Analysis of the
Avis Car Rental South Africa Call Centre

by

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Executive Summary

The Avis Call Centre is the first tier interaction with many customers. The contact centre must be able to satisfy any customer reservations, queries and support. The different activities at the call centre and the advancements in the call centre environment all conspire to increase the complexity of the call centre.

Managing the intricate process in the call centres requires special techniques and methodologies. Analytical models may be sufficient in analysing smaller call centres, but is not capable in higher complexity call centres. Skill-based routing and workforce management are some of the challenges that the Avis call centre must address in order to stay ahead of the competition and increase productivity.

Simulation modelling is introduced as a possible replacement to the analytical models. Literature indicates that simulation modelling is ideal for complex call centres. Different simulation software packages are available on the market, but the Arena® software was chosen for the Avis Call Centre project.

The conceptual design of the simulation model regards the design considerations in a simulation study. These include the input and output parameters as well ad the decision rules. The data is acquired in line with the conceptual design, the data is then analysed before model construction starts.

The constructed model proves valid and is verified to determine if the model represents the real call centre deliverables. The various activity areas of the call centre is constructed and the set of scenarios is tested. The results obtained through the scenario development indicate that the simulation model is a true representation of the Avis call centre system. The input parameters influenced the output statistics as predicted.

Management can definitely benefit from the model across all levels of decision-making. The project aim is to test the call centre to external influences and the constructed Arena® model delivers real-world outputs to support decision-making.

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TO MY FAMILY - FOR THEIR UNCONDITIONAL LOVE AND SUPPORT

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AVIS

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Glossary

AST	Application Solution Template
ACD	Automatic Call Distributor
AHT	Average Handling Time
ANI	Automatic Number Identification
ASA	Average Speed of Answer
BPO&O	Business Process Outsourcing and Offshoring
CC	Contact or Call Centre
CSI	Customer Satisfaction Index
CTI	Computer-Telephone Integration
DNIS	Dialled Number Identification Service
DTMF	Dual Tone Multi Frequency
FIFO	First In First Out
FTR	First Time Resolution
ICMI	Incoming Call Management Institute
IVR	Interactive Voice Response
KPI	Key Performance Indicators
LP	Linear Programming
NCO	Number of Calls Offered
PABX	Public Automatic Branch Exchange
PC	Personal Computer
PSTN	Public Switched Telephone Network
SBR	Skills-Based Routing
VBA	Visual Basic® for Applications
WFM	Workforce Management

1 Introduction

1.1 Project Aim

The Avis Contact Centre is a dynamic network of activities and processes that are not easy to manage and control. Management aspire to generate better service levels and staff requirements without major economic expenditure. The decision-making process is manipulated by many varying inputs and external factors.

The aim of this project is to assist management in improving the avis Call Centre performance and decision-making for short, medium and long-term improvements. The level of decision-making falls into four categories (Koole 2007:8).

1. Strategic Decisions

   These decisions are made by upper management concerning the type of services delivered, budget requirements and generally impose the framework for call centre management.

2. Tactical Decisions

   Call centre managers typically decide resource allocation. The resources consist of the budget, the existing technology and the skill level of the current workforce. Decisions about agent skill level requirements and organisational scheduling are taken at this level, as well as hiring and training of agents.

3. Operational/Planning Decisions

   At the operational level, the time horizon in which the decision makes an impact is still distinct, ranging from weeks to seconds. The call centre supervisors make decisions relating to the weekly agent schedules, this is called workforce management (WFM).

4. Daily Control

   Daily decision-making requires quick action. The supervisors monitor the service levels, the call volume and the productivity and can react to that.

External factors that influence the internal operation of the call centre oblige concrete business decisions made by management. A balance between operating costs, service

quality and employee satisfaction is a continuous decision-making process (Mehrotra 2003:136).
Operating the call centre within the high quality standards particular to Avis requires constant assessment of the current system state and the sensitivity of the operations to both internal and external factors.

The report is an analysis of the decision-making parameters of a call centre. These parameters include:

- Resource allocation and capital investment
- Service characteristics such as (but not only) the queue length, waiting time in queue, time spent in the system by a customer, service time, status of completed call, the expected number of customers in service at any given point in time.
- Staff scheduling
- Meeting service levels consistently and decrease the abandonment rate
- Higher quality and efficiency
- Managing a wide range of contact channels
- Enhancing the organisation's sensitivity to the call centre market environment factors that influence it and respond to these factors more effectively

Operations management tools such as analytical models and simulation models are investigated, and according to the facts and findings, a model is developed for the Avis call centre. The aim is to evaluate the response and sensitivity of the call centre to internal and external pressures.

1.2 Project Scope

All operations pertaining to the call centre of Avis Car Rental South Africa is included in the project. The scope of the project consists of the three business divisions namely:

1. Rent-a-Car
2. Chauffeur drive and Luxury cars
3. Point-to-Point

The three divisions of the call centre (CC) each have the following internal determents:

- Historical trends
- Number of staff members

- Daily shifts of operators
- Resource capabilities
- Trunk requirements
- Expansion in business operations at Avis Car Rental

The external determents included in the scope for each business division:

- Growth in customer demand
- Technological advancement of resources
- Seasonality in demand on a monthly basis
- The daily variation in call volumes
- Public holidays and weekends within a month
- Inflation rates and the high cost of petroleum

Process examination and understanding entails statistical analysis of the basic components in the cc and the effect of the external determents on the performance levels:

- Arrivals
- Customer abandonment behaviour
- Service duration

The operation analysis of the call centre is a queuing-science perspective. Skill-Based Routing (SBR) is another important concept that is covered in this report. Matching the customer need to a specific agent is the basis of SBR.

2 Project Environment Analysis

2.1 Introduction to the Call Centre Environment

The Incoming Call Management Institute (ICMI 2007) defines a call centre as "A coordinated system of people, processes, technologies and strategies that provide access to organisational resources through appropriate channels of communication to enable interactions that create value for the customer and organisation."
Organisations globally, are increasingly experiencing the immense strategic and economic importance that contact centres play in their business. These centres are the primary customer interface and increasingly the focal point of interaction, where customer relationships are obtained, retained and grown. Some organisations rely almost completely on the call centres for customer interaction. Therefore, the success of the organisation greatly depends on the careful design and management of the call centre.

Call centres were established in the early 1970s where the customer required a standard service at a standard price. The process was based on uniform customer demand and a simple First In First Out (FIFO) call management queuing method (Faulin et al. 2007). The depiction of recent call centres is much more complex and dynamic. The call characteristics, such as customer preferences and history are unique to every caller. The customer satisfaction is depended on these unique qualities, and the call centre's ability to meet these specific customer requirements.

Customer satisfaction is the driving force behind a potentially extraordinary contact centre, generating efficiency and high service quality. The service level provided to the customer defines the customer satisfaction levels. The key concept behind good service levels consists of many features, such as waiting time of the customer. Some of these features are not always easy to quantify, i.e. agent friendliness. Yet other features may be easier to measure. The Avis call centre is committed to a service level that answers 90% of all inquiries correctly during the first call and that 80% of the calls are answered within 20 seconds waiting with no more than 3% of the calls abandoned before reaching an agent.

The growing complexity of call centres can also result in the widening of the gap between achieved levels of performance to those required by management. Recent trends in technology, especially skilled-based routing (SBR) and Workforce Management (WFM), can increase the challenge of successfully managing a call centre. The extensive growth of the Internet and a myriad of demanding customer expectations also complicate matters (Bapat & Pruitte 1998:1396).

The way that companies manage their CC has undergone a dramatic paradigm shift. It is only recently that contact centres are seen as potential profit-generating entities and separate business divisions, with the ability to create significant revenue for their stakeholders. Nathan Stearns (2008) states that, the pressure to improve revenue and profitability while maintaining customer and employee satisfaction persists.

2.1.1 Current Trends in the Industry

The transformation in the CC environment from a static one-dimensional operating facility to a dynamic multi-channel enterprise is occurring at an alarming rate. According to Dimension Data in their annual benchmarking report (2006), the key trend in contact centre strategies includes customer satisfaction, quality/process improvements and technology strategy.

The rate of change in the technology field is extremely fast, with the self-service and the use of natural speech technology phasing out the touch-tone and dual tone multi frequency (DTMF) tools. The changing multi-channel requirements of customers, such as e-mail and IVR (Interactive Voice Response) are current technology issues that a CC needs to address. The Dimension Data Benchmarking Report indicates that VoIP (Voice over Internet Protocol) is also making geographic history and that a global telephony revolution is at our doorstep.

The Dimension Data report defines the three most important commercial drivers for current contact centres, which are to improve service, increase efficiency and to reduce costs. These business drivers affect many call centre characteristics such as the volume, pattern and length of contacts. All of these factors influence the development of the call centre (Dimension Data Benchmarking Report 2006).

It is interesting to note that despite the mentioned industry changes that are occurring, the alterations in the key metrics used to gauge performance is relatively low. Performance ratings on customer satisfaction, such as resolution rates and response time have not changed, but the trend indicates that more CC enforce these ratings and use the output metrics for statistical analysis of the CC. Offshoring and outsourcing are also on the rise and these trends are not temporary (Granered 2005:18).

2.1.2 South Africa as outsourcing destination of choice

Outsourcing a contact centre is often the most economically viable option, and the Philippines, India and South Africa are currently the destinations of choice. Rod Jones of Strategic Solutions (2008) declares "South Africa – Now the world's new first choice for outsourced Call Centre and BPO (Business Process Outsourcing) operations."

"Following the sun" is a popular phrase that refers to the ability to utilise support services around the world, twenty-four hour a day, seven days a week. Taking customer language, customer base and economics into account, South Africa is in the geographical time zone that benefits from the English speaking customer service (Granered 2005:136).

The South African government has identified the Business Process Outsourcing and Off-shoring (BPO&O) sector as one of the top three priority sectors to stimulate growth within its Accelerated Shared Growth Initiative (ASGI-SA). The department of Trade and Industry introduced an incentive program to attract investors and as an element of a "holistic value proposition", that supports South Africa as an enterprising BPO&O location (The Department of Trade and Industry 2008).

The significant investment opportunities and economic growth implications for South Africa, forces this country to re-evaluate it's stance on customer satisfaction and the CC industry as a whole. It is consequently imperative that research and development in the CC environment receive the attention it deserves.

2.2 Industry Challenges

In order to improve the current state of the CC, we need to understand the underlying problems experienced in the CC environment and only then, can we set our performance standards higher and achieve improvements by overcoming or managing these problems.

A major problem in CC management is the size of the CC. (Faulin et al. 2007). Self-service technologies and voice and data convergence are more important and challenging issues in contact centres (Dimension Data Benchmarking Report 2006:67). The Dimension Data Report (2006) states that if a CC does not meet the internal service standards it will almost certainly fail to deliver external business standards.

