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Heterogeneous Hybrid Routing Rule for Call Centre Management using Multi-Agent Approach

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Abstract: This paper proposes a robust heterogeneous hybrid routing rule for minimizing call waiting times and maximizing call resolutions for effective call center management and performance using multi-agent approach. The outcome of this study will allay the worries of customers spending more time on call queues and also having call issues promptly resolved. It tends to improve operational performance in call center, increase customer satisfaction and brand loyalty by optimally improving two call performance indicators- low Average Speed to Answer (ASA) and high Call Resolution (CR) rate

Keywords: Call Centre, Call resolution, wait- time, Agent, Call Routing;

1. Introduction

Globally, businesses provide information and assistances to both existing and prospective customers through active Customer Relationship Management (CRM) systems [14]. The proliferations of innovative Information and Communication Technology (ICT) products have drastically reduced the cost of service delivery across telecommunication networks and have consolidated effective information functions leading to the emergence of specialised personnels actively engaged in handling customer's requests or calls on queues. Business owner may require a third party call service provider (out-sourcing) to maintain their call centre or employ skilled personnel (in-source) to manned their information function in-house. Be it outsourcing or in-sourcing, customers usually experience long queues at call centres before they can access the products and services they desire and that may cause some dissatisfaction that affect the trust and loyalty of customers on call centre. It may be as a result of the call routing rules adapted by the call centre, call centre receiving calls in different languages, call centre infrastructures and call centre agents experiences.

Call centre agents are trained with various skills to handle multiple entry calls to a call centre but operate with different performance level for calls in terms of Average handling time (AHT) and call resolution rate (CR) [29]. Wait-time reduction is accomplished by reducing the time spent on route calls to agents who can deal with customer problems more efficiently and who can easily address calls[2, 28]. This could further increase congestion, repeat calls from unreceptive issues and put unnecessary burdens on certain agents. The failure of an agent to address a call leads to recall and frustration of the customer.
Key performance indicators (KPIs) are essential to the effective management of call centers. KPIs are classified into product-related and process-related metrics. Product-related metrics includes; FCR First Call Resolution, Turnover, Performance and Punctuality and Customer Satisfaction. Process-related metrics are Probability of Blocking, Probability of Abandonment, Short Abandonment, Service Level, Average Speed of Response, (ASR), Longest Wait in Queue, and Agent Occupancy. [13].

In this work, a multi-agent approach for the path of various forms of calls to a wide number of call center agents was investigated. The remaining part of this work is as follows: In section two, an account of relevant literatures on call resolution management is given. System modelling and conceptual design of the proposed hybrid architecture are discussed in section three. Section four outline the evaluation and model performance measurement while section five gives the conclusion and further direction for future work.

2. Review of Related Literature

When a customer's problem is resolved the first time a call is initiated to the call centre, this is regarded as First Call Resolution (FCR). According to [23, 24], FCR rates drive customer satisfaction. [8, 5], Emphasizes that FCR is not a major determinant of customer satisfaction, but recognizes that the FCR metric for customer satisfaction is a poor indicator. [6] high-lights the value of FCR as a main performance metric, but he cautioned against using FCR as the only performance measure. In [3], consumers in a call center face real-time delays due to queue and call back delays. The probabilistic option model was applied and the dynamics of the system was modeled as a multiclass M / M / N system. The study explains that, as the number of agents increases, the load of the network reaches its full processing power. The study did not consider the AHT in relation to customer decision, routing rules and system design.

In [12], conducted a qualitative study that explores the understanding of FCR through analysis of existing literature and interviews were conducted with Management of the South African Communication Center. They developed varying views on the importance and measurement of FCR and identified the key factors influencing FCR and the relationship between these factors. The study did not determine effective routing rule for FCR rate in these call centers. [30], examine the challenges on how to determine relevant control of routing i.e. A decision as to which agent will manage an arriving call when more than one agent is available. They constructed an inverted-V model environment and developed an optimization problem with the dual performance goal of reducing average customer waiting time and optimizing call resolution. It was noted that concentrating on reducing average waiting time as the primary goal of success may not deliver the best customer experience. It also failed to address how does agents make decisions that are relevant to the call center environment (trade off).

