Simulation of Optimal Routing in Call Centers

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Abstract

Call centers can provide service to customers, handle queries, offer product support, carry out telemarketing, or market research. The challenge of queue at call center is a function of both wait-times resulting from lack of available severs and ineffective call resolution which is has to do with the agent's skill and experience to handle the problem. This paper studies the concept of call center and its challenges, discuses related literatures and adopted the results obtained from [14,16], indicating optimal as SSTF and SQR while [15] further hybridized both optimal rules to obtain Hybrid Heterogeneous Call Routing Rule (HHCRR). The methodology deployed was discrete event-driven simulation. In the displayed simulation result between SSTF, SQR and HHCRR, findings from the result proves that HHCRR performs better than both the optimal rule for wait-time (SSTF) and call resolution (SQR) routing rules.

Keywords: *Simulation, Routing Rule, Call Center, Optimization.*

1. Introduction

A call centre is a Department or an office in which incoming and outgoing telephone and voice calls from new and existing customers are handled by a team of advisors or agents. It is a traditional set-up for companies of a larger size. Call centers can provide a service to customers, handle queries, offer product support, carry out telemarketing, or market research. A call centre differs from a contact centre in that it traditionally only deals with voice calls and no other form of channel of contact. It usually consists of a large team of agents who carry out call handling. Call centers can be flexible in size and set up, so it can be utilised by many companies in different sectors. Virtual call centers are built up with a small team of agents or individual agents who are not working at the contact centre, but more typically they are working at home. Call centers are valuable to companies because they provide a platform to customers where the company has the opportunity to enhance its image, resolve problems and to create a stronger customer base.

There are certain factors which can be used to measure the customer experience and function of the call centre. These include metrics of average handling time, customer satisfaction, service level, cost per call and many other parameters. Call centers use many technologies such as queuing systems, automated scheduling, speech recognition, multi-channel call routing and workforce management. A call centre is a system that offers complete management of all communication channels between a business and its customers, optimizing polices, eliminating duplicated workand making better use of time [5]. The call centre service has grown a great deal with its application in all sectors of the economy. It serves as a primary contact between businesses and clients. The major challenges at call center are unnecessary wait-time due to queue and some agent's inability to resolve customer problem effectively, which is a function of the agent's skill and experience.

[7], defined a queueing system as a birth-death process with a population consisting of customers either waiting for services or currently in service. A birth occurs when a customer arrives at the service facilities. A death occurs when a customer departs from the facility. The state of the system is the number of customers in the facilities. A queue is a situation whereby customers wait in line to be attended to. [19], defines it "as any place where a customer (human beings or physical entities) that requires service is made to wait due to the fact that the number of customers exceeds the number of service facilities or when service facilities do not work efficiently and take more time than prescribed to serve a customer.

A customer's experience during a service encounter consist of two parts namely: the time spent waiting for the service and the service itself. Most research in the domain of call canter focuses on waiting time which is a result of queue. The issue of queuing has been a subject of scientific debate, for there is no known society that is not confronted with the problem of queuing [14]. Wherever there is competition for limited resources, queuing is likely to occur. Beyond the challenge of queue in a call center is the problem of call resolution. This is the ability of a call center agent to resolve the customer's issue effectively the very first time the customer calls the call center. Dissatisfied customers call back for more help for the same problem, the load on the system increases. It is important for customer's issues to be resolved the first time the call is routed to the call center agent. First Call Resolution (FCR) is perhaps the most powerful call center metric. FCR measures the percentage of customer issues resolved the first time.The challenge of queue at call center is a function of both wait-times resulting from lack of available severs and ineffective call resolution which is has to do with the agent's skill and experience to handle the problem. Based on the foregoing, a routing rule that can reduce wait-time on the queue and also enhance effective call resolution for effective call routing in call center will improve call center efficiency and increase customer satisfaction.

2. Related Work

Call routing is the sequence of path taken to convey a customer's call to a service agent. Call routing also known as call distribution relates to a set of rules which are applied to isolate the most appropriate resource for a specific call. Call routing is experience by the customer as being guided through a decision tree. By progressing through that tree the system provides information to and collects user inputs from the caller. The corresponding realization is often referred to as routing path. All routing techniques used in call distribution follows a baseline routing rule which serves as a benchmark for routing calls [13]. [9], they modeled a call centre as an M/M/s+M queue which is develop to determine the behavioural queue model in which customers arrive in and depart from the system based on their satisfaction with waiting time. The model of the abandonment behavior was developed by the extension of the Erlang-A formula, which can be viewed as an M/M/s+M queuing system with feedback. In reducing the challenges of waiting queues experienced by customers at call centers, our model considered wait-time oriented routing rules [16].