Frost and Sullivan (2008) identified three very important challenges to contact centre performance, these are:

- Today's customer is sophisticated and has a higher expectation for customer care.
- High agent attrition rates for contact centres of all sizes and functions.
- Current technologies produce one-dimensional performance parameters due to individual reporting mechanisms.

Lastly, the most important challenge to manage in a CC is overstaffing and understaffing due to poor resource planning. (Reynolds 2003:39).

2.3 Call Centre Operations

The large-scale emergence of call centres and the increasing impact it has on society has brought about many advances in Information and Communication Technology (ICT).

Figure 1: Schematic Diagram of Inbound Call Process

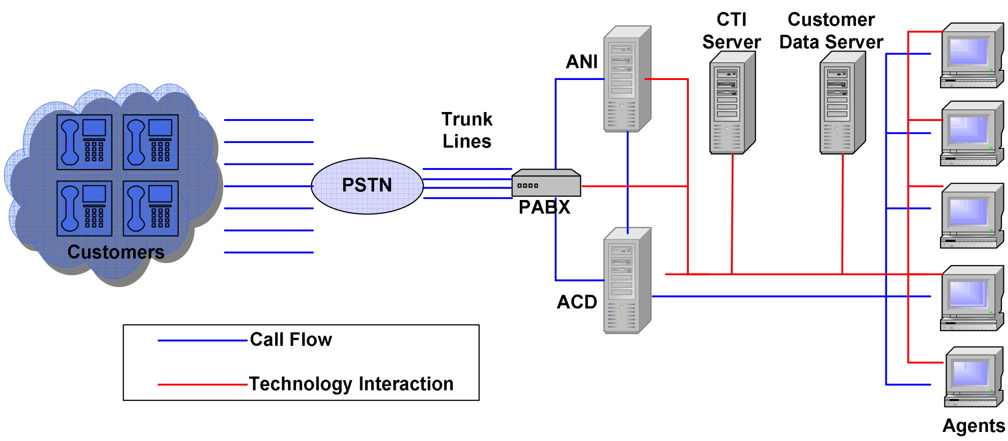


Figure 1 depicts the process flow of the inbound call characteristics (Telecorp Products, Inc. 2001). The process flow is divided into three phases and is now described in detail (Telecorp Products, Inc. 2001).

Phase 1: Connection

A customer contacts the call centre and the Public Switched Telephone Network (PSTN) determines the number from which the incoming call originates by Automatic Number Identification (ANI). The PSTN utilises the trunk lines to connect the call to the Private Automatic Branch Exchange (PABX). If a trunk line is available, the call is connected to the PABX, but if all the trunk lines are in operation, the customer receives a busy signal and terminates the connection. The PABX is a large computer that replaces the switchboard used in previous call handling systems.

The PABX sends the call to the Interactive Voice Response (IVR). The IVR is the “answering machine” of the CC and initiates the welcome messages. The IVR then relates the call requirements to the Automatic Call Distributor (ACD). An ACD is a specialised switch designed to route calls, connected via the PABX, to individual agents within the call centre. The ACD captures operational data that is used in the potential simulation problem of this report. The ACD have flow control capabilities and automatically delivers callers to agents.

The ACD is capable of routing calls to certain agents by various techniques. Firstly, the ACD can route the call depending on the agent skill level required. If no suitable agent is available, the ACD places the call on hold and the customer waits in a queue until a suitable agent is available. The skilled-based routing (SBR) system is a highly advanced method of routing. The Computer-Telephone Integration (CTI) technology assimilates the telephone and the CC’s information system. The call’s ANI is identified by the CTI. The CTI compares the ANI with a computer database and then based on the customer routing history, routes the call to a specific agent.

If the ACD is unable to route the call timeously to an agent, the customer may hang up before an agent can answer the call. This is called “call abandon”. The customer may abandon the call at any time during the connection to the CC. Should a customer stay on line, the ACD will connect him to an agent as soon as his call is the first in the queue.

Phase 2: Call Answered

The conversation takes place and the ACD can store all data pertaining to the call, average handling time, rate of resolution etc. During the conversation, an agent can access the information system via the personal computer (PC) at their workstation. If the CTI routing technique was used to route the call, the customer's information is automatically conveyed from the customer database to the agent's PC. Should the agent require outside assistance or consultation regarding the call in process, the customer is manually put on hold, allowing the agent to gather the information, and thereafter assist the customer. If the agent does not have sufficient expertise to resolve the customer query, the agent may transfer the call to another agent for assistance.

Phase 3: Wrap up and Retry

The agent may perform after call work, i.e. entering information into the customer database, retrieving information or consult with a superior. The ACD capabilities allow an agent to stop new calls delivered to his/her phone. The ACD collects operational data that is of major importance as far as evaluating statistical process control is concerned.

Customers that have abandoned call at any stage of the process or received a busy signal may call again or if the agent could not resolve the query, the customer may phone back later in order to clear the matter.

The three described phases (Telecorp Products, Inc. 2001) can interact with several other productivity enhancements such as, call blending, virtual call centre and multi-media. These enhancements fall outside the scope of the project, but the proposed simulation solution can easily be adapted to the situations stimulated by these enhancements.

Another very important concept is skill-based routing (SBR). SBR allows different agent groups to answer specific calls. The ACD routing capability is designed to match each caller with the agent with the most appropriate skills to resolve the customer query on a real-time basis (Call Centre Management Review 2006:47).

The aim of call centre management is to minimize the total time a customer spends in the system and still provide a high level of service, and resolve any queries. The contact centre must regard the customer in the queue as priority and treat the inbound call process as a queuing system (Bapat & Pruitte 1998:1395). This is an important concept, as it will define the parameters for the simulation approach described later in the report.

2.4 The Avis Call Centre

The Avis Call Centre is the front line of customer relationship. It is the face of Avis and therefore their most valuable asset.

The Avis Car Rental Brand is an international car rental company with an extremely large stakeholder setting. The call centre provides information concerning all of the available programs and customer applications.

The success and efficiency of this highly interactive call centre depends greatly on the commitment and level of involvement of its partners. An intense strategic alliance between the call centre and airline, hospitality and other partners is therefore paramount.

Avis Car Rental South Africa has identified the need for upgrading and strategic analysis of their current call centre. Obtaining desired customer satisfaction levels and the CC capabilities are identified problem areas initiated by Avis.

The complex operating environment depend on a wide variety of sophisticated technology to process transactions. The call centre technology is important but the agents leave a lasting impression on customers and are therefore an important factor in retaining and enhancing customer relationships.

A Customer Satisfaction Index (CSI) is used to rate agent performance. The call centre conducts a customer survey where questions relating to specific agents are asked. The agent is then rated according to the customer answers on the CSI. The agent financial measure requires R450 000 sales per agent per month.

The wide variety of customer choice creates a very real need for an effective and efficient call centre.

A study of the project environment is imperative, it introduces the challenges of the environment, the operations specific to call centres and gives a clear view of the final goal.

3 Literature Study

3.1 Resource Planning

The transition of call centres from telephone centric operations to multi-channel communication powerhouses, managing the CC requires specialised knowledge and skills.

The Call Centre Management Review (2006:1) pronounces successful CC management as getting the right people and supporting resources in place, at the right times, to handle an accurately forecasted workload, at service level and with quality.

Labour costs account for three-fourths of all CC expenditure, managing this fundamental operation of the business is extremely important. Resource planning, workforce planning or more commonly workforce management (WFM) is the process of getting the 'just right' number of resources in place to handle customer contacts (Reynolds 2003:9).

Datamonitor (2006) states "From efficiency in operations, to effectiveness in dealing with customer interactions: WFM is more important than ever as a tool for improving customer service."

The business benefits acquired in using WFM are immense, but features/functionalities that determine WFM solutions are (Datamonitor 2006):

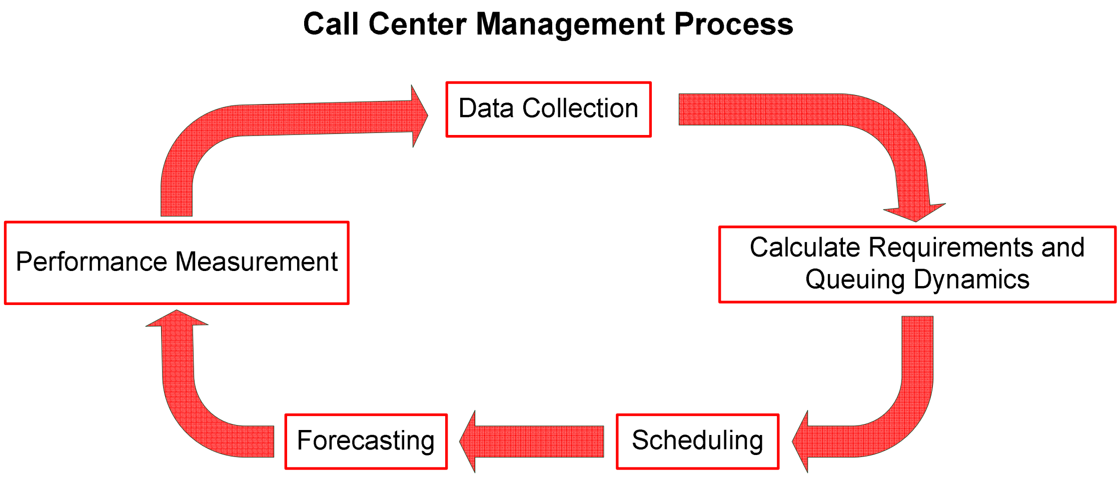
- Efficiency in scheduling is not just about improving agent resource allocation. It can mean deploying new contact centre strategies;
- Effectiveness is an important part of the benefits associated with high-end WFM. This might include skills-based routing, and process re-engineering;
- The return on investment associated with WFM from a business point-of-view is easily quantifiable.

These functionalities guide resource planning and consequently a better understanding of the key concepts is imperative. An increase in management performance requires a linked approach between the key functionalities and WFM.

The steps in performing WFM are (Reynolds 2003:11-12):

1. Data Collection and Analysis
2. Forecast call workload
3. Calculate Staff Requirements and Queuing Dynamics
4. Scheduling
5. Measuring and Tracking Performance

Figure 2: The steps in the call centre management process



WFM is an extremely valuable concept, but without defined service levels it may prove inaccurate. Therefore, before proceeding to the WFM steps, we explore the fundamentals of setting service levels and response times.

3.1.1 Setting Service Levels and Response Times

The service level is at the heart of effective incoming call centre management. Resource planning has long been based on achieving a specified service level objective (Call Centre Management Review 2006:2).