[26], emphasizes that in a service base call center, the two key Challenges are where the call will be routed and which agent will handle the call. They deployed case base First-In, First-Out (FIFO) approach for the simulation modelling and the result shows the potential for significant improvements in call center performance especially in terms of Average Speed to Answer (ASA), Using guidelines based on historical performance data such as Average Handling Time (AHT) and First Call Resolution (FCR) levels. The study did not consider call abandonment in call centres. [17], submit that the efficiency measure in call centers is AHT and call RP. Simulation tests were performed to analyze the relative efficiency of the routing rules. The study did not consider the effect of these rules on the rate of CR when different agent groups have different AHT and RP values for different call forms. [7] Notes that main performance metrics such as ASA, Cost per call, Agent utilization rate, FCR rate, customer satisfaction and aggregate call center performance do effectively measure call center performance. He employed Call Logic system to improve the fundamental call routing logic of the Northeast Utilities call centers and the findings lead to discoveries and ideas on how to improve the fundamental call routing logic.

[11], Display a deterministic queuing scheme with repetitive and impatient behaviour, predicting that pleased customers will return and dissatisfied customers will not. Based on the queuing model, staffing has been developed and evaluated to optimize profits. The consumer behavior model is more in line with market reality and protects Markovian assets. Wait-time regulations concentrate on reducing the estimated waiting time spent by the customer; the CR routing rules focus priority on CR rates [10, 1, 28]. For Shortest Queue Routing (SQR), A call of a particular type that arrives while several matching agents are free will be redirected to the matching group agent that has the highest relative effective service rate for that call type , i.e. the shortest queue for that call type.. Probability Resolution (PR) rate indicates that a call of a particular type that arrives when multiple agents are free will be routed to an agent from the group that has the highest resolution probability for that call type [18].

[19], argue that, the nature of service i.e. Resolution status is a key performance indicator (KPI) that measures the progress of a call center. A simulation test was performed to assess the performance of three call resolution (CR) routing rules, using data obtained from the call center of a telecommunications company in Nigeria. The result shows that shortest queue routing (SQR) with an improved call resolution rate and a very low call back rate performs optimally than other routing rules. [20] performed a study using a JAVA software set to simulate the current rules on wait-time routing, the software evaluated four rules, first come first serve / longest wait (FCFS / LW), Fastest call first (FCF), Shortest service time first (SSTF) and Highest service time firs (HSTF). Raw data were obtained from a Telecommunications call center in Nigeria. The authors recommended SSTF as the optimal routing rule based on the outcome of the result from the evaluation.

This study is based on the work of [20], in which they designed a hybrid framework for routing calls, the hybrid rule consisted of the optimal rule for wait-time [19], and the optimal rule for resolution rate [17].Their model evaluation was a MIN/MAX optimization and the study demonstrated that minimization of wait-time and maximization of call resolution rate can be achieved at the same time deploying a hybrid routing techniques.

3. Model Analysis and Design

Formally, the term "routing rule" is used to denote both the rationale that specifies which agent group to which an incoming call is allocated if there are no calls in queue and agents from multiple groups are safe. This is also the logic that decides which call the agent is assigned to handle when he / she is free when calls from more than one form are in the queue waiting for service. In reality, there is a need to establish a routing rule that will achieve both low waiting time and enhanced CR simultaneously. The absence of academic literature that covers both call resolutions and waiting time simultaneously was identified in [18]. As identified in simulation conducted by, [18, 22, 20] for the wait-time and CR routing rules, Shortest Service Time First (SSTF) was better fit for Wait-Time Routing Rules and SQR for Call Resolution Routing Rules. Both were hybridised in [20].The hybrid rule was modelled with routing protocols using mathematical formalisation. A conceptual framework was designed to illustrate how the hybrid rule will work when implemented. The framework was evaluated using logic flow diagram and Graph theory analysis [22]. The hybrid routing rule achieved low wait-time (minimize) and enhanced call resolution rate (maximise). Therefore, the model expresses a MINIMAX mathematical programming problem which is classified under Multiple Objective Programming (MOP) [25].

3.1Model Approach

Table 1 outlined Operationalisation of model variables while figure 1 and 2 depict the proposed Hybrid Heterogeneous Call Routing Rule (HHCRR) model and logic flow diagram respectively. Model formulas are expressed in equation 1-20, which depicts the various operations of call centre functions (table 2).

Table 1: Operationalization of process variables

The Variable	Variables description
$time\ periods\ t_i$	Time duration every day: 7 a.m. to 9 p.m. for all agents 15 hours a day.
Call type i	Multiple call categories such as I = 1 , 2 ... l where l is 8 in our design

