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Building a Generic Simulation System to Enhance the Performance of Call Centers

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Abstract: Now a days, there are many call centers where a group of agents services customers remotely via telephone. Each call center company has its net objective and goal to achieve. This study uses suitable performance measures to evaluate a current call center model. The measures are average waiting time in queue and call abandonment rate. To evaluate the performance of a call center, one suitable technique is a simulation. The objective of this study is developing a generic simulation model and evaluate the results of the performance measure regarding average waiting time in queue and call abandonment rate. The main two goals are using as a benchmark analysis. The solution yielded from the proposed model is proven to be efficient and able to achieve the manager's goal.

Key words: Call center, average waiting time in queue, call abandonment rate, simulation technique, efficient

INTRODUCTION

A machine answer of an apologized phrase is a common answer given by a voice response unit when all agents handling calls are busy. Even though a company should be happy when a customer calls, too often it seems that a customer is made to think that his/her call is not necessary, especially when he/she is forced to wait an indeterminate period to speak with someone. Naturally, the customer has to wait a long time to get a response. When this happens, it appears that the quality of service provided by the call center is not perceived to be satisfactory. Cronin and Taylor (1992) assert that quality service is essential for customer satisfaction to enhance repeat purchases, to win customer loyalty (Zeithaml *et al*., 1990) and to retain customers. Quality service also affects a company's market share and thus profitability (Zeithaml *et al*., 1996).

The call center is a facility designed to support the delivery of some interactive, services via telephone communications. It is typically an office space with multiple workstations manned by customer service representatives (staff, agent) who place and receive calls by Gans *et al*. (2003). Call centers are used by marketers, collection agencies and fundraising organizations to make contact with customers in an efficient manner.

A call center handles inbound or outbound calls, also referred to as incoming or outgoing calls. An inbound call center handles incoming calls initiated by outside callers into a center (Koole and Mandelbaum, 2002). Incoming calls usually are processed by a stand-alone Automatic Call Distributor (ACD) and are often supported by Interactive Voice Response (IVR) units. The IVR unit will attempt to respond to a customer's need and help to route the call to an available agent. On the other hand, an outbound call center handles outgoing calls initiated from within a center (Mandelbaum and Zeltyn, 2007). The call center that handles both incoming and outgoing calls does so through the use of a predictive dialer that facilitates call blending. This study only focuses on the inbound call center.

Literature surveys: The following are some commonly used to estimate the performance measures (Feinberg *et al*., 2000).

Average speed answer: It represents the average delay of all calls in a queue. Also, can be calculated by dividing the total delay by the number of calls in a queue. In other words, it is the average waiting time of a customer in a queue (Cleveland and Mayben, 1997).

Average Handling Time (AHT): It is a call center metric for the average duration of one transaction, typically measured from a customer's initiation of the call. It includes any hold time, talk time and related tasks that follow the transaction. The AHT is a prime factor when deciding the call center staffing levels.

Agent utilization: It is the percentage of time that agents spend in Average Handling Time (AHT) with the total time of their shift in schedule.

Abandonment rate: The abandon rate tells us what percentage of the callers who hang up before reaching an agent.

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Service time: The amount of time taken by an agent in handling a call. It starts fro when a caller reaches the agent until the conversation finishes. Anton *et al.* (1999) identify three major elements of a modern call center environment. They are listed below:

Unpredictable call arrival times: Calls tend to arrive in bunches at a call center, making it very difficult to adequately staff without the analytical tools. To support this unpredictable situation, managers have to decide how many resources to provide to accommodate this demand, i.e., arrival of the incoming call.

Call center complexity: Mehrotra *et al.* (1997) discuss the complexity of a call center. Managing and designing a call center is becoming more complicated for various reasons, such as new technology as in the rampant growth and popularity of the internet, a myriad of customers' expectations and reengineering initiatives that include designing call routing and staffing strategies. Armony and Maglaras (2004) noted that today's call centers have more functions, more services to fulfill diverse customer needs and much more complex systems with a time-varying workload, general service time distributions, and different types of agents. This means that there are too many interactions and interdependencies to predict accurately and manage call center performance (Koole and Mandelbaum, 2006).