In order to meet or even exceed customer expectations; a clear view of the performance goals and objectives of the CC is imperative. The performance objective of inbound transactions (requests handled when they arrive) is the service level. Another performance objective of inbound transactions is response time (requests not handled upon arrival). Setting the standard service level and response time respectively is the link to on-phone staff requirements and the achieved results (Call Centre Management Review 2006:2)

Resource planning is a direct application to meet set service levels and response time (Call Centre Management Review 2006:3). For example: not having enough agents to answer calls will increase the customer waiting time and result in a high abandonment rate, by adding more agents the delay times drop, but just how many agents should you add? Using the set service level that is accepted by the customer and the CC, you add enough agents to reduce the queue to the acceptable levels (Call Centre Management Review 2006:3). Different outcomes can now arise; later in the project, we evaluate these scenarios as a proposed solution of resource management.

Benchmarking is an effective method for establishing service levels and response times. It may not be the most celebrated method for performance standard development, but benchmarking does have unique advantages. Benchmarking provides an objective analysis of the current service delivery in comparison to competitors and can help to identify the strengths of the current process, but provides actionable feedback on weaknesses (BPA Worldwide 2008).

If the service levels are not met, a vicious cycle may develop (Call Centre Management Review 2006:3). Customers complain about poor service levels, this increases the call time because the agent needs to apologize for the poor service level or long waiting times. The increased call times promotes a higher call-answering pace that can lead to agent burnouts. Less accurate work due to poor concentration drives a decrease in quality. This results in more call backs due to mistakes made by overworked staff (Call Centre Management Review 2006:3).

The Avis CC is committed to a service level of: 90% of all calls answered within 10 seconds and an abandonment rate of only 2%. These service level standards are extremely high and above the current benchmarked service levels. The Dimension Data Benchmarking Report (2006) set the current service level benchmark for African and Middle East countries at 77% of call answered within 20 seconds with an abandonment rate of 12%.

Response time of inbound transactions (requests not handled upon arrival) such as correspondence, e-mail and voicemail allows for a larger window of time in which the CC can respond. According to the Call Centre Management Review (2006:6), it is difficult to track and evaluate the response time of agents to e-mail, therefore appropriate levels of priorities of e-mails is categorised as follows:

- Urgent Messages: Agents must respond to these messages immediately or at least within an hour.
- Routine Messages: As soon as possible
- Informational messages: Require no response

A customer that spends a long period of time in the queue is prompted to leave a voice message. If the customer leaves a message, the voice mail is sent to an agent as an e-mail and is treated as such. The e-mail is transferred via skill-based routing (SBR).

Effective resource planning is comparing current performance levels with the established service levels and response times. Defining the steps in WFM and the current methodologies and tools used in WFM allow us to develop an effective resource plan based on knowledge.

3.1.2 Data Collection and Analysis

Reynolds (2003:13) states, "Past history is the best predictor of the future, so gathering call history is the first task in the WFM process. This data and validation step is the foundation of the entire staffing cycle."

To manage a process, the data that is produced must be measured. The measurements should be timely, since there is no use in last month or even yesterday's data if improvements are done today. It is essential that specific objective measures are implemented so that an unambiguous approach is adopted and removes subjectivity (Calvert 2004:101).

The most obvious source of historical data is the ACD. The CTI can also serve as a good source of data. Some of the historical data on the ACD that might prove useful:

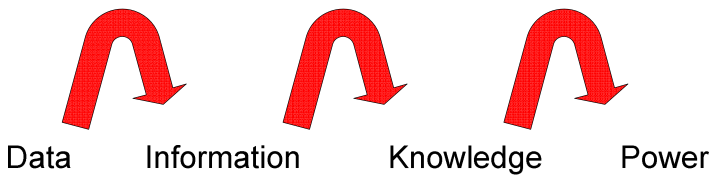
- Number of Calls Offered (NCO) by the half hour
- Average handling Time (AHT) by the half hour

- Blocked calls and retry behaviour (First attempt call load)
- Abandonment half hourly

An analysis of the acquired historical data is identifying the abnormalities, track the source of the abnormality and deal with it accordingly. The Call Centre Management Review (2006) suggests that data is adjusted so that it accurately reflects the individuals attempting to reach the CC should be an ongoing part of the forecasting process.

Effective data management and analysis can only be a powerful tool if the data is relevant and valid. Figure 3 (Calvert 2004:101) illustrates the importance of overcoming the obstacles in data analysis so that powerful management decisions are made:

Figure 3: Data analysis



Data on its own is useless. Constant improvements in an organisation's performance originates from data driven decisions and in order to make these decisions the three key data sets must be considered:

- Operational Delivery
- Product Performance
- The customer

The reality of customer service delivery is where the aforementioned three data sets converge (Dimension Data Benchmarking Report 2006:32).

The arduous process of gathering data is imperative in order to provide accurate, representative data into the next forecasting step. The WFM cycle is useless without the data gathering and validation step and all further efforts based on inaccurate data is futile.

3.1.3 Forecasting

Klungle (1997:9) states that forecasting is the most critical step in the call centre management process.

A study of the current and historical literature on forecasting methodologies and tools is a research topic in its own. The vast number of forecasting techniques, software and mathematics is beyond the scope of this project, yet an accurate forecasting method is imperative to efficient workforce planning.

The most commonly used call workload forecasting techniques are point estimation, averaging approaches, regression analysis and time series analysis (Reynolds2003:24).

Point estimation is the simplest approach and simply predicts what an element of data will do in the future by using an equivalent point in the past and copying it. This approach works for weather forecasting, but is very ineffective in call centre forecasting (Reynolds2003:24).

The averaging approaches is similar to point estimation, but several data points are used as a predictor as apposed to just one. The averaging approaches consist of the simple average approach, the moving average approach and the weighted average approach. While the above-mentioned averaging approaches are a step up from the point estimation approach, they are still not applicable in the call centre business model (Reynolds 2003:25).

Regression Analysis is useful where future call volumes are dependent on an event or variable in addition to the normal historical influences. The complexity of the contact centre limits the forecasting technique. The relationship between the event and the call volume may be too complicated and can vary over time (Reynolds 2003:27).

The most accurate approach to call centre forecasting is time-series analysis. This approach assumes that the call volume is influenced by a variety of factors over time and that each of the factors can be isolated and used to predict the future (Reynolds 2003:28). In the time-series approach the first step is trend analysis, the effect of the trend on the data is isolated. The next step is to identify the seasonal patterns represented by each month of the year and then isolate the effect of the seasonal trends. The final step is to break down the prediction into daily forecasts and then determine the calls per half hour of a particular day (Reynolds 2003:30-38).

The proposed solution of simulation serves as a forecasting tool, in the sense that historical data is the input, the current process is the driver and the future repercussions are the output.

Building a forecast on accurate data is critical. The forecast is the basis for determining staffing needs and requirements for other resource (Call Centre Management Review 2006:14).

The proposed dynamic simulation model allows the forecaster to make assumptions about internal variables and external environment in the model. Depending on the variables in the model, the forecaster may develop several scenarios (Chase et al. 2006:514).

3.1.4 Calculate Staff Requirements and Queuing Dynamics

Calculating the number of staff required to handle the forecasted workload is the next step in WFM. Call Centre operations depend greatly on placing the exact number of people at every half hour of the day. Understaffing results in poor service with unsatisfied customers. On the other hand, overstaffing drives up unnecessary labour costs. The most investigated step in WFM is balancing the number of staff members for every half hour to meet the service levels and predicted workload (Reynolds 2006:39). Determining the right number of staff involves the use of detailed mathematical models that replicate the unique staffing issues of the CC (Reynolds 2006:43).

Studying the call centre relates to solving many mathematically challenging problems, the modelling questions that most often arise is queuing models (Koole 2007:188). The queuing dynamics of a call centre is a specialised field of study and the research done by mathematicians on this specific subject is immense.

3.1.4.1 Analytical Models

Mathematical modelling to predict staff capacities for telephone systems has long been an accepted technique. Several mathematical models are used in the telephone traffic engineering applications. The primary traffic models include Erlang C, Erlang B, Erlang-Engset and the Equivalent Random Theory. Agner Krarup Erlang, a Danish mathematician, statistician and engineer developed the model in the 1910s while working for the Copenhagen Telephone Company. The determinants for these mathematical models are the arrival rates and usage patterns in telephone calling (Reynolds 2006:43).

The selection and application of a specific model depends on the unique CC characteristics such as the source population, holding time distribution and call disposition (Parkinson 2006: 8). The Erlang C model is the most commonly used in estimating CC performance. The queuing model is a simplified version of the real situation; the correctness of the Erlang C performance ratings depends greatly on how close the assumptions are to the real situation (Tanner 2004).

The Erlang C model calculates the number of agents required to perform required tasks at the set service level based on the forecasted workload. The Kendall-Lee notation for queuing systems describe the Erlang C as a basic M/M/c queuing system characterised by a continuous random variable (Winston 2004:318). The notation M/M/c denotes the first M as the *M*arkovian arrival process specifics, the second M specifies the nature of the *M*arkovian service times and the c is the number of parallel servers (agents).

The Erlang C model assumes (Parkinson 2006: 20):

- Poisson arrival process
- Exponential service times
- Multiple servers (c) in parallel with a single queue
- All servers are identical (agents have the same skills)
- Service is FIFO
- Unlimited queue length
- No abandonment or reneging
- Infinite queue length

Parkinson (2006) states that the era of “one size fits all” application to CC is outdated, and any minor departure from the Erlang assumptions will result in an imprecise real-world model. The model completely ignores abandonment causing significant overstaffing; therefore, the use of the Erlang model is limited.

Further limitations to the Erlang models exist (Klungle 1997:5):

- Static results of analytical models are insufficient
- Analytical models only provide averages, not variability and extremes
- The models cannot identify process bottlenecks
- Cannot compensate for SBR

The movement towards SBR and using abandonment as a performance measure due to advances in technology outdates the Erlang C model (Klungle 1997:4). Even with partial cross training, considerable overstaffing occur in using Erlang C, this problem is highlighted when it comes to the next step in WFM to wit scheduling, which is discussed here in later.

The dynamic environment of CC management requires a different approach to resolve the current problems at the CC. The aforementioned mathematical models just do not apply in the technology-driven era of CC management.

3.1.4.2 Analytical Models vs. Simulation

Mathematical analysis, when appropriate to a specific problem tends to be fast and inexpensive, but the only real question is whether the system is accurately represented (Chase et al. 2006:707). Simulation is defined as the technique that imitates the operation of a real-world system as it evolves over time (Winston 2004:402). Simulation explicitly models the interaction between contacts (call or e-mails), routes and agents as well as the randomness of individual contact arrivals and handle times (Rockwell Automation 2007). Simulation is characterised by dynamic, time varying behaviour and is used to reproduce the dynamic activities of a real environment (Randolph 1991:90).