Agent j	Multiple agent classes such as J = 1, 2 ... J. where J is 35 in the model
$C_{j,t}$	Cost of an agent of type j having/working in time t
p_i	Proportion of call category I from the total new arrival that goes to the specific call category I queue
$Q_i(t)$	Type number i call waiting for service at time t
$f_j(t)$	Number of available group j agents that are free at time t, where 0 ≤fj(t) ≤nj, for all j, t.
λ_i	arrive rate of calls of type i
λ_T	The total arrival rate
n_j	Number of agents in group j, such that n_j ε Z^+
X_{ij}	Number of calls type i directed to agent group j
$X_{ij,t}$	Number of calls type i directed to agent group j at time t
$y_{ij,t}$	Number of agents in agent group j that handles call type i at time t
μ_{ij}	Agent group I service rate for type I call
μ_z	Agent Group j service rate for Type i call
β_i	arrival of unresolved calls of call type i who call back
β_{ij}	Maximum arrival rate of agent category j for call type I calling back.
θ_{ij}	probability resolution rate of agent group j of call type i
ρ_j	Maximum use of agent group j
$\Gamma_{i-}\Gamma_{i+}$	the lower and upper bound such that each call type i must be served at total utilization between bounds
ρ	proportion of time each server is busy
AHT	is average handling time
AHT_j	is the mean call handling time of all agents in group j,
$\lambda_{i\prime j}$	Is the rate of arrival excluding the call type I (Sisselman and Whitt, 2007)

Table 2: Model formulas, adopted from [21].

Description	Formula	Eq no.
Proportion of call of type i (p_i)	$p_i = \frac{Total\ Calls\ of\ type\ i}{total\ Calls\ \ in\ queue}$	1
Maximum rate of arrival of call type i ($\boldsymbol{\lambda_T}$)	$\lambda_T = t_1\lambda_i + t_2\lambda_2, + \cdots + t_i\lambda_i = \sum_1^i t_i\lambda_i$	2
Maximum rate of arrival of call type i in group j category	$\boldsymbol{\lambda_{ij}} = x_{ij}\lambda_i$	3
Effective arrival of unanswered call type I phones that call back ($\boldsymbol{\beta_i}$) (Sisselman and Whitt, 2007)	$\beta_i = \frac{\lambda_i}{1 - \sum_j(1-\theta_{ij})X_{ij}}$	4
Service rate of agent group (μ_{ij}) is the reciprocal of the (AHT) of all the agent (Gans, et al., 2010)	$\mu_{ij} = \frac{1}{AHT_j}$	5
Complete arrival rate of agent category j for call type I calling back	$\beta_{ij} = \frac{\beta_i X_{ij}}{n_j}$	6
Maximal service rate of Agent group j is	$\rho_j = \frac{\left(\sum_i \frac{\beta_i X_{ij}}{\mu_{ij}}\right)}{n_j}$	7
The total fraction of time spent serving queue I (TF_i)	$TF_{i=} \frac{\frac{\lambda_{ij}}{u_{ij}}}{\sum_{i=1} \frac{\lambda_{i\prime j}}{u_{i\prime j}}}$	8
Maximum call type service rate I	$(\mu_z) = \sum_{i=1}^{j} n_j u_{ij}(TF_i)$	9
Total utilization boundaries for call type i (Mehrotra and Fama, 2003)	$\Gamma_i = \frac{\beta_i}{\mu_z}$	10
Costs function:	$\mathrm{c} = \left(\mathrm{c}_{1,1}, \ldots, \mathrm{c}_{1,j}, \ldots, \mathrm{c}_{i,1}, \ldots, \mathrm{c}_{i,j}\right)^{\mathrm{t}}$	11
Decision variables	$x = \left(\mathrm{x}_{1,1}, \ldots, \mathrm{x}_{1,j}, \ldots, \mathrm{x}_{i,1}, \ldots, \mathrm{x}_{i,j}\right)$	12
Auxiliary variables	$y = \left(\mathrm{y}_{1,1}, \ldots, \mathrm{y}_{1,j}, \ldots, \mathrm{y}_{i,1}, \ldots, \mathrm{y}_{i,j}\right)$	13
x-y Matrix	Ax = y	14
no of call type i directed to an agent in group j,	$\beta = E(i,j)$	15

total call type i directed to agent group j	$\alpha = \sum_{1}^{j}\sum_{1}^{i} E(i,j)$	16
Service level (SL) or fraction of call type i answered by agent in group j is computed $g_{i,j}(y)$	$g_{i,j}(y) = \frac{\beta}{\alpha}$	17
Aggregate SL for call type i per day	$g_i(y) = \sum_{k=1}^{i} SL_k$	18
Aggregate SL for agent group j per day	$g_j(y) = \sum_{m=1}^{j} SL_m$	19
Aggregate SL for both call type i and agent group j per day	$g(y) = g_i(y) + g_j(y)$	20

