$ and $\tau_a$. The busy factor grows when an average time the dialer spends to reach a live person

$$T_a = (1 - p)\tau_1 / p + \tau_a$$

is becoming smaller than the average handling time $T_s$. For example, if a live person picks up the phone with the twice higher probability $p$ = 60% than in the experiments described in Figure 6, the busy factor will be equal to 74% instead of 54%.

The super-progressive busy factor has more complicated relationship with the model parameters. Here we point out only general tendencies. The super-progressive method such as the predictive one gives a higher busy factor for a large agent group (see Figure 7). We also expect that its efficiency is improved when the average time $T_a$ becomes much smaller than the average service time $T_s$.

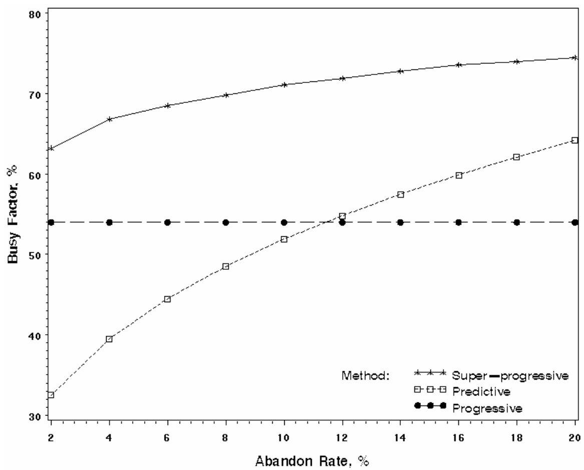


**Figure 6. Busy factor vs. abandonment rate for predictive, progressive and super-progressive dialing methods. Parameters: $m$ = 5, $T_s$= 200 sec., $\tau_1$ = 60 sec. and $\tau_a$ = 30 sec., $p$ = 30%.**

### 5.2 Predictive vs. Super-progressive. Large group case.

Figure 7 allows us to compare the efficiency of predictive and super-progressive methods depending on the number of agents.

As can be seen the predictive method outperforms the super-progressive one for relatively large agent groups of size 30 or higher.

## 6 CONCLUSION

In this paper we presented some analytical methods of outbound dialing and their analysis using simulation. We have shown that the predictive dialing method works satisfactorily for a large number of agents. For small agents groups it is more preferable to use a modified progressive method called super-progressive.

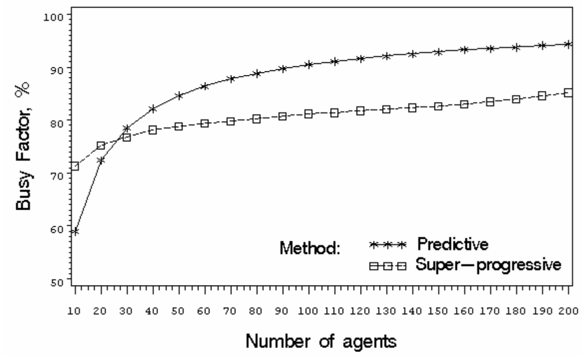


**Figure 7. Busy factor. Parameters: $T_s$= 200 sec., $\tau_1$ = 60 sec. and $\tau_a$ = 30 sec., $p$ = 30%, $A_{\max}$ = 5%.**

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