Simulation is particularly appropriate to situations where the size and complexity of the problem makes the use of optimising techniques difficult (Chase et al. 2006:693). Complexity and stochastic relations deprive analytical models the ability to represent adequately all real-world situations. Using analytical models in such systems require so many simplifying assumptions that the solutions are inferior or inadequate for implementation. In such instances, the only alternative form of modelling and analysis is simulation (Winston 2004:402).

In contrast to the exact mathematical solutions available with most analytical models, the simulation process involves executing or running the model through time to generate representative samples of the measures of performance (Winston 2004:402).

Typical scheduling methods, such as Erlang C or multi-server queuing formulas, become less effective when applied to agents with multiple skills (IEX Corporation 2004). The modelling required in CCs is complex and, unfortunately, Erlang C based methods alone are insufficient (Kosiba 2002:1).

The simulation method is based on creating a computerised “copy” of the actual contact centre system and running this system on the computer for a period of time representing a day, week or month (Rockwell Automation, 2007). By employing a simulation tool, management can create schedules to better utilise the skills of the workforce at the right time. As a result, a contact centre may be able to handle more calls and improve customer service with fewer agents (IEX Corporation 2004).

As with most other modelling techniques, simulation has its advantages and disadvantages. The advantages of computer simulation given by Chase et al. (2004:706)

- Developing the model leads to better understanding of the real system
- Time is compressed.
- Simulation does not interrupt ongoing activities of the real system.
- Simulation provides a more realistic representation of a system than mathematical analysis.
- Simulation answers what-if questions.

The Call Centre Management Review (2006:45) also outlines some of the important benefits of computer simulation:

- Assume a wide variety of variables including, overflow, overlapping groups and SBR.
- The assumptions include abandonment and busy signals.

Furthermore, the computer simulation model is used repeatedly on different policies, parameters or designs of the CC (Winston 2004:402). Simulation provides information on variability and extremes for queuing and staffing, unlike analytical models that provide averages for the key performance indicators (KPI) (Klungle 1997:4).

Disadvantages of Computer Simulation (Chase et al. 2004:707):

- There is no guarantee that the model produces good answers.
- The model's performance may be unreliable
- Model building can take a long time.
- Simulation may be less accurate than mathematical analysis because it is randomly based.
- A significant amount of computer time may be needed to run the model.
- No standardised approach to simulation modelling exists.

The major disadvantage of Erlang based models is that no consideration to abandonment behaviour is modelled. This is an extremely important setback since abandonment and reneging represent an excellent measure of the service quality that the CC provides to the customer (Faulin et al 2007:4).

Expanding computer power and memory permit the simulation of almost any system. Chase et al (2004:704) directly state, “Call centres are a good application for simulation.”

Simulation provides flexibility to study systems that are to complex for analytical methods (Winston 2004:445). Applying computer simulation to the call centre environment is a celebrated approach to understanding the system, develop strategies for increased performance and scenario development for the what-if questions.

3.1.5 Scheduling

Scheduling is the next step in resource planning and the main strength of WFM. The set service level, the call volume forecasts and staffing level requirements and operating rules, generate staff schedules based on various optimisation criteria (Klungle 1997:4).

The schedule requirements by the half-hour are used to assemble shifts, start and stop times, break periods and other operating rules (Reynolds 2006:65). Superior scheduling of agents is not only meeting call volume requirements, but also off-phone requirements as well (Wise 2004:3).

Various adaptive scheduling techniques are available to ensure staffing requirements are efficiently met. The rostered staff factor (RST) or “shrink” factor calculates the minimum staff needed on schedule (Call Centre Management Review 2006:62). Another important prerequisite to effective staffing and scheduling is to identify the various activities and events (off-phone included) that will occupy the agent’s time (Call Centre Management Review 2006:65). Staff shrinkage is defined as the amount of time that an employee is not available to be on the phone. The CC must track the amount of time that is lost to any type of non-phone activity to derive an accurate prediction of future shrinkage (Call Centre Management review 2006:68).

Linear programming (LP) is a popular technique used to solve the requirements of scheduling and several LP models exist, these LPs assume relaxed parameters and are sufficient for simple low-level skill requirements (Pot 2006). The best approach in turning overall staff requirements into numbers of staff by shift is computer simulation (Calvert 2004:190).

3.1.6 Tracking and Measuring Performance

Continuous improvement suggests that the CC managers and agents must constantly seek new ways of improving the quality of the process, performance and service to the customer (Calvert 2004:103). Performance management is a process-driven approach, creating a culture in which organisational, individual learning and development is a continuous process (Calvert 2004:103).

Ultimate performance management is dissolving the set service levels and goals into key performance indicators (KPI) and then aligning them with individual objectives (Calvert 2004:101).

Appropriate real-time KPIs for and inbound and outbound transactions (Calvert 2004:25):

- Percentage of calls abandoned
- Percentage of calls answered
- Schedule adherence (by agent)
- Speed to Answer
- Volume of calls handled
- Percentage of calls resolved first time (FTR)
- Average handling time (AHT)
- Number of calls in the queue (Reynolds 2003:94)
- Age of oldest call (longest waiting delay time) (Reynolds 2003:94)

A narrow-minded approach to KPI without the 'voice of the customer' input can create a high performance illusion. The analysis of KPI is an internal representation of customer satisfaction (Calvert 2004:207), but no measurement can tell you more accurately what the CC deficiencies are than the customer you serve.

Managing the daily results of the contact centre requires constant decision-making. Today's modern contact centres have complex routing strategies, multi-skilled agents and multimedia contacts (IEX Corporation 2008).

The IEX Corporation stipulates, "Achieving optimal results with a workforce management deployment takes a symbiotic relationship between the people, processes and technology in the centre. When one of the elements is out of balance, efficiency and effectiveness inevitably suffer."

WFM ensures the right people are in the right place at the right time (Calvert 2004:159). This is the sole objective in meeting customer demand. The WFM tool we use should imitate exactly the current operations in the CC and based on this we proceed to simulation modelling.

3.2 Simulation Modelling

There are two types of simulation models: static simulation models and dynamic simulation models. Winston (2004:443) defines static simulation modelling as a representation of a system at a particular point in time and dynamic simulation modelling as the representation of a system as it evolves over time.

Simulation models are further divided into discrete or continuous models. A discrete simulation model according to Winston (2004:443) is one in which the state variables change only at discrete points in time. In a continuous simulation, the state variables change continuously over time. Continuous models are based on mathematical equations with values for all points in time (Chase et al. 2006:703).

3.2.1 Simulation Languages

Computer programming is the basis of simulation study and writing the computer code for a complex problem is a difficult and arduous task. Special purpose simulation languages simplify computer programming. The most widespread and readily available simulation languages include GPPS, GASP, ACSL, SIMSCRIPT, SLAM, SIMAN (Winston 2004:440) and many more.

3.2.2 High-Level Simulators

High-level simulators operate by instinctive graphical user interfaces, menus and dialogs (Kelton et al. 2007:10). The user selects from several offered modelling constructs, connects the constructs and run the model. A dynamic graphical animation of the system components is also available (Kelton 2007:10).

3.2.3 Simulation Modelling Software

The first phase in selecting the appropriate software is to understand the different types of simulation. In the next phase, the current programs on offer are reviewed and the one that fits the specific needs is obtained (Chase et al. 2006: 704).

At the Winter Simulation Conference (WSC) of 2006 (Rockwell Automation, Inc. 2007) the simulation software packages used in over 300 research papers clearly illustrates the most popular simulation packages available today. We examine the top two software simulation packages used at the WSC in order to determine the most appropriate one for this project. The top two software packages are (Rockwell Automation, Inc. 2007):

1. Arena® Version 11.00.00 with 48% of the all simulation products used.
2. ProModel, with 12% of the papers using this package.

3.2.3.1 Arena® Version 11.00.00

Arena® Software provides a flowchart-style, model-oriented simulation environment to model practically any scenario involving flow transactions among a set of processes (Altiok et al. 2001:78). This user-friendly approach makes Arena® the most extensively used simulation package on the market today. Arena® combines the ease of use of the high-level simulators with the flexibility of simulation languages and general purpose procedural languages like the Microsoft® Visual Basic® (VBA) programming system or even C (Kelton 2007:10).
Arena® maintains its modelling flexibility by allowing the user to interchange between templates of graphical simulation modelling and analysis modules (Kelton et al. 2007:11). Low-level modules can be used at any time and access to simulation language flexibility is unlimited. The Arena® software is completely hierarchical allowing access to a whole set of simulation modelling constructs and capabilities, such as the SIMAN constructs together with higher-level modules from other templates. Arena® even allows some of the model written in Visual Basic or C/C++, all in the same consistent graphical user interface (Kelton et al. 2007:11).

Arena® exploits two Microsoft Windows® technologies that are designed to enhance the integration of desktop applications. The first is called ActiveX® Automation; it allows applications to control each other and themselves via a programming interface. Programming languages such as C++, Visual Basic or Java is used to create the program that controls the application (Kelton et al. 2007:420).

The second technology exploited by Arena® for application integration is Visual Basic® (VBA). VBA is the same language that works with Microsoft Office, AutoCAD and Arena®. Kelton et al (2007:421) explain that these two technologies work together to allow Arena® to integrate with other programs that support ActiveX® Automation. It is also possible to write Visual Basic® code directly in Arena® that automates other programs such as Microsoft® Excel, AutoCAD or Microsoft® Visio (Kelton et al. 2007:421).

Arena® implements a programming paradigm that combines visual and textual programming (Altiok et al. 2001:77). Arena® provides dynamic animation in the user interface. It also provides integrated support, including graphics, for some of the statistical design and analysis issues that form part of a good simulation study (Kelton 2007:12).

Arena® Contact Centre Edition

The Arena® Contact Centre Edition is a simulation system developed by Rockwell® Software Inc. for the performance analysis of contact centres. It is built on Rockwell® Software's Arena® Simulation system and allows users to build and run simulation models specifically for contact centres quickly and easily and to analyse the results that these models produce (Rockwell Automation, 2007).

Since the Arena® Contact Centre Edition is built on Arena as an Application Solution Template (AST); it allows full functionality including VBA and MS Office compatibility (Arena Automation 2007).

3.2.3.2 ProModel

The ProModel Simulation Software is a leading provider of simulation based decision-making tools and techniques. The ProModel utilises Six-Sigma Analysis and the MiniTab forecasting software package (ProModel Corporation 2008). Six-Sigma is a quality improvement process that accurately measures how far a given process deviates from perfection (Chase et al. 2006:319).