3.2 Proposed framework for the hybrid routing rule

The framework in Figure 1 is the overall system approach which depicts how call Center agents are responsible for responding to customer problems. Due to the number of phone calls, the majority of call centers hire multiple agents to deal with customer problems. Calls are initiated by the customer as they call the call centre. The different call types enter into queue through Private Automatic Branch eXchange (PABX) as denoted as $Q_1 1 - Q_i Z$, when all available agents are busy. Each call type enters into the system as call arrival which is denoted by $\lambda_1, \lambda_2, \ldots \lambda_i$ (arrival rate). The feature extraction retrieves vital attributes [4] from calls on queues. The different call types are sent into the hybrid rule module, where the MIN-waiting oriented attributes and MAX-resolution oriented attributes are integrated and analysed. The MINMAX decision support system retrieves information of the AHT and RP rate from the agent group Case Base Reasoning (CBR) System. This information enables the system to make cognitive and optimal decision to assign task to the agent in the agent group with the relative shortest service time (which is the lowest AHT) as well the shortest queue (highest CR) for that particular call type. Unresolved calls return back to the queue as call back. The framework also handles properly the issue of call abandonment. With all the variables put in place in the proposed framework, the system minimizes waiting time on the queue and maximise CR rates. The framework also depicts that all customer calls must enter the call network queue through dedicated customers call centre lines which are classified according to the call type. These calls queues are influenced by the queue length, the waiting time and services time and in turn affect customers' preferences and satisfactions. Long wait and low service leads to call balking, blocking and reneging. The calls arrival follows some stochastic process and arrival rate (λ) of the call types changes with time and are also stochastic. Incorporating a decision support system will help influence and moderate the system operations towards reducing call abandonment/reneging, blocking and balking.

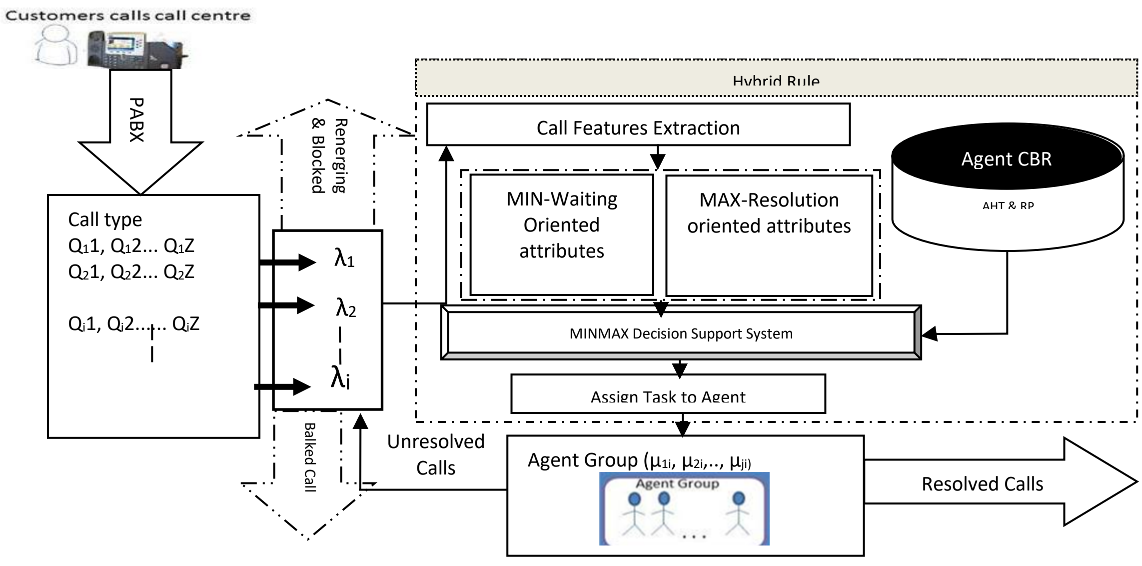


Figure 1: Conceptual Framework of the proposed model

3.3 Implementing the optimized proposed model

A proportion of call type i, maximum arrival rate of call type i in agent group j and effective arrival of call backs are determined using equation 1, 2, 3 & 6. Each agent is capable of answering a subset of all the call categories so as to reduce wait time and reduce call abandonment [28]. Having several agents in groups can increase the system overall cost and in most cases can increase agent idleness. Here, knowledge features-AHT, RP rate of agent group, Average Call Abandonments (ACA), Average no of absenteeism of agent, Occupation Ratio (OR) of agents per call are key indicators kept in agent group CBR for easy retrieval. As calls arrive, features or attributes of the calls are extracted based on the Service Level (SL) of agent group designated to resolve the specific call type. The SL is determined by the cost of agent in group j, number of call types routed to an agent in a group and number of agents in that group capable of handling the call type. The services rate (μ) may be exponential but lognormal will fits well. It is determined via iterative steady state approximations of SL. These attributes are used to compute the μ of individual agent and agent groups as shown in equation 5.