[20], observed that the Erlang B model is a formular for blocking, a probability derived from Erlang distribution. The Erlang B describes an unsuccessful call, when all servers are busy and the call is neither queued nor retired but loss completely. It is assumed that calls attempts arrive following a passion process [20; 17; and 2], so calls are independent. More also, it is assumed that message length (holding times) are exponentially distributed as depicted in (Markovian system) and this is generally applied under general holding time distributions.[3]Observed that Customers in a call service center experiences real time delay as a result of queue and call back delay. This metrics affect customer's perception of the product or service and this impact on customer's loyalty. The study deployed Probabilistic choice model and the dynamics of the system are modeled as an *M/M/N* multiclass system. The result from their study indicated that as the number of agent's increases, the system's load approaches its maximum processing capacity.

[8], noted that as time spent on queue at the call centers increases, it becomes unacceptable for customers, and this affect their satisfaction level. The researchers conducted a survey using Univariate Analysis of Variance (ANOVA) to determine customer's perception of their wait experience at call centers. From the result obtained the researchers noted that though the time spent on the queue waiting can lead to customer dissatisfaction. Nevertheless it is not as important as the agent's ability[18].

[14], opines that lack of available servers leads to queue, as a result, capacity planning and call routing software systems strive to minimize costs while achieving self-imposed service level constraints, such as "average wait in queue less than 15 seconds". These traditional approaches do not consider, however, the quality of answers provided by the call center agent. For a call centre that is primarily focused on call resolution, it seems optimal to route each call type to the agent who can handle it the best, therefore holding such calls in queue even if other agents are not busy, until the agent who can handle such calls properly become available later. Determining agent's resolution ability across the various agent groups and determining the routing rule that is appropriate to route calls to agent according to the order of their resolution ability will definitely, reduce undue burden on some agent groups while other agent groups experience low levels of utilization and excessive idle time [14].[10], work was on call center and the presence of impatience consumers due to unnecessary delay which can lead to abandonment. They used a simple skilled call center including customer abandonment. The authors considered a member of different level of service definitions, especially those used in practice. They also demonstrated how to explicitly compute their performance measure using data collated from different call center. The methodology deployed was the extended Erlang A model.

[6], attempted to classically study the world of business intelligence and the implications this domain of study has on the operations of call center. The author discussed business intelligence and considered top key performance indicators of call center on business intelligence. He used as a case study a successfully implemented north east utilities call logic as a business intelligence project." Business intelligence is defined as the process of providing decision makers with valuable information and knowledge by leveraging a variety of sources of data as well as structured and unstructured information. The paper highlighted that the performance of an intelligent business can be measured using a dynamic call center. The key performance indicators help an organization define and measure of its organizational goals. The call center can utilize some metrics to measure an organizational performance. These metrics includes average speed of answer, cost per call, agent utilization rate, contact resolution rate, costumer's satisfaction and aggregate call center performance.The average speed of answer or call wait time has an important impact on costumer's satisfaction. Call wait exist between the time a costumer dial the number and the moment the costumer makes with the agent. Study shows that the more a costumer wait on the queue the less likely he will be satisfied.

[22], tries to answer the major question or challenge that borders on the operation of call center. These challenges are; 1 Where should a particular call be routed to? 2 Who should handle the call? They posited that proffering solution to these two questions will help any call center improve performance. They also observed that rules for routing incoming calls have a great impact on both call center performance and customers' satisfaction. Also, a scenario where customers experience long wait on queue before service or calls not been handle/resolved successfully by the first agent encounter affects costumers' satisfaction and decrease good will' This is also noted in [12]. In a related study by [18, P.5], observed that customers dissatisfaction increases exponentially with each poor experience and often result in lost in business. [22], considered three measures of call center performance as average speed to answer (ASA), Average handling time(AHT) and first call resolution(FCR) rate.