This software package allows planning in manufacturing, warehousing, logistics and other operational and strategic situations to improve productivity of the system (ProModel Corporation).

3.2.4 Choosing the Simulation Package

Simulation software packages are unique with individual characteristics that take time to learn, for this reason once a program is learned the tendency is to use it for a long time, so selecting the most applicable software program must be done carefully (Chase et al. 2006:706).

Arena® Software is designed for contact centre analysts and industrial or systems engineers, as an enterprise business analysis and productivity tool (Rockwell Automation, 2007).

The Arena® Software is provided by the Department of Industrial Engineering of the University of Pretoria to the student without any expense. The student completed the course Simulation BUY 321, and is familiar with the Arena® software package.

3.3 Literature Study Conclusion

Extensive research on the current call centre literature and the operations of the Avis call centre highlights the methods, tools and techniques available to achieve improvement.

Uncertainty is the main contributor to the problem areas in the call centre operations. The problems experienced in resource planning are cased by variable demand, fluctuations in the service levels and many external factors.

Management requires insight into the repercussions of a decision made today. The decision-making process must be fast and accurate, based on sufficient understanding of how the call centre may react to the external factors.

There are several techniques available to support the decision-making process. The models considered are analytical models and simulation models. Although analytical models are used extensively, it is restricted by complexity. Skill-based routing and multi-channel technologies are some of the technologies that analytical models fail to define.

A simulation study of the call centre reflects the sensitivity of the call centre performance to the external factors and generates several outcome scenarios. Management analyses the scenarios and determines the best course of action to ensure higher service level and customer satisfaction. Several simulation modelling software packages are available, but the Arena® simulation model is the most appropriate and is selected for the completion of the study.

4 Conceptual Design

4.1 Design Considerations

The success of Avis Car Rental is attributed to its ability to stay one-step ahead of its competition, by considering their customer's opinion and fulfilling the requested customer needs. The call centre is the first tier interaction with any of the Avis clients, be it a current relationship or a future relationship and for this reason the cc must perform at extremely high levels if Avis seeks to retain their impeccable reputation.

The external factors affecting the call centre generates extreme fluctuations and variability. Modelling the call centre is estimating the impact of these random variables on the internal performance of the cc and the repercussions if the necessary changes are not implemented. The unstable demand and growth distribution are some of the serious considerations that will affect the model structure.

Simulation is the best choice for designing the structure of the Avis Call Centre because of the intrinsic dynamics of this call centre. The call centre is a discrete-event stochastic simulation model, with more than one input random variable. The random variables and forthcoming functionalities such as SBR increase the complexity of the entire call centre management process. As part of the redesign and smoothing of the current WFM approach, the new complexities are included in the simulation and then all possible "what-if" scenarios are confidently analysed.

The objective of the simulation model is to evaluate the entire call centre system in a changing, real-time situation, without disrupting the current workflow and customer services. An important step before any modelling can start is defining the performance criteria, the model parameters and the identification and definition of the state variables (the input characteristics). Even though Winston (2004:442) affirm that the initial formulation of the problem will undergo modifications as the call centre is investigated, it is imperative that a clear set of objectives are stated.

4.2 Simulation Study

A systematic approach to the simulation model building is followed. The major phases in the simulation study are illustrated in figure 4 below. This flow-chart view of model construction simplifies the modelling process significantly, especially when changes to the model are made as the system is investigated.

As stated earlier call centre modelling is a discrete simulation, events occur only at specific points in time. The calls arriving at the PABX is a discrete event. Operations management applications almost exclusively use discrete event simulation (Chase et al. 2006:703). Discrete-event simulation is a powerful tool, both for determining the optimal service levels and for answering many other difficult “what-if” questions (Kosiba 2002:1).

The unique nature of the Avis call centre simulation model means that the procedure for building and executing the model is distinctly different to any other model.

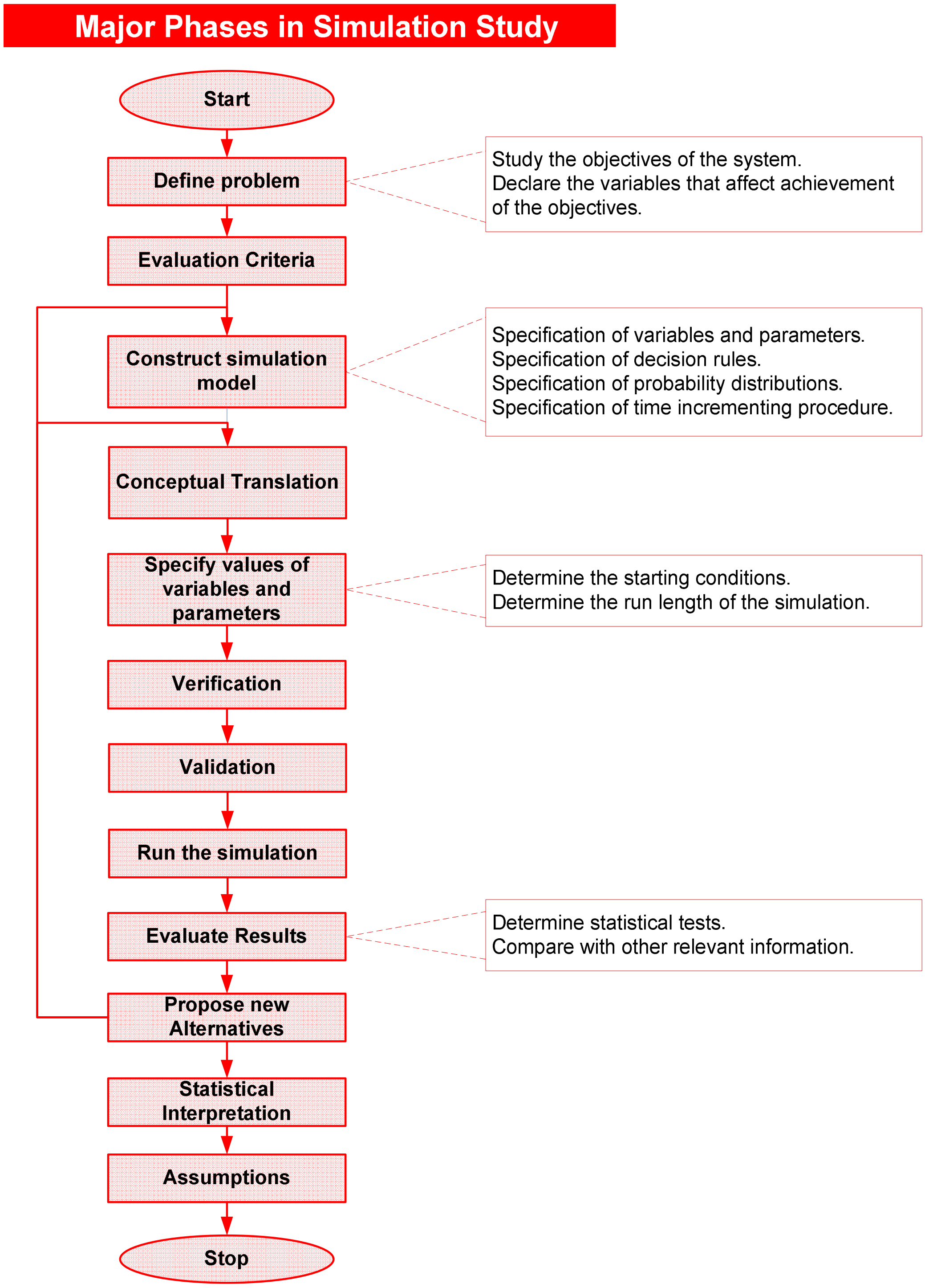
In a system, an object of interest is called an entity, and any properties of an entity are called attributes (Winston 2004:403). The distinct entity in this model is the incoming call.

The simulation model is also a queuing system, with many incoming calls or entities entering the system through many channels. It is one thing to analyse a queuing system in the abstract; it is quite another to create the design that transforms the results into physical reality (Hall 1991:90).

The model construct is controlled through a user and data interface with Microsoft Visual Basic® for Applications (VBA) and ActiveX®. Graphical editor describes schedules associated with staff and equipment, as well as arrivals of customer transactions or other system entities.

In simulation nothing is fixed, there are no boundaries to building the model and no assumptions are made about the system (Chase et al. 2006:707). Constructing the model as a true representative of the real-world system is the aim of any simulation study.

Figure 4: Major phases in a simulation study



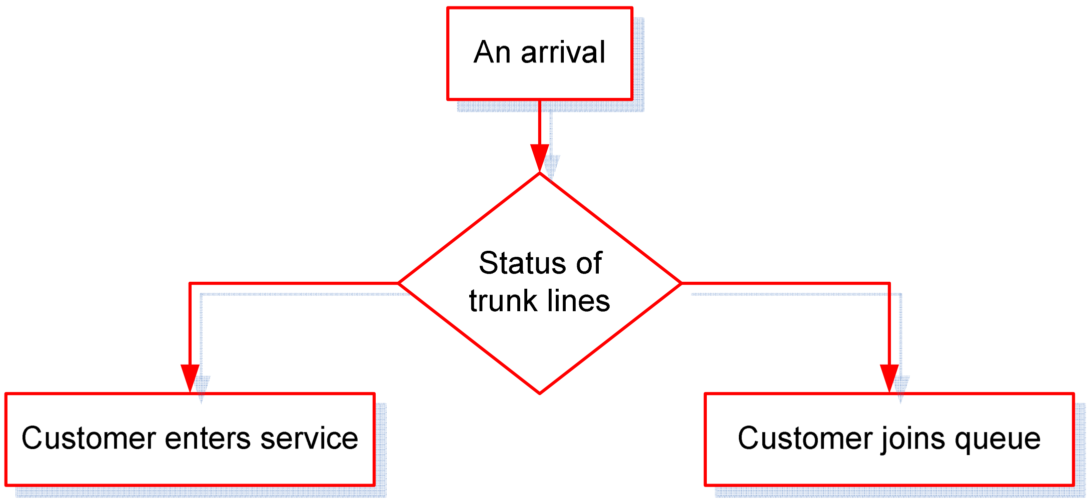
4.3 Conceptual Inputs and Outputs of the Model

The input analysis specifies the model parameters and distributions. The logical aspects of the model, such as the entity and resource characteristics, the path an entity follows through the system and any other activities is called structural modelling (Kelton et al.2007:172).

The structural modelling of a system is an arrangement of the fundamental logic that describes the system. The mathematical input that describes the logic is called quantitative modelling. Quantitative modelling specifies the numerical nature of the resources and entities including but not only, the distributions and model parameters (Kelton et al.2007:172).
The inputs to the queuing model are the arrival process of the offered call, the service times, the patience distribution, the number of agents, and the number of lines (Koole 2007:183).