The utilization of the system in term of the μ and waiting time of agent group and number of call type is determined using equation 7. The condition for stability is Maximal service rate(ρ_j) < 1, which is to say that the mean total arrival rate must be less than the mean of ρ_j model also tries to address call types mishandling By restricting the usage associated with every call form i. It ensures that each call type I must be represented within the overall usage limit. To evaluate this limit, utilize connection with call type I is first determined which require calculating the effective service attention given to calls of type i from all agent groups. The total fraction of time spent serving queue i (TF_i) and the total service rate of call type i is given in equations 8 and 9 respectively. The total effective utilisation associated with call type i is calculated using equation 10. The hybrid model intuitively merge the maximisation problem of [18] with the minimisation of [15] and the MIN/MAX optimisation framework of [20] to form a Multiple Objective Optimization (MOP) model to determine optimal feasible solution that minimise waiting time and maximise call resolution. As earlier stated, every agent in a group has a unique cost function expressed as c (equation 11), where $c_{i,j}$ = cost of an agent of group j handling call type i. Decision variables is expressed by x (equation 12) where $x_{i,j}$ = number of call type i directed to an agent j. Auxiliary variables is expressed by y (equation 13) where $y_{i,j}$ = number of agents of call type i in agent group j. In matrix form such that vector y satisfies is given in (equation 14) where A is a diagonal block with i blocks, A' (transpose of A), and element (i, j) of A' is 1 if agent in group j can handle call type i, 0 otherwise [15]. The Service level (SL) or fraction of call type i answered by agent in group j is computed using equation (19).

Similarly, the aggregate SL over call type i is the expected total number of calls of type i answered within by group j over the day divided by the expected total number of calls of type i received over the day. Hence, Aggregated SL for call type i, $g_i(y)$ (equation 18), Aggregated SL for agent group j, $g_j(y)$ (equation 19) and Aggregated SL for both call type i and agent group j, g(y) (equation 20)

Therefore, the objective function is formulated thus:

$$\text{Max } Z = \sum_{ij} \beta_i \theta_{ij} x_{ij} \text{ Min } C'X = \sum_{j=1}^{J} \sum_{i=1}^{I} c_{i,j} x_{ij}$$

Subject to:

$$Ax = y$$

$g_{i.j}(y) \geq Min\left(SL_{i,j}\right)$ $\forall i,j$ }Service level of call type i in agent group j

$g_i(y) >= Min\ (SL_i)$ ∀j }Service level of call type i estimated by Erlang C

$g_j(y) >= Min\ (SL_j)$ ∀j }Service level of agent group j estimated by Erlang C

$g(y) >= Min(SL)$ }Overall Service Level of system estimated by ErlangC

$0 \leq x_{ij} \leq 1$ $\forall i,j$ }bound fFraction of calls bound

$\sum_j x_{ij} = 1$ ∀i }Total calls routed to different agent group j

$\rho_{j-} \leq \rho_{j_i} \leq \rho_{j+}$ $\forall j$ } Usage of each agent category

$\Gamma_{i-} \leq \Gamma_i \leq \Gamma_{i_+}$ $\forall i$ }Utilization boundaries of each call type

$c_{i,j}, x_{ij}, \theta_{ij}, x_{ij}, \Gamma_{i-}, \Gamma_{i_+} \geq 0$ *and Integer non negativity constraint*

The utilisation constraints Γ_{i-}, Γ_{i_+} give the call centre freedom to moderate calls during service period, the objective function Max Z help resolve problems maximizing CR. Similarly, Min $C'X$ will help moderate the influence of cost, abandonment and excessive queue length on staff performance and systems overall efficiency. It is on this premise that calls are routed to agents who handles call type I with the highest call resolution, the lowest call waiting period and optimal performance effectively.

3.5 Model logic flow diagram

The logic flow diagram in figure 2 represents the evaluation and feasibility of the hybrid rule. It is observed that the calls come into call queue in random fashion. Features from the call type are extracted based on some predefined logic. These features are used to compute steady state parameters using either Erlang A or B models. These parameters will be combined to form a Multiple Objective Programming (MOP) problem and could be solved using breath-first techniques, greedy algorithm and genetic algorithm. If max Z and min $c^t x$ are achieve, then adopt and use results to route call to agent in group capable of handling such call. If the agent is busy, then route the call to the next most performing agent in that group. If the call types are prioritised, route calls to the most significant optimal solution exactly or close to the agent group with the highest service rate and minimum queue length. If the call is not resolve, the call is re-queued and solved further.