[21], used a mathematical program to minimize the total value derived from n different agents handling m different call types, here each agent j is assumed to have a specific value V_{ij} for handling a call type i. Each V_{ij} is a function that may correspond to financial value and the preferences of individual agent for handling a particular call type i, and at the same time minimizing the overall system. The authors sorted for a call routing rule/policy that meets traditional constraints involving customer wait time matrices. The method deployed by the authors was simulation in order to accurately incorporate the impact of random call arrivals, handling time and call resolution on performances.[11], were motivated by the fact that in the context highly congested call centers, the use of alternative service channels can be proposed to customers so as to better match demand and capacity. [4], established that in a call center there are tendencies to tradeoff between minimizing customer wait-time and fairly dividing the work load among agents of different skill level. The control measure is the routing policy deployed any time a customer initiates a call. [1], considered a system based on assumption that the system is overloaded and a such all server are always busy and a fraction of the customers are forced to abandonment. They deployed FCFS and skilled based routing rule

[15], proposed a framework that consists of a Hybrid Heterogeneous Call Routing Rule (HHCRR). HHCRR is made up of the optimal of both wait-time routing rules SSTF and call resolution routing rules SQR. This research work is set to test and determine the viability of the proposed HHCRR. This paper also determine if HHCRR performs better than the optimal routing rule for wait-time rules Shortest Service Time First (SSTF) as opined by [16], and the optimal for call resolution routing rule Shortest Queue Routing (SQR) as observed by [14].To evaluate the proposed HHCRR against the SSTF and SQR, we conducted a simulation using HHRCRR, SSTF and SQR to determine which of the rules perform better.

3. Methodology

Having established a proposed hybrid framework, HHCRR [15], in this section, a simulation analysis on the framework was conducted to determine if the proposed hybrid framework is workable and can be implemented.

3.1 Platform for Hybrid Simulation

A collection of java simulation library was used for the simulation analysis which invokes the SSJ simulation library, used for discrete event simulation. Java programming language was used for the design, and NetBeans 8.2 as Independent Development Environment (IDE).

3.2 Data for Hybrid Simulation

The data used for the hybrid simulation is the same as explained in table 2, and the outcome of the result in table 3, for SSTF and SQR. The procedure adopted the steps in the flow diagram in figure 1, which expresses the MIN/MAX optimisation for the proposed hybrid routing rule.