Figure 5 (Winston 2004:405) illustrates structural modelling of a simple flowchart for an entity arrival.

Figure 5: Flowchart for an arrival



The conceptual outputs of the queuing system are typified by a specific probability distribution, which governs a customer's service time (Mehrotra et al. 2003:137). The random variable input data generates random variability in the output data. The most important output statistics of a simulation model will include the following performance measures (Mehrotra et al. 2003:137):

- Abandonment Statistics
- Queue Statistics
- Volume Statistics

The output statistics are measured to the set service levels and response time as stipulate in paragraph 3.1.1. Achieving the customer service levels and maintaining the abandonment rate are prominent output statistics.

AVIS

5 Data Collection and Analysis

Data collection is the first step in a simulation project. The availability of data and the quality of the data can influence the model profile and the level of detail in the model (Kelton et al. 2007:174).

Translating call centre data (forecasts, contact-routing vectors, contact-handle time distributions, agent schedules and agent skills) into actionable information about service levels, customer abandonment, agent utilisation, first-contact resolution and other performance measures (Rockwell Automation, 2007).

Arena® has an Input Data Analyzer that automatically fits existing data values to the best statistical probability distributions. The Input Data Analyzer fits a distribution to the data and provides an estimate of the parameter values and an expression for the model (Kelton et al. 2007:176).

5.1 The Input Data

The input data is retrieved from the ACD and then captured by the Ericsson Solidus Software program. The data is then transferred to Microsoft Excel®, which is more accessible.

5.1.1 Offered Calls

Any call received by the cc is an offered call. The three call types represent the three main business divisions of the cc namely, Rent-a-Car (RAC), Point-to-Point (P2P) and Luxury Cars and Chauffeur Drive (LUX). The number of offered calls to the system and the probability distribution of the offered calls per call type are stored in the ACD. Daily, weekly, monthly and quarterly data is available, depending on the planning horizon required in the level of decision-making. The sufficient time period is from 15 May 2007 to 13 May 2008 and the work hours is 6h00 to 22h00.

5.1.2 Average Handling Times

The company policy regarding call handling times changed in October 2007, when First Call Resolution (FCR) was implemented. FCR requires longer call handling times at a higher service level. The Avis cc management deemed the FCR approach successful and any analysis on the AHT only include data collected post-policy change.

5.1.3 Abandonment

Abandonment is an extremely important parameter with daily, weekly, monthly and quarterly data available. The ACD captures the data and the Ericsson Solidus eCare™ generates reports with the latest statistics and abandonment records. The abandonment rate is volatile and sensitive to time and staff issues.

5.1.4 Call Waiting Times

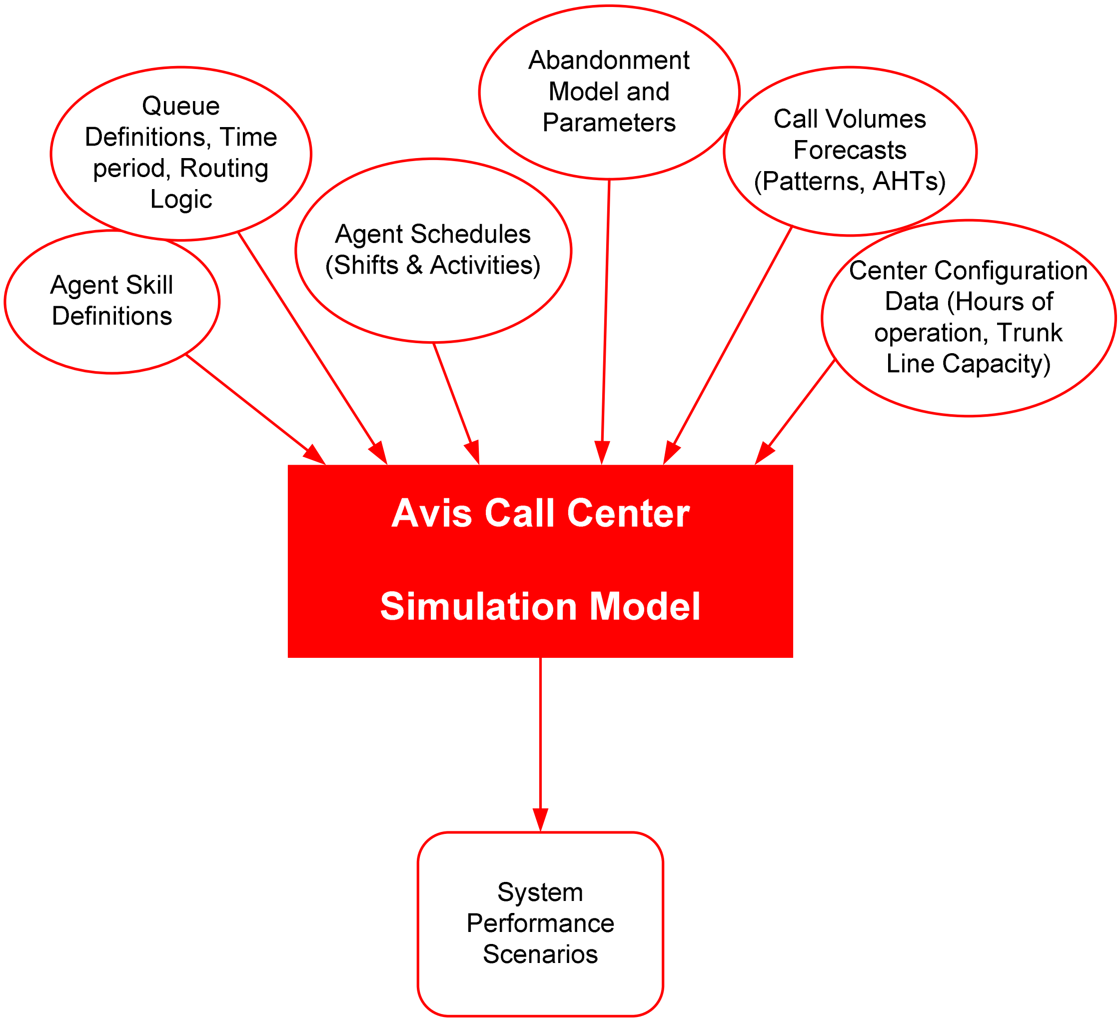
The Call Waiting Times is also captured by the ACD. The Automatic Number Identification (ANI) identifies the specific call type and directs the call to the specific call type queue. The time spent waiting in the queue by the identified call type is the call waiting time. Figure 5 on page 37 illustrates the arriving entity process and the queuing method.

5.2 The Soft Data

Company policies govern the staffing regulations, such as the number of staff members available with their respective skill levels, the daily shift hours and weekly schedules. The soft data encompass all the data relating to the workforce and personnel.

Figure 6 is adapted from various sources and illustrates the data involved in the simulation study.

Figure 6: The simulation model data inputs



5.3 Input Data Analysis

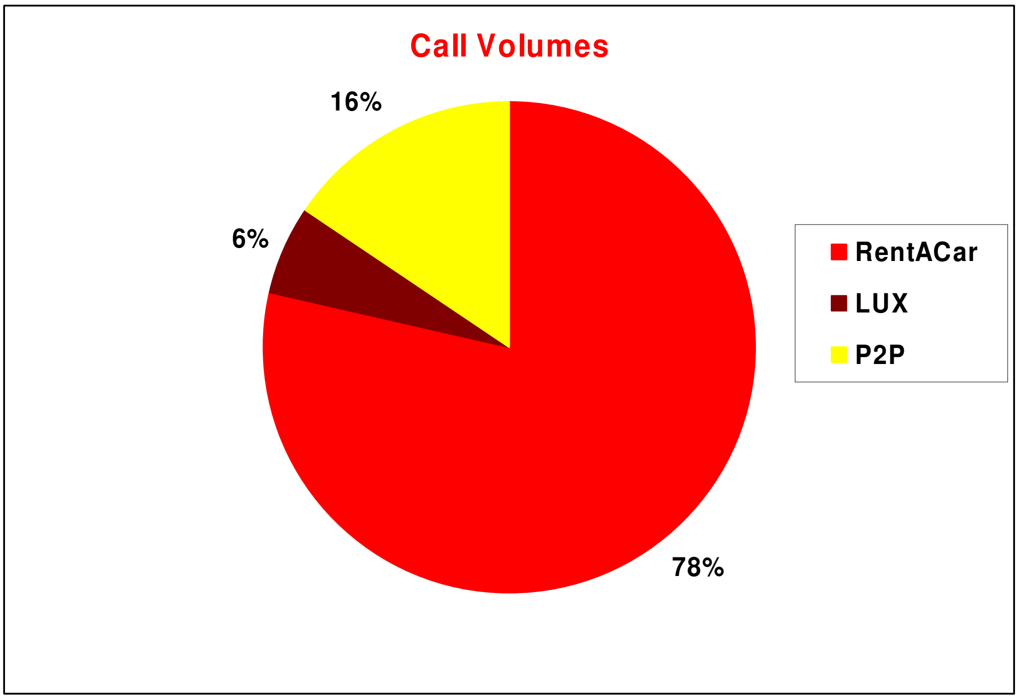
5.3.1 Offered Calls

The calls offered distribution is unique to each call type and is sensitive to the day of the week. The offered calls distribution for the Point-to-Point call type on a Monday may differ significantly to the distribution of the same call type on any other day of the week. The planning horizon of the project depends on the level of decision-making. The work shifts and schedules are planed one week in advance, for tactical and strategic decision-making. The workforce turnover time is three months.

As discussed is section 3.2.3.1 the ActiveX Automation technology allows integration with other applications. The VBA programming environment supports the ActiveX Automation and through these technologies, the exact simulation modelling requirements as stated by the user is modelled. The user simply states the required distribution of the specific call type for any day of the week and the Arena® simulation model produces the results for the stated distribution.