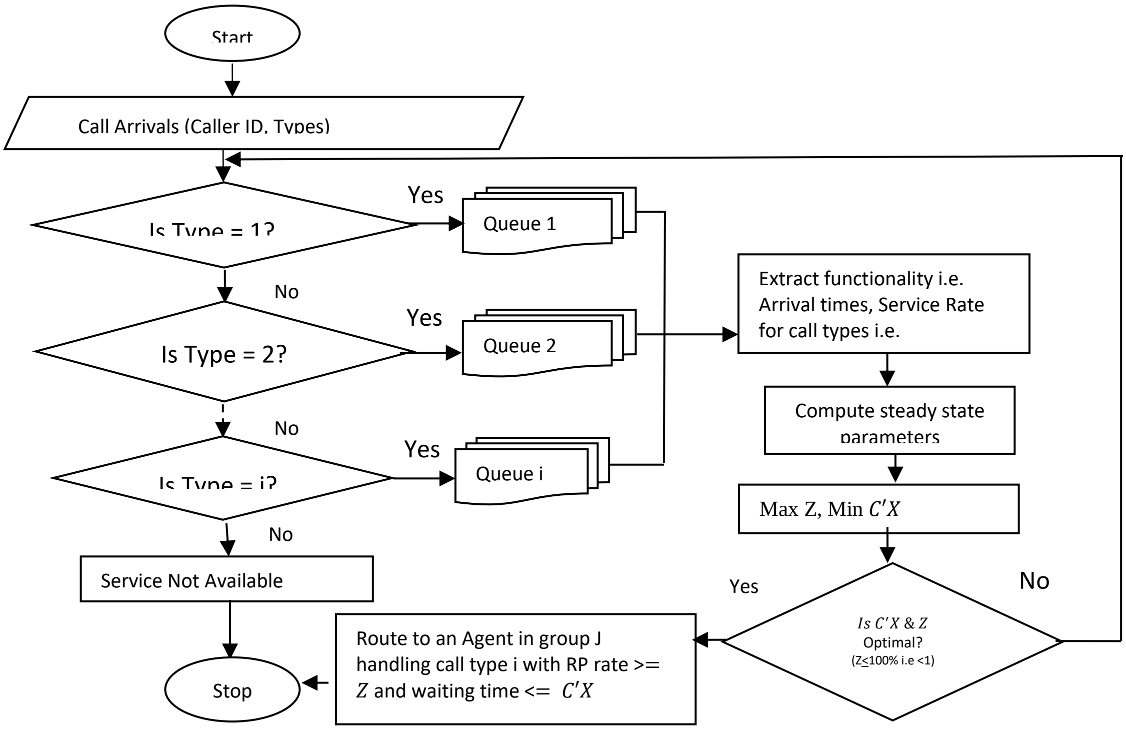


Figure 2: Logic diagram of proposed framework

3.6 Graph Theory Analysis of Model Formulation

A graph theory representation of the optimal hybrid model is stated as follows $(G) = X \cup Y$

Where $X = \{x_1, x_2, \ldots, x_i\}$. is the set of call types

$Y = \{y_1, y_2, \ldots, y_j\}$ is the set of available agents handling various call types and an edge joins call type x_i to agent y_i if and only if call type x_i can be handled or resolved by Agent y_i. The problem is to determine whether G has a matching which saturate agent Ys. Figure 3 shows the graph diagram and it adjacency matrix is shown in Table 3

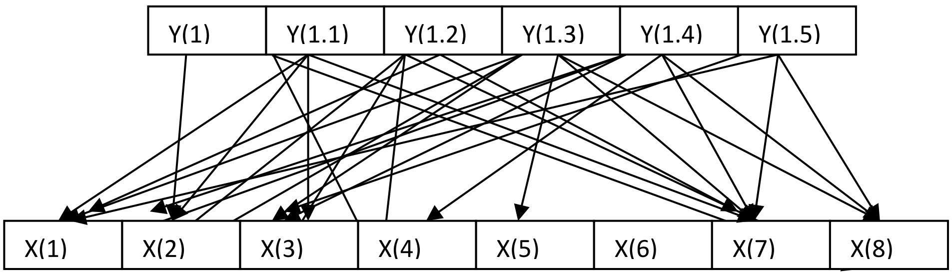


Figure 3: Graph diagram showing interactions between agent groups, adapted from [21]. **$Y_{1, 1.1, 1.2,.., 1.5}$ and the various call types $X_{1,2,..,8}$**