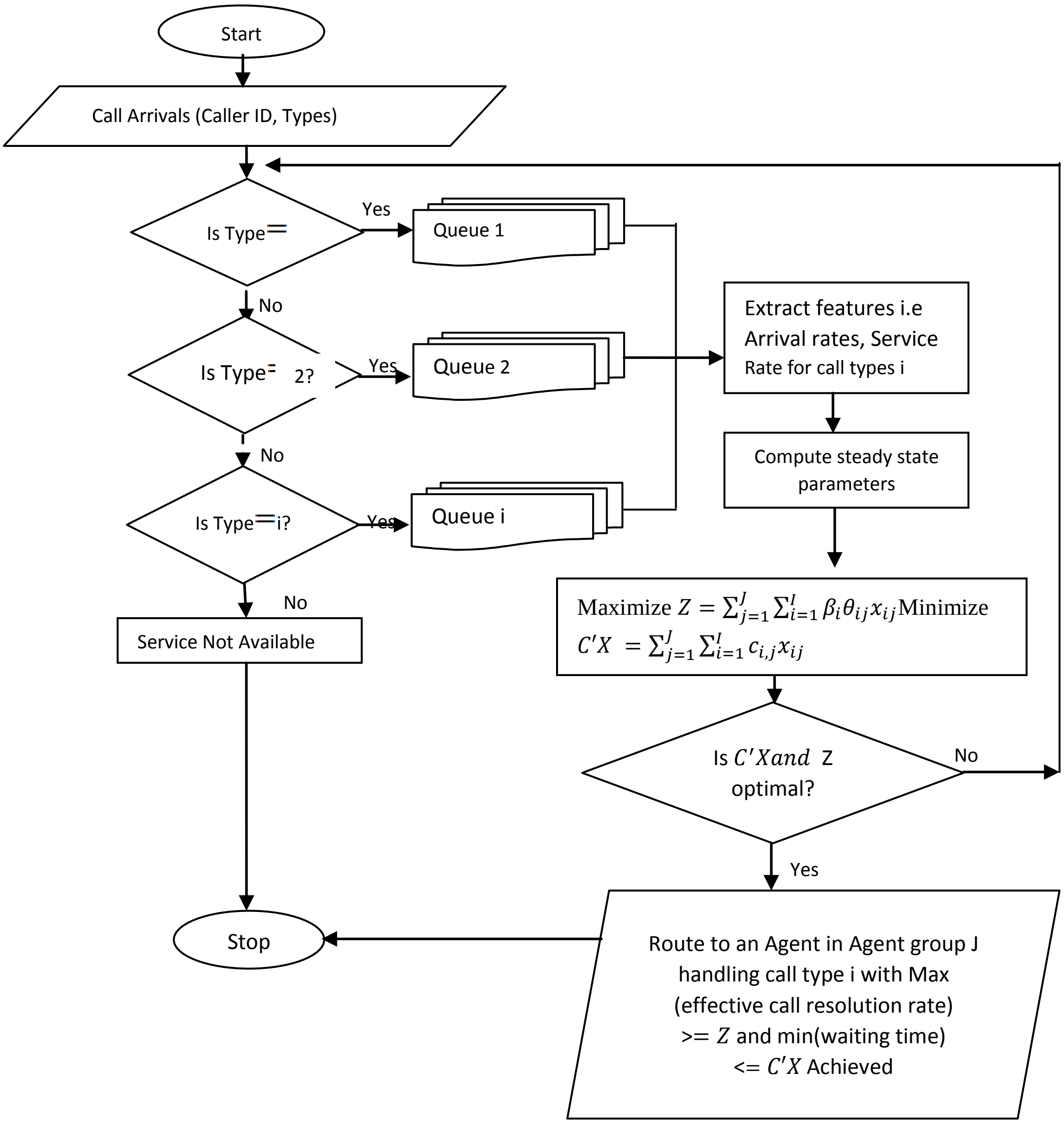

Figure1: Flow diagram for MIN/MAX optimization for HHCRR framework [15]

The flow diagram in figure 1, expresses the minimization/maximization which demonstrates that optimiszation is achieved for the proposed framework (hybrid routing rule). The flow diagram depicts call arrivals with call ID and call types. Our framework is consisted of eight (8) call type and multiple agent groups in line with the call type. Calls are routed to the agent once service is available and queues emanates when service/agents are not available. Calls are routed when the conditions for optimal routing rule is met. To determine the agent that will handle effectively handle a particular call type, the features of the call type is extracted to compute the steady state parameters. The hybrid rule is determined when Z is maximized implying high call resolution rate and C'X is minimized which indicates low wait-time. Once C'X and Z are optimal, the call is routed to an agent in agent group J with the highest resolution rate and the lowest average speed for answer (handling time).

Table 1:Operationalisation of equation variables for research

Variable	Description of variables
$time\ periods\ t_i$	time period per day :7am to 9pm for all agents that is 15 hours per day
Call type i	Multiple call types such that i = 1, 2 ...I where I is 8 in our model
Agent j	Multiple agent groups such that j = 1, 2 ...J. where J is 35 in our model
p_i	represent the proportion of call type i from the total new arrival that goes into the various call type i queue
$Q_i(t)$	number of type i call waiting for service at time t
$f_j(t)$	number of available agents of group j who are free at time t, where $0 \leq f_j(t) \leq n_j$, for all j, t.
λ_i	arrive rate of calls of type i
λ_T	The total arrival rate
n_j	no of agents in group j, such that $n_j \varepsilon Z^+$
X_{ij}	proportion of calls type i routed to agent group j
$X_{ij,t}$	proportion of calls type i routed to agent group j at time t
$y_{ij,t}$	No of agents in agent group j that handles call type i at time t
μ_{ij}	service rate of Agent group j for call of type i
μ_z	service rate of Agent group j for call of type i
β_i	arrival of unresolved calls of call type i who call back
β_{ij}	total arrival rate of agent group j for call type i who call back.
θ_{ij}	resolution probability of agent group j of call type i
ρ_j	total utilization of agent group j

Table 2: Weighted Average Results for evaluation obtained from simulation Analysis

ROUTING RULE	ASA (seconds)	CALL BACKS	% Call backs
FCFS/LW	47	0.124444444	20.74074074
FCF	36	0.088055556	14.67592593
SSTF	28	0.018055556	3.009259259
HSTF	95	0.203333333	33.88888889

Result for optimal wait-time routing adapted from [16], established from the result of their simulation That Shortest Service Time First (SSTF) routing rule is the optimal rule for reduction of queue in call center.