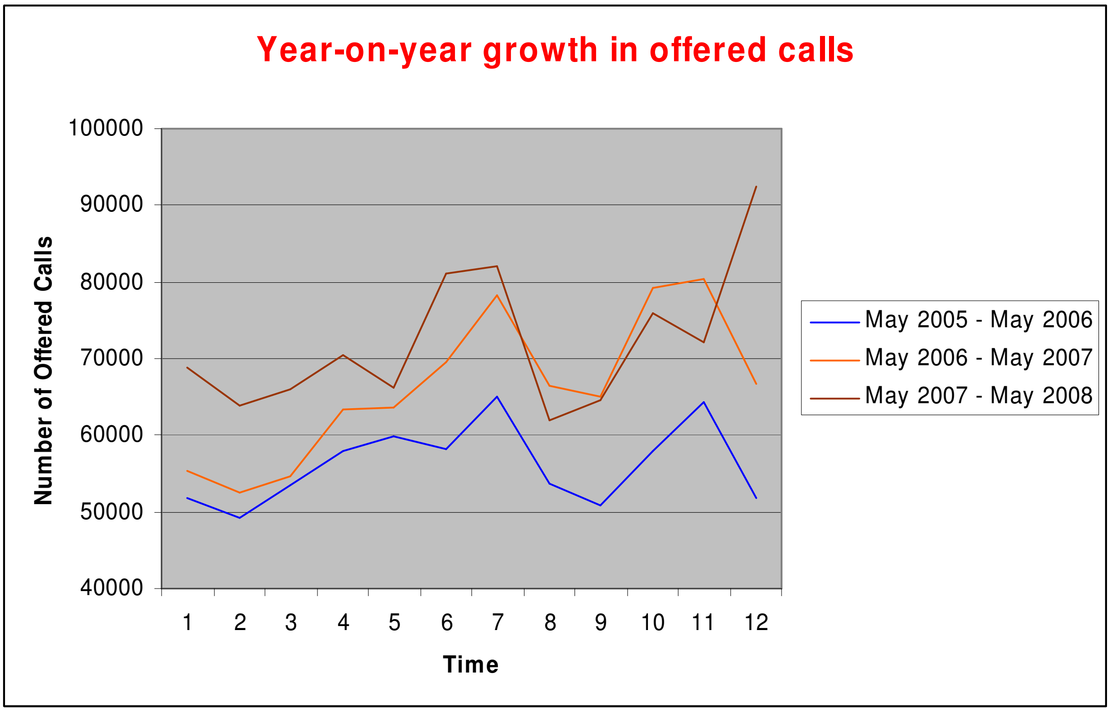
The task of fitting the correct distribution to the incoming call type data may seem redundant to management, therefore a default distribution is estimated for the current input parameters and company policies. These distributions are referred to as incoming call distribution profiles and are generated in Arena® Input Analyzer using only the applicable and most current data from the Microsoft Excel® spreadsheets. The analysis of the call distributions shown in Appendix 11.4 on page 72. The call volume for one year per call type is summarised in figure 7 below.

Figure 7: Call Volumes for the specific call types



The default distribution profiles should not be used after June 2009. The growth of the Avis cc are shown in figure 8 and other external influences may severely alter the probability distributions. Annual default profiles should be constructed that include that specific year's growth.

Figure 8: Growth in Offered Calls for Rent-A-Car



5.3.2 Average Handling Times

The average handling times (AHT) for each call type is demonstrated in the mathematical expressions developed in the Arena® Input Analyzer (Appendix 11.4 on page 72). The AHT determines the customer satisfaction and queue waiting times.

6 Depiction of Simulation Model

The conceptual depiction of a model lays an imperative foundation in the development or design phase and is referred to as identification or the 'pieces of the model'. Conceptual translating a model is to formulate the model design and approach before one actually commences on building the model in Arena®. The rationale behind this is to ensure that all mechanisms and 'building components' are considered. Some of the things that one should take into consideration are the data structure or constraints, the type of analysis to be performed, the type of animation required and replication length, just to name a few.

6.1 Conceptual Translation

The development of the model is the most difficult and critical part of this simulation study. Mathematical or logical relations must represent the essential features of the cc process. The simulation model is divided into five activity areas. The activity areas depict the cc system.

6.1.1 The Entities

Entities are the dynamic objects of the simulation. They move around, change status, affect and are affected by other entities and the state of the system and affect the output performance measures (Kelton et al 2007:20).

The entities developed in the model represent the specific call type. The three call types are:

- Rent-a-Car Services
- Luxury Cars and Chauffeur Drive
- Point-to-Point Services

Each call type has a specific and unique characteristic. There are several 0861 ### ### numbers that a customer can dial. The ANI recognizes the call type by the 0861 number and automatically routes that call type to the correct service. If the customer reaches the wrong service, the call type is routed to the correct service provider.

A single entity is created for each call type entering the system, in order to assign several attributes and variables. Abandoned calls are included in the call type arrival process.

An agent entity is generated for every agent that is available to answer a call. The agent entity is used primarily to assign a specific subgroup or skill set to a call type.

6.1.2 Attributes

An attribute is a common characteristic of all entities, but with a specific value that differ from one entity to another, an attribute individualise an entity (Kelton et al 2007:20). The different attributes that define each activity area, is indicated in table 1 below.

Table 1: List of Attributes

Attribute Name
Agent ID
Call Type
Call Type ID
Served By
Skill Level Index
Subgroup
Time Call Enter Queue
Time in Queue

6.1.3 Variables

The user-defined variables reflect the characteristics of the cc system. Each variable is unique and not tied to any specific entity. The cc simulation model requires several user-defined and built-in variables that guide the model entities. The list of variables in Appendix 11.2 on page 66 clearly outlines the different user-defined variables.

6.1.4 Call Arrival Pattern

The call arrival rate of the avis cc varies over the course of the day. A distinct arrival pattern is visible Appendix 11.1 on page 64. The data collected must be expressed in 30 minute periods for the working hours of 6:00 to 22:00. The call arrival rate and pattern is of extreme importance to managing an efficient workforce.

The most commonly used routing strategy upon call arrival is the longest-idle-agent (LIAR) policy. This policy sends the call to the agent that has been waiting the longest for a call, since the completion of the last task performed (Wallace et al 2004:2673).

6.1.5 Trunk Groups

Trunk groups represent groups of phone lines that are dedicated to a particular set of contact types. Multiple contact types can be served by a single trunk group, but each contact type may only be served by one trunk group. Trunk groups have an associated capacity, cost, and a default routing script and call priority. Any incoming contact assumes the default priority and follows the default routing script unless these attributes are overridden at the contact level.

Note that trunk line capacity determines the maximum number of contacts that the contact center can accommodate simultaneously. If a trunk line is not available when a contact attempts to enter the center, the contact is blocked and does not gain entry. Otherwise, the contact is attached to a trunk line and remains with that particular line until exiting the center or until transferred to another trunk line (Arena Online Help File 2008).
Avis management recently installed a new trunk line with increased capacity, ahead of the expected 2010 FIFA World Cup tourist boom. The increased capacity allows, for the moment, enough space to test any applicable scenario.

6.1.6 Routing Scripts

Routing Scripts are sequences of actions that control the flow of contacts through the centre’s phone system. This will result in contacts being connected with agents, leaving messages, being disconnected, or abandoning the center (Arena Online Help File 2008). These scripts specify the actions, activities, and states that each call undergoes as it attempts to reach an agent.

6.1.7 Agent Groups

An Agent Group represents a group of agents within the contact center that have the same skill sets and follow the same schedule. From a modelling perspective an agent group is a set of identical agents(Arena Online Help File 2008).

The Agent Skill Matrix defines the skill set of the agents. In developing the agent skill matrix the approach suggested by Wallace and Saltzman is followed. Agents have skills at various skill levels, with the number of different skill levels equal to the number of call types. Since the Avis model have three call types the skill levels for each call type is also three, with one being the primary skill and two the secondary skill and so on.

The agent skills are given and represented by a $C \times n$ matrix called A, where the number of agents denotes C and n the different call types or skill level.
Each entry of the agent-skill matrix A is

$$a_{ki} = \begin{cases} q & \text{when agent k supports call type q at skill level I,} \\ 0 & \text{otherwise.} \end{cases}$$

where $k = 1,\ldots,C$ and $1 \leq q \leq n$ and $1 \leq i \leq n$.
The rows of the agent skill matrix represent the unique agent identification (AgentID), the columns represent the skill level and the entry a_{ki} indicates the call type supported. The agent skill matrix for the Avis cc is given in Appendix 11.1 on page 64.

6.1.8 Queues

Call queues are the mechanism by which contacts and agents interact in the contact center. Queue sizes clearly amplify the efficiency and effectiveness of the cc. The different queues defined in the Avis cc simulation model is listed in Appendix 11.2 on page 66. Each agent group has a queue associated with it to hold its contacts while they wait to be handled. Contacts may move from one queue (i.e., one agent group) to another before being serviced based upon the routing script that is assigned to that contact type (Arena Online Help File 2008).

The call queues give a clear picture of the performance of the cc. The service waiting time by a customer determines the overall perception of performance to the customer. A customer waiting in a queue for an inappropriately long time is already impatient and unimpressed with the service, before an agent can even attempt to resolve a problem or simply deliver a service. The queue waiting time governs the customer satisfaction.

6.1.9 Schedules

Schedules dictate when agents are available to handle contacts. Each schedule specifies on-duty shifts for each day in the planning horizon an each call type. In addition to call handling time, the schedule includes lunches, breaks and meetings. Precise scheduling is an extremely difficult task. Management do not adhere to a strict scheduling policy and shifts are considered as flexible.

6.2 Key Performance Measures

Several sources where consulted, but the most comprehensive and pertinent performance measures or output parameters are provided by Wallace and Saltzman. Table 2 lists the most important performance indicators for any call centre.

Table 2: Key Call Centre Performance Measures

	Performance Measure	Description
1	$P(Q = C + K) = \varepsilon$	Probability of blocking a call
2	$E[D \mid Q < C + K] = W$	Average speed to answer (ASA) given system entry
3	$E[D_i \mid Q < C + K] = W_i$	Average speed to answer call type i given system entry
4	$P(D \leq \tau \mid Q < C + K) = 1 - \delta$	Percent of calls the are answered within τ minutes given system entry
5	$P(D_i \leq \tau \mid Q < C + K) = 1 - \delta_i$	Percent of calls of call type i that are answered within τ minutes given system entry
6	v	Agent utilization
7	v_j	jth work group utilization

The random variable Q has steady-state distribution for the queue length process of the system. The random variable D has steady-state distribution for the delay time of a caller admitted to the system and the random variable D_i has steady-state distribution for the delay time of a caller admitted to the system that requests type i service.

Performance measure one in Table 2 calculates the cc's readiness to work. The performance metrics two and four in the aforementioned table indicates the speed-to-answer capabilities. Performance measures three, five, six and seven express agent utilisation.

7 Simulation Model Construction

The best approach to simulation modelling is to start with a simple model and make it more detailed and complex as system knowledge improves. The Arena® Call Centre Edition is not available for modelling, but Walter and Saltzman developed a model that is used as outline in the model construction. Kelton also describes call centre modelling in detail and many guidelines are used in the modelling of the Avis cc.