Dynamic environment: Most call centers today are going through dramatic changes in technology and workflow process (Anton *et al.*, 1999).

MATERIALS AND METHODS

Framing of specific problem: This study focuses on just one particular aspect of the queuing theory the arrival of calls to a call center. The data source for this study collected from the large U.S. bank call center. Some features of this general example of a queuing system are described below. Before studying the statistics related to the call arrivals to the bank, we need to understand the processing flow of an incoming call to the call center. This process flow is summarized in Fig. 1.

Usually, the bank call center received approximately 300,000 calls weekly. When a customer makes a call, the call is first routed to a Voice Response Unit (VRU) (sometimes also known as the Interactive Voice Response [IVR]). During this phase of the call, the response unit will prompt the customer to identify himself/herself and find out the type of services the customer requires. It might be possible for the customer to perform some self-service doing at this point, for example finding out general information about the bank or receiving bank account information. In this bank, approximately 80% (~240,000) of the customers finish their service within the VRU. The remaining, around 20% (60,000) of the customers, request the assistance of a service agent. These customers are said to have entered the service queue. The time they "enter the service queue" is recorded (in seconds) for the first calling time at which they could have been assigned to an available and free agent to assist them. In fact, some of the customers joining the service queue to serve directly. Others are required to wait in a queue until there is either an agent available to get serve or till the customer decides to leave the system by hanging up the phone. This is a simple description of the process flow of an incoming call. In reality, the process can be much more complicated if we take into consideration the original flows of calls within the VRU and the difference in services rendered to high-priority and low-priority customers.

Call center optimization: The focus of the operational study is on queuing systems in that the call centers are optimizing efficiency within the system. This suggests minimizing the time a customer spends in the service queue. This study is thus on the 67% of the incoming calls that request to speak with an agent. The approach that has been adopted involves modeling the incoming call flow starting from where a call reaches a call center, lines up at a queue, reaches an agent until the end of service and is hang up.

The Automatic Call Distributor (ACD) is modeled with six queues which means one queue for one service requested. The system considers First In First Out per customer so that the first call will serve first. The agents are modeled as servers, who are divided into six groups depending on their skill. As mentioned, 67% of the incoming calls desire to speak with an agent and the remaining 33% complete the service through the IVR. The types of service required are also divided probabilistically for each type of service.

Model building with arena software: The queuing model in Fig. 1 is implemented using an Arena modeler. Arena Simulation, by Rockwell Software was used to simulate the call center. Arena has been proven to be the best simulation program in the world. It is extremely easy to use and has all the features required to simulate the problem at hand.

Calls received will be identified and placed in their adequate queue. The model was built to mimic the current system at the bank call center. The model simulates six

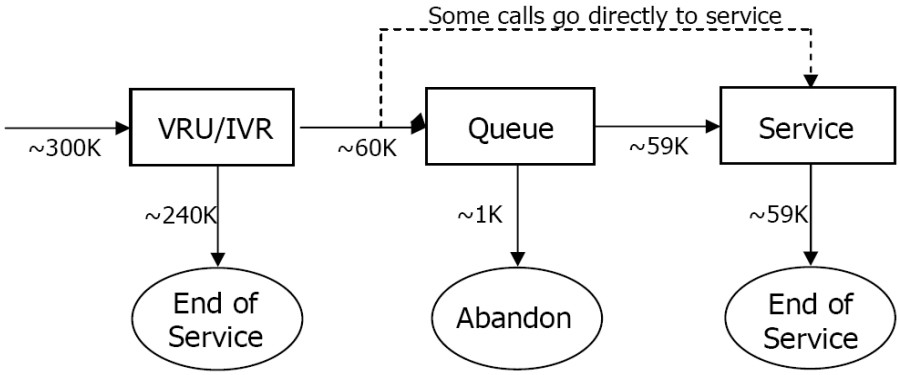

Fig. 1: Process flow of an incoming call to the call centre (Nurani Zulkfi, 2011)