Table3: Weighted Average Results for evaluation obtained from simulation Analysis

RULE	CR	Non CR	RESOLVED CALLS	CALL BACKS	% resolved calls	% Call backs
SQR	1795	205	0.498611111	0.056944444	83.10185185	9.490740741
PR	1775	225	0.493055556	0.0625	82.17592593	10.41666667
RRPR	1685	315	0.423611111	0.071944444	77.9480110	14.5519850

Result for optimal call resolution routing rule adapted from (Mughele and Chiemeke, 2016) [14], establish from the result of their study that Shortest Queuing Routing (SQR) performs better than other rules evaluated**.**

3.3 Hybrid routing rule (HHCRR)

Declaration

Start

Let $Q_i(t)$ represents the number of type i customers waiting for service at time t and

Let $f_j(t)$ be the number of available agents of type j who are free at time t,

Where $0 \leq f_j(t) \leq n_j$, for all j, t.

Let Multiple call types be indexed by i = 1, 2 ...I and

Let Multiple agent groups be indexed by j = 1, 2 ...J.

Calls of type i arrive at a rate of $\wedge_i$.

There are n_j agents in group j, with $n_j \varepsilon Z^+$

Each agent in group j serves call type i with rate μ_{ij}

/Here we allow agents to be trained to handle only a subset of all the call types/

If agent group j is not capable of handling call type I then $\mu_{ij} = 0$

When $\mu_{ij} > 0$ we say there is a "match" between call type i and agent group

In addition, we assume independent of past history each agent of group j has a resolution probability for each call of type i of $p_{ij} \varepsilon [0, 1]$.

/Shortest Service Time First (SSTF) and /Shortest Queue Routing (SQR)/

If($n_j > 0$)

Then
$J = \text{argmax}_{i:Qi(t)>0}\{\mu_{ij} - \max_{k\neq j}\mu_{ik} \,|\mu_{ij} > 0\}$

Else
$j = \text{argmax}_{j:fj(t)>0}\{\mu_{ij} - \max_{k\neq j}\mu_{ik} \,|\mu_{ij} > 0\}$

And
If($n_j > 0$)

Then
$i = \text{argmax}_{i:Qi(t)>0}\{p_{ij}\mu_{ij} - \max_{k\neq j}p_{ik}\mu_{ik} \,|\mu_{ij} > 0\}$
Else
$j = \text{argmax}_{j:fj\,(t)>0}\{p_{ij}\mu_{ij} - \max_{k\neq j}p_{ik}\mu_{ik} \,|\mu ij > 0\}$
Stop

4. Results and Discussion

This section establishes that the optimal routing rules for wait-time and CR rate rules were SSTF and SQR respectively. A mathematical formalisation of the optimal rules was developed to form a framework for the hybrid rule called Hybrid Heterogeneous Call Routing Rule (HHCRR).

Figure 2: shows the interface for the input data for the simulation of the hybrid rule.

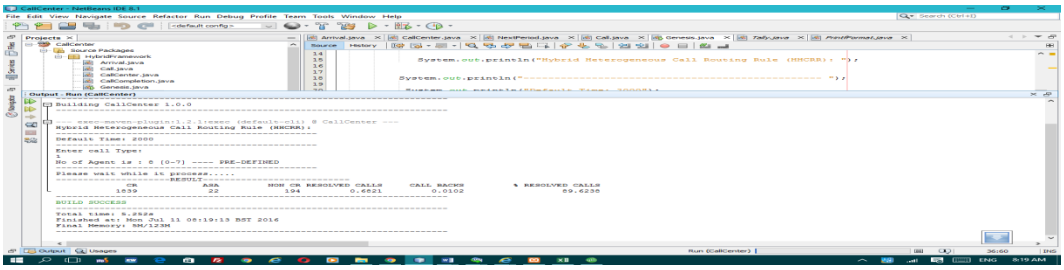

Figure 2: Input data for hybrid simulation

Figure 2, is a screen shot showing the interface for the input data for the simulation of the hybrid rule (HHCRR)

After the program execution, the screenshots in figures 3 – 9 shows the hybrid simulation processes.