Table 3: Adjacency matrix Agent 1s and the various call types Xs

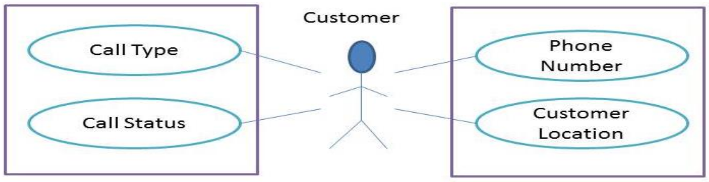
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y_1	0	1	0	0	0	0	0	0
$Y_{1.1}$	1	1	1	1	0	0	1	1
$Y_{1.2}$	1	1	1	1	0	1	0	0
$Y_{1.3}$	0	0	1	0	1	1	1	1
$Y_{1.4}$	1	1	1	1	0	0	1	1
$Y_{1.5}$	1	0	0	0	0	0	1	1

Note: 1 represent an edge or arc between Xs and the Ys while 0 indicates no link or arc.

The matrix in Table 3 can be solved as an assignment problem using mathematical programming technique (Linear and dynamic programming) or Breath-First Algorithm to determine the optimal solution. Hence, the flow diagram and the Graph theory analysis of model formulation represent the evaluation and feasibility of the hybrid framework [22].

3.7 Software Design and Implementation Tools

Several tools were deployed for the design process. The Unified Modelling Language (UML) was deployed to show relevant interaction among key stakeholders in a call centres. The use case and entity relationship diagram was used. While Use case diagram (figure 4) creates an abstract model of the call centre system describing its major actors, Entity Relationship (E-R) diagram (figure 5) was used to describe the relationship among entity in the system. The implementation of the hybrid model was done using Microsoft Excel solver and results were graphically



Client actor and features

Centre call Agent actor and features

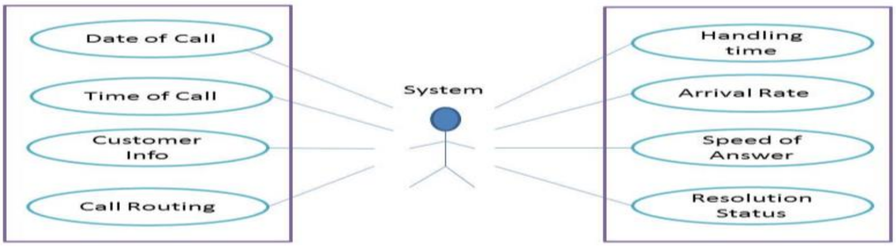


Figure 5: Entity relationship diagram

3.8 Method of data collection

The main data used to conduct this study was collected from automated data logging system of Telecommunication organisation in Nigeria. The data collected from the database were limited to eight categories of call centre agents including (1). 121 call Agents, (2).General call Agents, (3). Pidgin calls Agents, (4). Igbo call Agents, (5). Hausa call Agents, (6).Premium call Agents, (7). Yoruba call Agents and (8).Sim registration call Agents.

The various categories of calls that are routed to these agents are either resolved or unresolved. These categories include: 3G, Blank calls, Language calls, PREMIUM, Organisational calls, Prepaid Broad Access, Post-paid Blackberry, Post-paid, Broad Access, Prepaid, Prepaid Blackberry, SIMREG and Top up.

Table 4: Summary of Data collected

Service Type	Calls Offered	Calls Answered	Calls Abandoned	Calls Abandoned in Queue	Calls Abandoned in Ringing
3G HSI	672	557	115	83	32
Blank calls	6601	2234	4367	4339	28
Conoil	3	2	1	0	1
Glo1	1	1	0	0	0
HNI	443	392	51	40	10
JustDialNew	39	31	8	8	0
NBC	32	24	8	8	0
Others	38	38	0	0	0
PREMIUM	1552	1330	222	196	26
Pepaid BroadAccess	6	3	3	3	0
Postpaid Blackberry	75	55	20	19	1
Postpaid BroadAccess	8	5	3	3	0
Postpaid_new	857	743	114	101	13
Prepaid	134830	30794	104036	103856	177
Prepaid Blackberry	3455	2634	821	780	41
SIMREG	19663	9563	10100	10019	80
Shell	5	4	1	1	0
Topup	2	2	0	0	0
Total	168282	48412	119870	119456	409

Table 4 is extracted from the call centre database of a major telecommunication outfit in Nigeria. The table gives the service type, indicating the total number of calls offered, calls answered, calls abandoned, calls abandoned in queue and call abandoned in ringing. This data is a summary report for the period of six months.

4. Results and discussion

A collection of Java event driven simulation was used to run the program used to simulate between the hybrid rule

(HHCRR), SSTF and SQR. Figure 6 shows the simulation interface to determine the performance of the hybrid rule. The interface for the implementation of the hybrid rule shows the platform from where the results for this study were obtained.