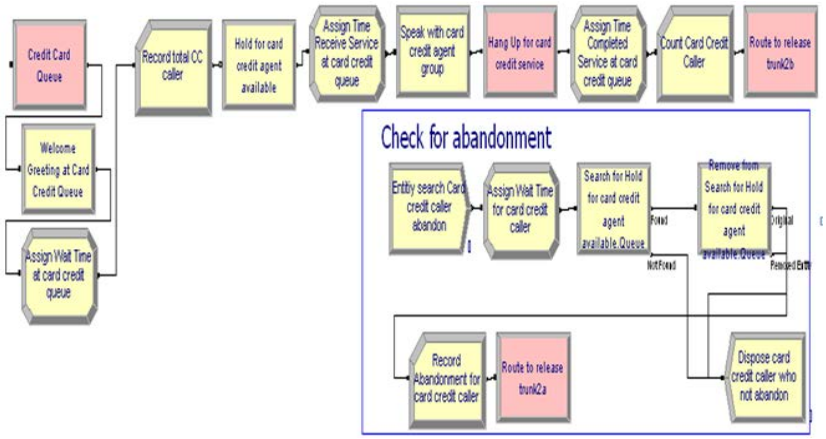

Fig. 2: Incoming call arrival sub model of model 1

primary queues, namely credit card, loan, internet banking, account inquiries, rates information, and lost or stolen card. Total time 720 min were used to run the simulation by applying a terminating condition which means the system will stop until all the callers in queue receive the service completely before the system terminated.

Model breakdown: The model is divided into two sections, namely call arrivals and Skill routing by each type of call.

Call arrivals: Figure 2 illustrates the main logic of an incoming call arrival, starting from when the call arrives, and the call routed to an agent. Create module provided by Arena Software was used to simulate the incoming call. In the create module, we put 20 entities per arrival which means the entity will create 20 callers in 1 min. The arrivals call will check the phone line availability; if there are available phone lines, the incoming calls will successfully get the phone and the remaining will receive a busy signal, indicating that the call blocked. From information gathered, the caller typically waits for just about 2 min before abandoning the queue. Figure 3 show the credit card queue model. There is rectangular labeled as "Check for abandonment". This model logic was created to check any entity (caller) that has been waiting for >2 min before disposing him or her of the credit card queue to compute the total number of callers who abandon the queue.

For callers who have issues regarding a loan, they will be lined up in a loan queue and wait for an available agent (Fig. 4). The call routing for loan service is the same as other queues but it differs in the number of agents staffed. Four agents are tasked in the loan group. We also created a separate model logic labeled as "Check for abandonment" to detect how many callers who already lined up the queue but could not wait any longer after 2 min. The number of callers who abandoned the queue will be recorded using a record module. Each agent in this group has the same skill and is able to serve a caller in a triangular distribution time: 0.7 min minimum, 1 min in average and 1.8 min in maximum. The value of handling time was set in the process module called "Speak with agent internet banking agent group" (Fig. 5).