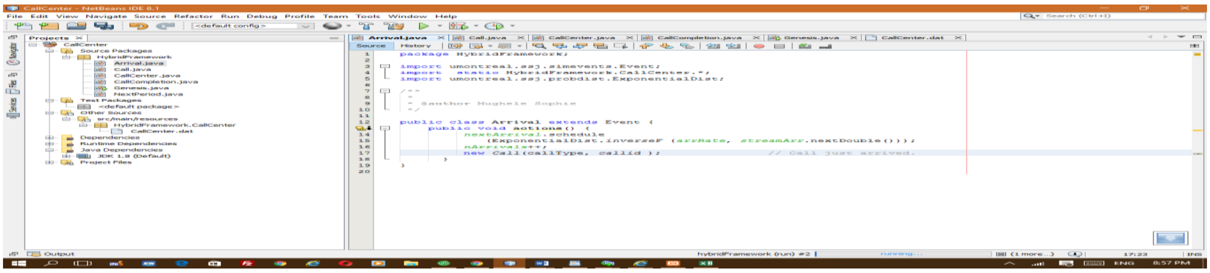

Figure 3: Call- Arrival class

This is the main Class the class extends the parent class of the External Simulation Library (SSJ Library) which is an abstract class that provides the tools for scheduling. It accepts call Type and call ID has input parameters.

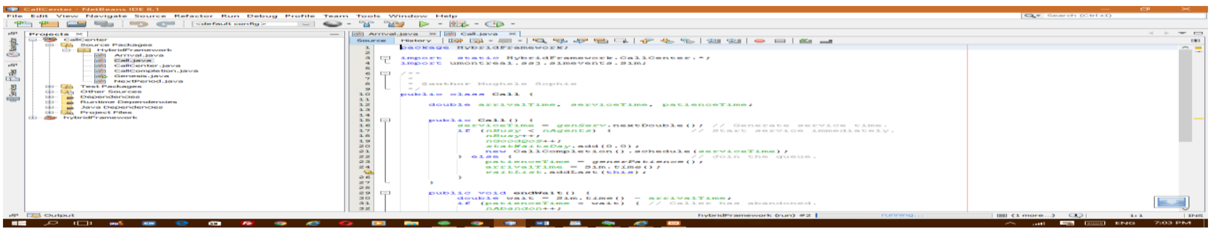

Figure 4: Call-process Class

This class is the scheduling process, it follows the flow of the flowchart routing a call type to an Agent in Agent group J handling call type i with Max(effective call resolution rate) $>= Z$ and min(waiting time) <= $C'X$. It also checks the optimal of $C^{'}Xand$ Z. If this is true, the agent is being saddles with the call-responsibility of handling call type i otherwise the process is being repeated to ensure that call type i is routed to an agent in group J that has the highest capacity to effectively handle the call.

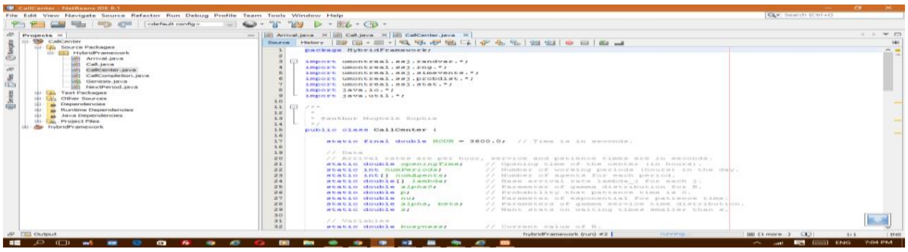

Figure 5: Call-Centre class

This is the call centre class where the Extract features are been deduced from features such as Arrival rates, Service Rate for call types and AHT for agent group j. These information from the feature extraction aids call routing decision