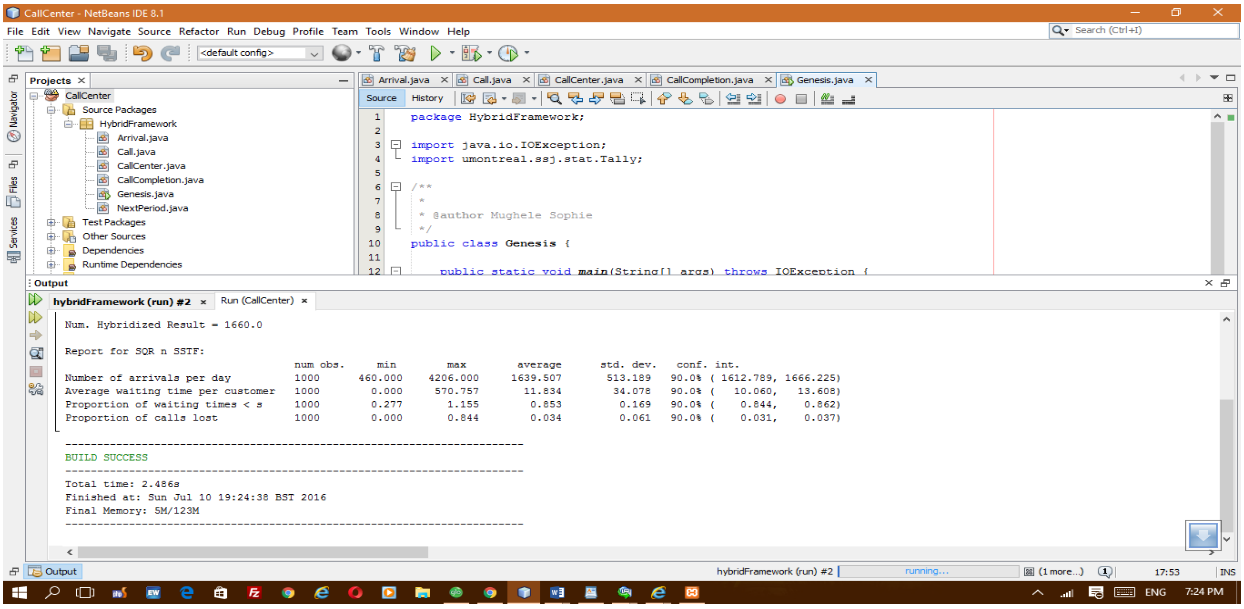


Figure 6: Simulation Interface for Hybrid Rule

The result of the simulation of the hybrid routing rule and optimal rules from [17], is displayed in Table 5.

Table 5: KPI Results of proposed model (HHCRR), SSTF and SQR Rules

RULE	CR	ASA (seconds)	Non CR	Resolved Calls	Call Backs	% resolved calls	% Call backs
HHCRR (proposed Model)	2012	22	194	0.68	0.01	89.62	2.07
SSTF [17]	1935	28	65	0.54	0.02	89.58	3.01
SQR [16]	1795	34	205	0.50	0.06	83.10	9.49

Table 5 shows result for the three rules, obtained from a collection of Java simulation libraries program (event driven). The hybrid rule CR was 2012 and ASA was 22 seconds performing optimally than each of the individual SSTF (1935 For CR and ASA 28 seconds, and SQR (CR 1795 and ASA 34 seconds). And, also the hybridised model demonstrated significantly with respect to higher percentage of resolved calls (89.62%) and lower percentage of call backs (2.07%) compared to 89.58% of resolved calls and 3.01% of call backs for SSTF rules and 83.10% of resolved calls and 9.49% of call backs for SQR rule.

5. Conclusion

In this research, combining SSTF, an optimal routing rule for wait-time and SQR, an optimal routing rule for CR routing rules brings about a novel approach for resolve call centre core issues. Given the model framework for the hybrid routing rule, a fundamental principle was establish that improve operational performance of call centres output dimensions which are low wait-time and high CR. The proposed hybrid routing rule performed significantly well compared to using separate optimal rules. Therefore, a hybrid routing rule can help bring about solving salient issues that call centre managers and general business owners are facing.

Direction for future studies

This study can further be expanded to (1) consider environments with multiple call types when there are clear issues about which agents to train to handle call types when both customer waiting times and call resolution rates are considered. (2) Arrival rates taken as inputs to the proposed framework as time-independent inputs can be included, though in practice all call centres experience different arrival rates at different times of the day and (3) develop, test and implement a web base HHCRR to improve call centre operational performance. (4) Studies can consider the computational complexity of the proposed routing protocol HHCRR

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