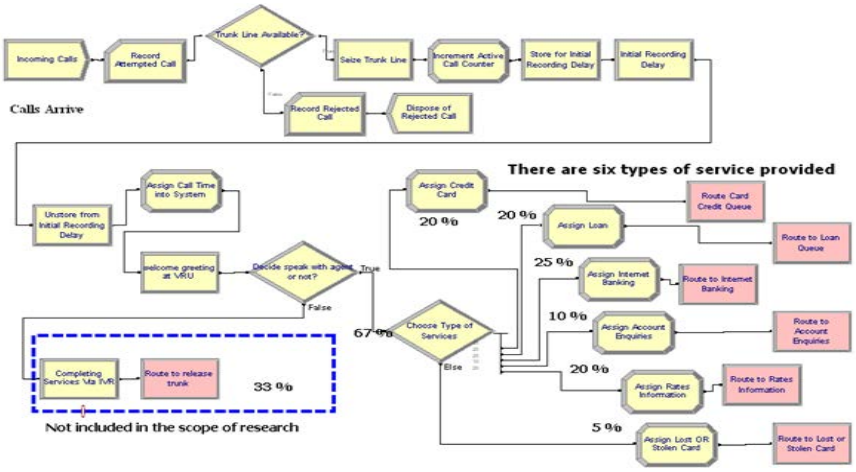

Fig. 3: Credit card queue model logic

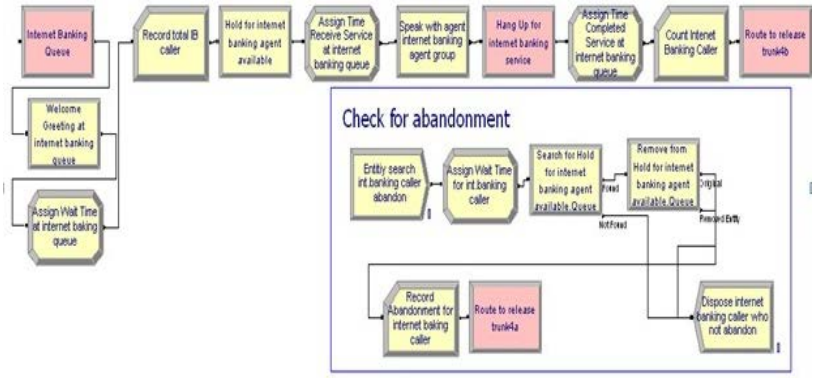

Fig. 4: Loan queue

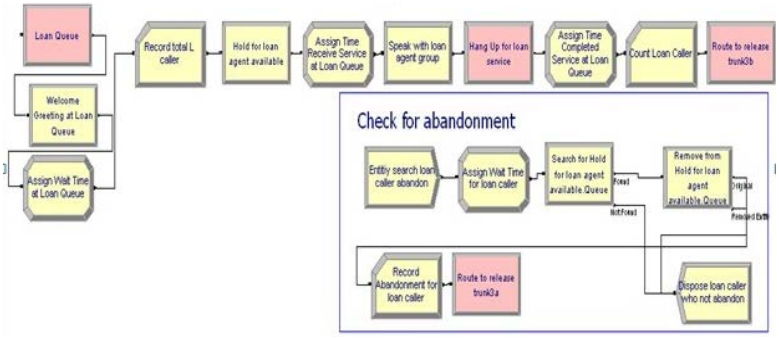

Fig. 5: Internet banking queue

A caller who has any enquiries regarding his/her account will be given the option to get through the available agent. Three agents are staffed to handle this type of caller.

Normally getting through the agent is smooth, but a long queue will occur when there is a big number of callers at certain times. The entire module used to build the model logic for account enquiries is also the same as the other queues (Fig. 6).

With regards to the rate information queue in Fig. 7, the module used is the same like other queues. Five agents are staffed to handle the call for the rate information service required by the callers.

The model logic labeled as "Check for abandonment" was created to detect if any caller who waits for >2 min is disposed of the queue. The caller that is disposed of the queue will be recorded as a caller who abandons the queue.