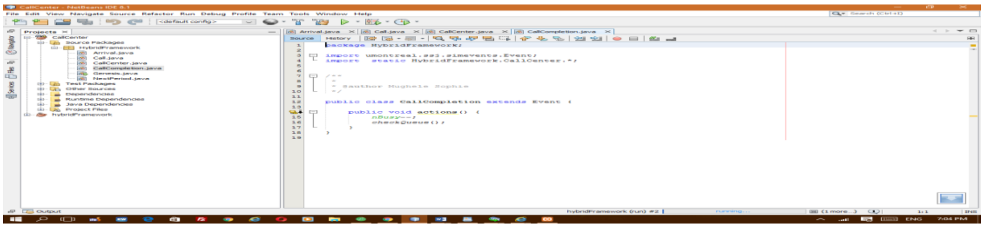

Figure 6: Call Completion Class

This class Stores the CR rate results

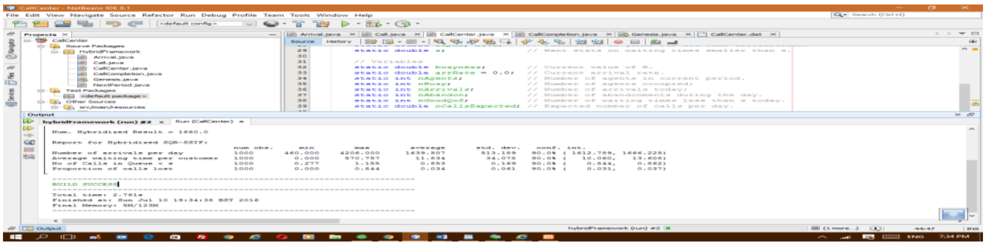

Figure 7: Call –Simulation class

This class prints the result of each of the simulation process

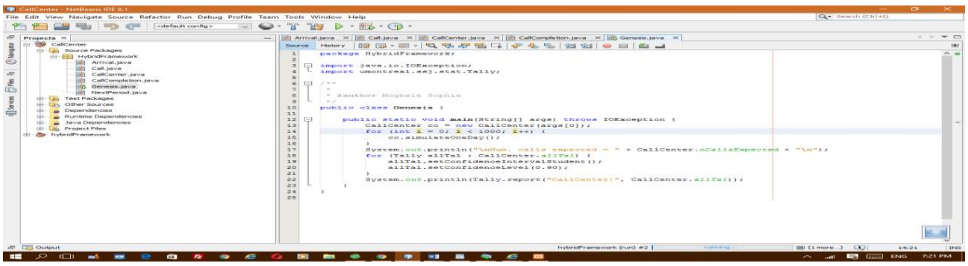

Figure 8: Hybrid Rule (HHCRR)

This is the interface for the implementation of the hybrid rule

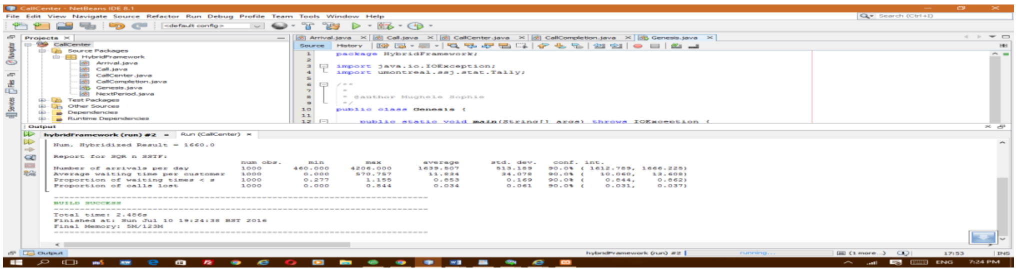

Figure 9: Result

This interface combines both the SSTF and SQR to determine the result of the hybrid rule

4.1 Results from Hybrid Simulation

The result obtained from simulation of the hybrid routing rule is displayed in Table 4.

Table 4: Simulation result for hybrid rule

RULE	CR	ASA (seconds)	Non CR	Resolved Calls	Call Backs	% resolved calls	% Call backs
HHCRR	2012	22	194	0.8821	0.0101	91.6238	1.07

Table 4, shows simulation result for the hybrid rule, with value for CR as 1839 and 22 seconds for ASA, the hybrid rule performed optimally than each of the individual routing rules whose result is displayed in tables 2 and 3

Table 5: shows the percentages for CR rate and call backs for the hybrid rule and result indicates that the hybrid has a higher enhanced performance rate.

Table 5: percentage of CR and Call Backs for Hybrid Rule

RULE	CR (%)	Call Backs Rates (%)
HHCRR	91.95	1.07

Table 5, shows the percentage of the hybrid rule for CR and for call back rates, the percentage for call back is 1.07% indicating that the Call Resolution rate of the hybrid rule is efficient with a CR rates of 91.95%.

Table 6: Comparing HHCRR, SSTF and SQR Rules

RULE	CR	ASA (seconds)	Non CR	Resolved Calls	Call Backs	% resolved calls	% Call backs
HHCRR	2012	22	194	0.6821	0.0102	89.6238	2.07
SSTF	1935	28	65	0.5375	0.0181	89.5833	3.0093
SQR	1795	34	205	0.4986	0.0569	83.1019	9.4907

Table 6 is used to compare the result for hybrid and the optimal for wait-time and CR rates routing rules, the result from the table clearly shows that the hybrid rule performs better than SSTF and SQR rules, which are both optimal routing rules for wait-time and Call Resolution rates respectively.