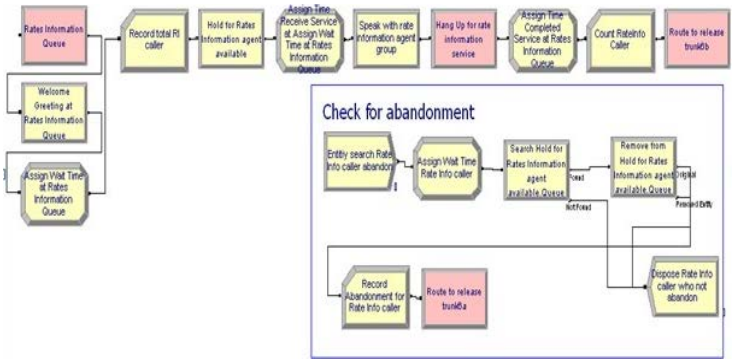

Fig. 6: Account enquiries queue

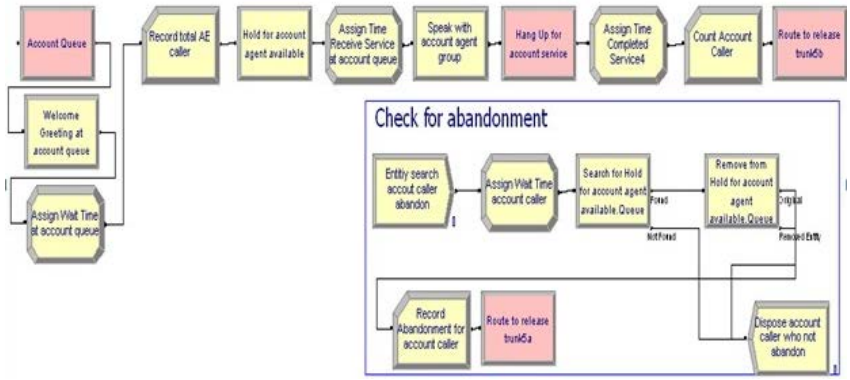

Fig. 7: Rate information queue

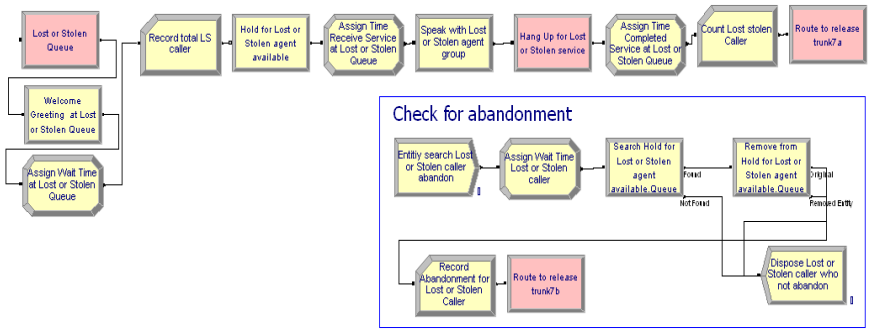

Fig. 8: Lost or stolen card queue

The call center also provides an agent who is able to handle cases that involve a stolen or lost card by their customer. Such a case has to be solved immediately before any irresponsible person makes use of the account. The agent usually will directly stop any transaction or renew the password and so on. But, usually cases like this rarely happen. Figure 8 displays the model logic for the call routing of a lost or stolen card. The entire modules used are the same like the other queues in which two agents are staffed to handle such cases.

Process queue: A process queue represents an agent handling a call for an expected amount of time. If a call arrives while another is still being processed, the arrival call will be put in a queue. But, the caller may not want to wait and as a result leave or abandon the queue. As soon as the processed call is completed, it is released and the waiting call is removed from the queue and processed.

RESULTS AND DISCUSSION

Result analysis of the model: The baseline model provides a view of the operation as it exists today. After completing a simulation run, we obtained the result as shown in Table 1.

In the baseline model, there are six types of services. The last column, Goal, corresponds to the goals set up by the managers. Call abandonment rate for credit card, loan,

Table 1: Performance metric of model 1

	Types of caller						
Performance metric	CC	L	IB	AE	R1	LS	Goals
Call abandonment rate (%)	11.7	5.9	13.9	11.1	8.7	1.2	≤5%
Average waiting time in queue (minutes)	4.3	2.9	6.4	1.8	3.9	0.3	≤1.5 min
Actual data	4.2	2.7	6.1	1.7	3.7	0.3	
Difference (%)	2.1	7.4	4.9	5.9	5.4	0.0	

CC: Card Credit; L: Loan, IB: Internet Banking, AE: Account Enquiries, RI: Rate Information, LS: Lost or Stolen card

Table 2: Total Number of Callers By Type

	No. of replications					
Type of caller	1	2	3	4	5	Average
Total number of caller						
CC	1957	2026	1988	2032	469	1694
L	1980	1934	1933	1995	477	1664
IB	2440	2549	2384	2529	477	2076
AC	1003	1004	967	1009	532	903
RI	2035	1982	1853	1989	2032	1978
LS	469	477	474	532	519	494

internet banking, account enquiries, and rate of information recorded 11.7, 5.9, 13.9, 11.1 and 8.7% respectively. If those values are compared with the goal, they have exceeded the goal desired by the call center. We can also see that all average waiting times for each queue exceeded1 minute except the average waiting time at the lost or stolen card queue.

Model validation and verification: In order to ensure that the built system accurately represents the practice or current model, validation and verification of the model have to be made.

Model verification via visual checks: We can observe the animation or the movement of the entity when running the model, the model logic and the behavior against the real world. We also can see the movement in a single step at a time by using the step buttons. This is useful to ensure that the model runs properly. The animation makes it easy to verify the model by checking the flow starting from when the entities enter the system until they are disposed of by the system. It mimics the real system and we can say that the system is verified.

Model validation via comparison simulation output and real data: A model validation is a task of ensuring that the model behaves the same like the real one. In other words, if it does, then we are building the right model. A validation process involves comparing the model's performance under known conditions with the performance of the real system by comparing the simulation output with the actual data. The comparison simulation output and the actual data was implemented in this study. The statistics collected from the simulation model include the average waiting time, call abandonment rate and resource utilization.

The simulation was run for five replications and the difference between the simulation outputs and the actual data was computed using the formula below:

$$\text{Different (\%)} = \frac{\text{Simulationoutput} - \text{Actual data}}{\text{Actual data}} \times 100\%$$

The differences in value between the simulation output and the actual data must be around ±10% or less to satisfy the level of validation of the model to the actual system. The length of simulation for this model is 720 min with a terminating system condition which is terminated at time 720 min and all the phone lines return to idle. For this study, the model was run for five replications and then we computed the average.

Average waiting time: The historical data recorded that the average waiting time for credit card queue is 4.2 min, loan queue 2.7 min, internet banking queue 6.1 min, account enquiries 1.7 min, rate of information 3.7 min and lost or stolen card queue 0.3 min. With five replications, the average waiting time for each queue for credit card queue is 4.3 min, loan queue 2.9 min, internet banking queue 6.4 min account enquiries 1.8 min, rate of information 3.9 min and lost or stolen card queue 0.3 min. The difference between the simulation output and the historical data for credit card queue, loan queue, internet banking queue, account enquiries, rate of information and lost or stolen card queue is 2.1, 7.4, 4.9, 5.9, 5.4 and 0%, respectively. These values indicate that the model is good and imitates the real model. Table 1 shows the value and the valuation of these data analyses. Thus, this model can be considered valid in imitating the actual model.

Call abandonment rate: The call abandonment rate was calculated by the number of callers who abandon the queue divided by the total number of callers. Table 2 shows the total number of callers by each type after

Table 3: No. of callers who abandon the queue

	No. of replications					
Type of caller	1	2	3	4	5	Average
Number of caller abandon the queue						
CC	173	223	192	225	180	199
L	85	94	92	101	122	99
IB	270	342	245	306	278	288
AC	90	112	86	102	110	100
RI	182	184	145	165	182	172
LS	3	4	9	9	6	6

Table 4: Call abandonment rate for each queue

Type of caller	Total average No. of caller by type	No. of caller abandon queue	Call abandonment Sim. output (%)	Actual data	Difference (%)
CC	1694	199	11.7	11.6	0.9
L	1664	99	5.9	5.4	9.3
IB	2076	288	13.9	13.2	5.3
AC	903	100	11.1	10.9	1.8
RI	1978	172	8.7	8.0	8.7
LS	494	6	1.2	1.1	9.1

Table 5: Percentage of resource utilization

Type of agent group	No. of resource available	Percentage of resourceutilization
CC	3	82.96
L	4	80.00
IB	4	87.65
AE	3	80.00
RI	4	83.55
LS	2	32.09

completing five replications of simulation run. Table 3 indicates that the number of callers who abandon the credit card queue, loan queue, internet banking queue, account enquiries, rate of information and lost or stolen card queue is 199, 99, 288, 100, 172 and 6, respectively.

The simulation output from the models shows that the percentage of call abandonment for credit card queue, loan queue, internet banking queue, account enquiries, rate of information and lost or stolen card queue is 11.7, 5.9, 13.9 , 11.1, 8.7 and 1.2%, respectively. The difference in percentage between the simulation output and the actual data is not >10%. Thus, we can conclude that the building model imitates the actual model, hence the model is validated (Table 4).

Resource utilization: Resource utilization is an indicator of measuring how busy the resource is. It is very important to know how the resource is being deployed. The resource measurement in this study includes the entire agents who serve each queue. The value of resource availability and resource business is listed in Table 5.