Figure 10: shows the graph for the simulation result for hybrid rule (HHCRR) for CR rate and ASA. The value from the simulation result of the hybrid rule (HHCRR) has a high CR of 2012 rate and an ASA of 22 seconds.

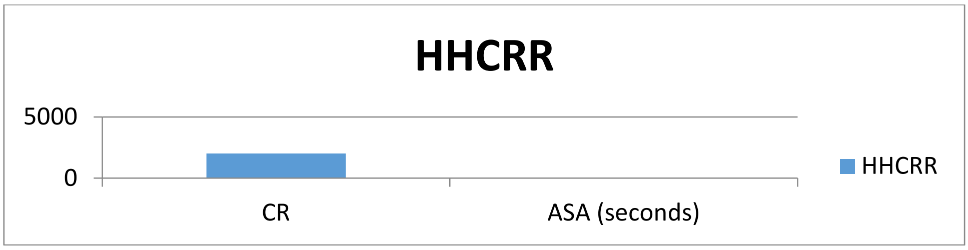

Figure 10: Simulation Result for HHCRR

Figure 11: shows a comparative graph between HHCRR, SSTF and SQR for CR rate and ASA. From the result HHCRR performed better than SSTF and SQR for both CR rate and ASA.

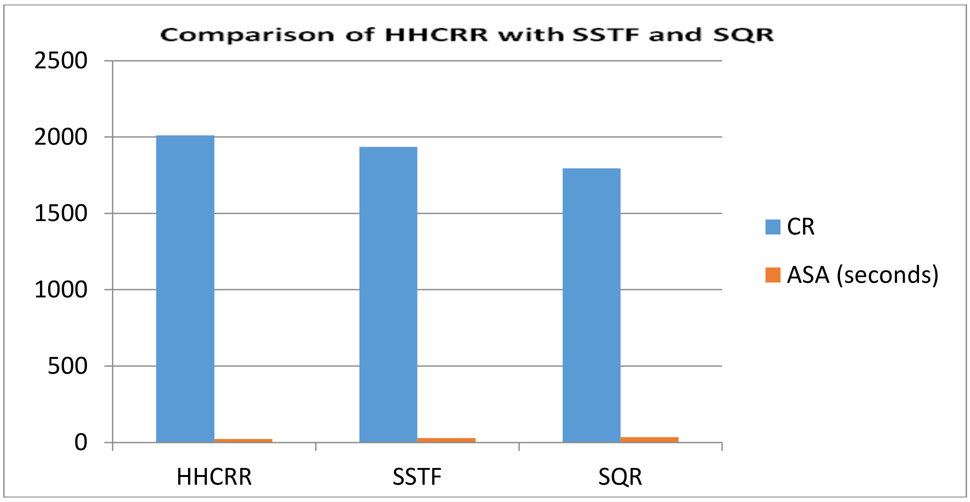

Figure 11: Comparison of HHCRR, SSTF and SQR

Figure 11, shows the comparison of the hybrid rule and SSTF and SQR for Call Resolution (CR) rates and Average Speed of Answer (ASA). Result from figure 11, for HHCRR for CR is 2012 and ASA is 22 seconds, SSTF for CR 1935 and 28 seconds for ASA, SQR for CR 1795 and 34 seconds for ASA. This result also depicts that HHCRR performed optimally than SSTF and SQR.

5. Conclusions and Future Work

5.1 Conclusion

The hybrid rule was simulated and the result was compared with that of SSTF and SQR, tables 3, 4, and 5 and figures 10 and 11 depicts that the hybrid rule performs optimally than other existing models tested in [14]; [16]; [15] . Therefore the hybrid rule HHCRR is now implemented using simulation and recommended for call center operators.

5.2 Suggestions for future study

Due to limited time and restricted access to data, further study can be conducted in the following areas

1) Arrival rates have been taken as inputs to the proposed framework as time-independent inputs, though in practice all call centers experience different arrival rates at different times of the day, therefore, study done to determine the distribution of delay times prior to callbacks, this can have a significant impact on operational performance.
2) The proposed hybrid routing rule Hybrid Heterogeneous Call Routing Rule (HHCRR) can be implemented with live data to develop a call center which will improve call centre operational performance

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