Table 3, shows that the performance of each group of agent is considered high except for the LS group. This is because the callers or the entities consistently arrive. The

Table 6: Priority in waiting time

Type of caller	Waiting time
Credit card caller	Will transfer to expert agent if waiting for 30 sec
Loan caller	Will transfer to expert agent if waiting for 30 sec
Internet banking caller	Will transfer to expert agent if waiting for 30 sec
Account enquiries caller	Will transfer to expert agent if waiting for 30 sec
Rate of information caller	Will transfer to expert agent if waiting for 30 sec

Table 7: Input parameters for expert agent for each type of call

Input	Credit card	Loan	Internet banking	Account enquiries	Rate of information
Handling time (min)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)
No. of agents	1	1	1	1	1

Table 8: Call Abandonment Rate for Each Queue

Caller type	Total average No. of caller	No. of caller abandon	Call abandonment
CC	1984	57	2.9
L	1971	41	2.1
IB	2494	28	1.1
AC	967	17	1.8
RI	1544	61	4.0
LS	472	8	1.7

LS group shows 32% of resource utilization. This value can be considered low performance of the LS group and cause the underutilization of resources. From the actual data, the performance efficiency of the CC group, L group, IB group, RI group and AE group reaches about 85% as the average of the resource utilization. But, the performance efficiency at the LS group is only 40%.

Construction of the proposed model: Once the baseline model was established, we built two models to attain the goal of the call center with average waiting time in queue less than or equal to 1.5 minute and call abandonment rate less than or equal to 5%. Note that the baseline model is identified as Model 1.

Result analysis of model 2: A caller who waits for 30 sec in each queue will be transferred to an expert group. So, the caller will get priority in terms of waiting time (Table 6).

After waiting for 30 sec, the caller will be given a chance to be transferred to the expert group. When the priority is given to the caller, this will lead to changes in call routing in each type of the queue.

We proposed additional one agent for each expert agent. The time of handling all calls is assumed to be uniform which is 0.5 minimum and 0.8 at maximum for all agents. These expert agents are able to serve the caller in less amount of time (Table 7).

When a caller is given priority several significant changes occur in terms of call abandonment rate and average waiting time in queue. Table 8 and 9 show that the call abandonment rate for all queues fulfill the goal of the call center. But, the average waiting time for the credit card group exceeds the goal with 0.2 difference. Table 10

Table 9: Performance metric of model 2

	Types of caller						
Performance metric	CC	L	IB	AE	R1	LS	Goal
Call abandonment rate (%)	2.9	2.1	1.1	1.8	4.0	1.7	≤5%
Average waiting time in queue (min)	1.7	1.5	1.1	0.7	1.4	0.2	≤ 1.5 min

Table 10: Expert group performance metrics of model 2

Input	Credit card	Loan	Internet banking	Account enquiries	Rate of information
Average waiting time in queue (after transfer to expert agent)	0.5	0.4	0.5	0.2	0.2
Total time in queue	1.0	0.9	1.0	0.7	0.7

Table 11: Input parameters for multitasking agent and expert groups

Input	Group 1	Group 2	Group 3
Type of caller being serves	Credit card caller	Loan caller	Internet banking caller,account enquiries caller and rate information caller
Handling time (min)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)	Uniform (0.5, 0.8)
Number of agents	1	1	2

Table 12: Call abandonment rate for each queue

Type of caller	Total average number of caller	Number of caller abandon queue	Call abandonment rate (%)
CC	2578	64	2.5
L	1960	31	1.6
IB	2000	115	5.8
AC	979	19	1.9
RI	1962	54	2.8
LS	478	9	1.9

Table 13: Performance Metric of Model 3

	Types of caller						
Performance metric	CC	L	IB	AE	R1	LS	Goal
Call abandonment rate (%)	2.5	1.6	5.0	1.9	2.8	1.9	≤5%
Average waiting time in queue (min)	1.1	0.8	1.3	0.7	1.3	0.2	≤1.5 min

indicates that the total time in queue is not over the goal's limit. The average time in queue for each group is also smaller than the waiting time in the queue before. Total time in queue refers to the amount of time a caller spends for waiting in a queue. This value was computed by adding the average waiting time in queue (after transfer) with time before transfer which is 0.5 min. Hence, the total time in queue for CC group is 1.0 min.

Result analysis of model 3: To further improve the performance metrics, we built model 3 by adding one group with multi-tasking agents and two groups of expert agents. In group 3, the agents have more than one skill so that they are able to manage >1 type of caller and also more experienced than the other groups ofagents. Hence, their call handling time is also lesser (Table 11).

Table 12 shows that the handling time for agents in group 1 in min is in a uniform distribution with a minimum of 0.3 min and a maximum of 0.8 min. There is a uniform distribution in group 2 with a minimum of 0.5 min and a maximum of 0.8 min. In group 3 that has multitasking agents who are able to handle internet banking callers, account enquiries, callers and rate information callers, the handling time in uniform distribution is as follows: a minimum of 0.5 min and a maximum of 0.8 min.

The performance metric in Table 13 shows that all the call abandonment rates for each type of callers are <5% and the average waiting time in queue is <1.5 min. The results show that by adding more expert agents who are multi-skilled will lead to the achievement of the management goal.

There is no caller who abandons the queue after he/she is transferred and served by agents in group 1-3 (Table 14). The average time in queue for each group is also lesser than the waiting time in the queue before. Total time in queue refers to the amount of time a caller spends for waiting in a queue. This value was computed by adding the average waiting time in queue (after transfer) with time before transfer which is 10 min. Hence, the total time in queue for group 1 is 1.0 min. Even when compared with the total time in queue after transfer to the expert group, the total time still does not exceed the goals desired by the management.

The results of the models are displayed in Fig. 9 and 10. By using the Microsoft Excel application, we computed the value and displayed it in Fig. 9, so that we can compare the three models. Model 3 appears to have the highest abandonment rate by an internet banking caller. The result of model 1 is displayed in the

Table 14: Multitasking agents and expert groups performance metrics

Performance metric	Group 1	Group 2	Group 3
Average waiting time in queue (after transfer to expert agent)	0.3	0.2	0.2
Total time in queue	0.8	0.7	0.7
Number of agents	1	1	2

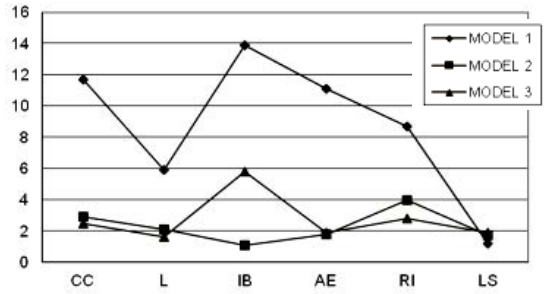

Fig. 9: Comparison of the abandonment rate

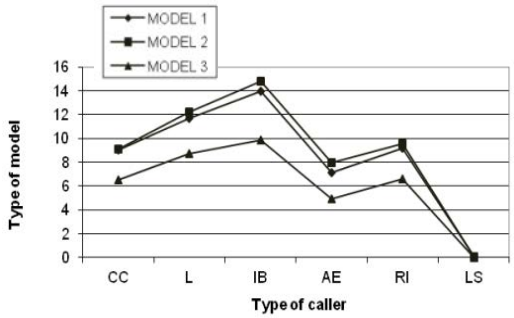

Fig. 10: Comparison of the average waiting time in queue

upper line. As a conclusion, we can say that model 3 is the best one compared to model 1 and 2 because the number of the abandonment rate is small for all types of callers. This means that the goal was achieved.

The same situation also appears in the three models in Fig. 10. The proposed model, i.e., model 2, does not show the desired result. The average waiting time in queue increases more than that in model 1. This might be because giving the priority to the caller without considering the number of callers at that time, hence the increase in the average of waiting time in queue.

CONCLUSION

As a conclusion, we recommend model 3 to the company to be implemented. The implementation of model 3 hopefully will assist the management to improve the current situation. However, to implement model 3, the company may have to spend an addition of RM 24,000.00 for four special expert agents with the assumption that each special agent will cost RM6,000.00. However, despite the additional cost, the company will enjoy a decrease in abandonment rate and waiting time in a queue. Additionally expert agents the company has to hire are worth compared to the loss the company will incur for every caller who abandons the queue. The company is likely to lose RM 300.00 for each caller who leaves the queue. If the number of callers who leave the queue is 100 a week, the company will have lost about RM 30,000.00. This is a serious issue that needs crucial consideration by the company to retain the loyalty of the customers and decrease the opportunity loss.

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