7.1 Model Activity Areas

The simulation construction is divided into several activity areas to better illustrate and understand the logic of the Arena® model:

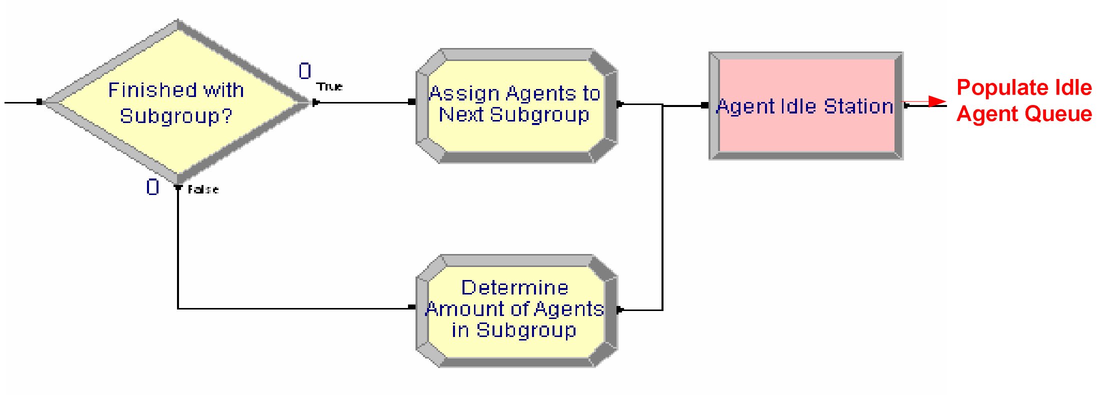
Activity Area 1: Agent generation
Activity Area 2: Populate incoming calls
Activity Area 3: Call Handling
Activity Area 4: Completed calls
Activity Area 5: Abandonment

7.1.1 Activity Area 1: Agent Generation

In this activity area the idle agent queue in initially populated with an entity for each agent. The create module generates entities called Agents, each with a unique AgentID. Section 6.1.1 describes the entities and the AgentID attribute is described in Table 1 on page 45.

The AgentID is assigned as an attribute indicating which subgroup the agent belongs to, where a subgroup is defined to be a set of agents with identical skills. The agent skill matrix, as discussed in Section 6.1.7, is entered as a variable to fill the subgroups as required by the skill set. The variable Number in Subgroup, regulates the number of agents in a subgroup as a subgroup number is assigned to an idle agent in the Idle Agent Queue. Figure 9 illustrates the initiation of the idle agent queue.

Figure 9: Populate Idle Agent Queue



Appendix 11.3 page 67 illustrates the complete Arena® model for this activity area.

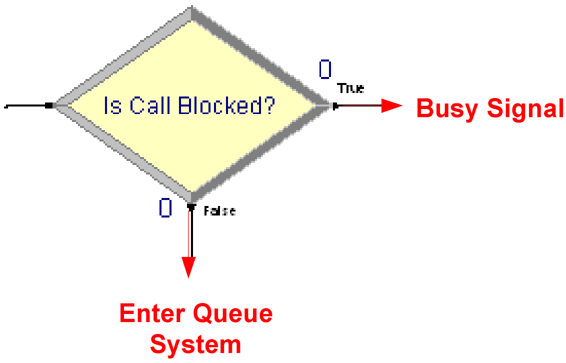
As calls are allocated to appropriate agents, the AgentID is removed from the Idle Agent Queue and sent to the Idle Agent Station. When the agent finishes service, its AgentID is placed back in the Idle Agent Queue.

7.1.2 Activity Area 2: Populate Incoming Calls

The activity area starts by creating inbound calls and assigning key attributes, namely call type and picture. The data analysis, section 6.1.4, for inbound calls stipulates the probability distributions for the incoming calls. The complete Arena® model for this activity area is shown in section Appendix 11.3 page 68.

The trunk capacity is regulated by the Maximum Queue Length variable. If trunk capacity is exceeded, the call is blocked and the customer hears a busy signal. Blocked calls are recorded and disposed of. The Decide module, indicated in figure 10, governs this process of call acceptance. If the number of calls waiting in the queue is less than the maximum queue capacity, the call proceeds into the system and the agent allocation process is initiated.

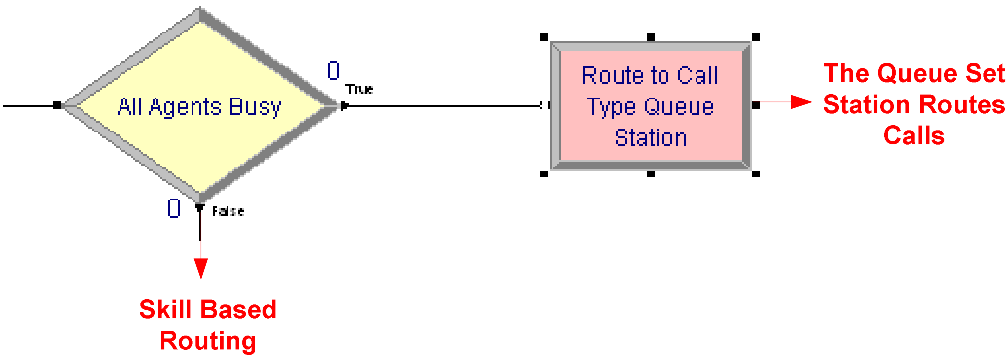
Figure 10: Call Accepted or denied



In order to regulate and report abandonment the Time Call Enter Queue attribute is assigned to the populated incoming call.

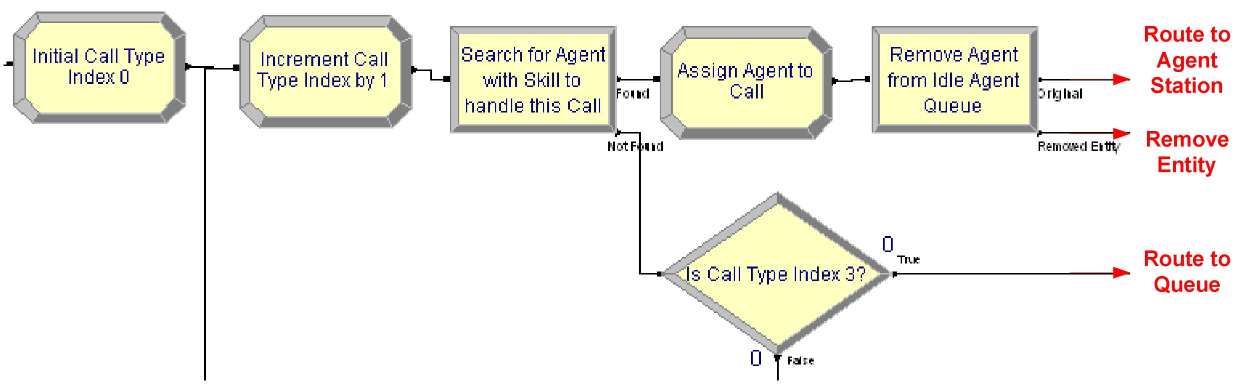
If all agents are currently busy, the idle agent queue is empty, then the call is sent or routed to wait in the queue or station specific to the call type. The Decide module indicated in Figure 11 illustrate the availability of agent. The route module, also in figure 11, sends the call to the specific call type station. The three call types govern the station module through the Advance Set module, Queue Station Set.

Figure 11: Is Agent available to service call



If at lest one idle AgentID exist, then the call searches the Idle Agent Queue for an agent with the suitable skill set for the call type. This is the process of SBR and is depicted in figure 12.

Figure 12: Skill Based Routing



The suitable skill set of an agent serves the Call Type Index variable in determining if the agent is rightly skilled. The Search module only use global variable, therefore the Call Type Holder variable is assigned to the Call Type attribute value. The Subgroup attribute related to the Agent entity determines the specific Subgroup in the Agent Skill Matrix.

7.1.3 Activity Area 3: Call Handling

The properly skilled agent is found and in the next activity area the call is serviced. Once an agent is allocated to the correct call type the AgentID is assigned to the call's Served By attribute. The call is then routed to the call type service station. As the agent serves the call, its specific AgentID is removed from the idle agent queue.

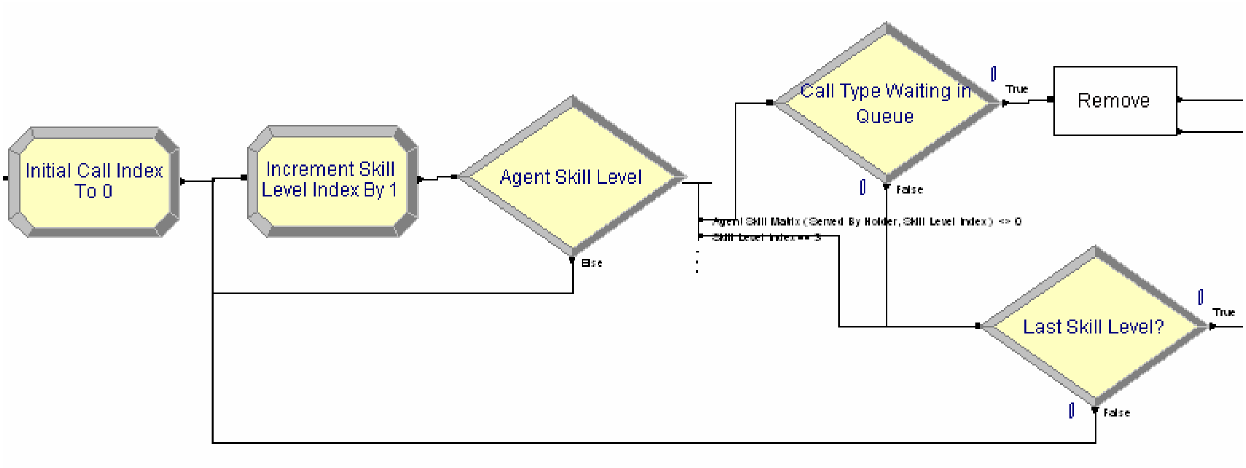
The call is sent or routed, by the Advanced Set called Queue Set Station, to the appropriate queue or station, specific to the call type, if no agent is available to service the call. The service and queue flow is shown in the Arena® model, Appendix 11.3 on page 69.

7.1.4 Activity Area 4: Completed Call

After the calls arrive at the check station, a Time In Queue attributed is assigned. The service levels and waiting times are recorded for measurements and statistical purposes. Appendix 11.3 on page 70 depicts the logic of the activity area.

As soon as the agent completes a call, the call queues are searched for any waiting calls. If a call is waiting the Served By attribute searches the agent skill set to determine if the agent is able to service the call. If the agent skill matrix finds the agent appropriate the Served By attribute is assigned to the call and the call is routed to the appropriate call type service station and the AgentID is removed. This process is illustrated in Figure 13.

Figure 13: Determine if any calls are waiting



If there are no calls waiting or the agent is deemed inappropriate the AgentID is place back in the idle agent queue.

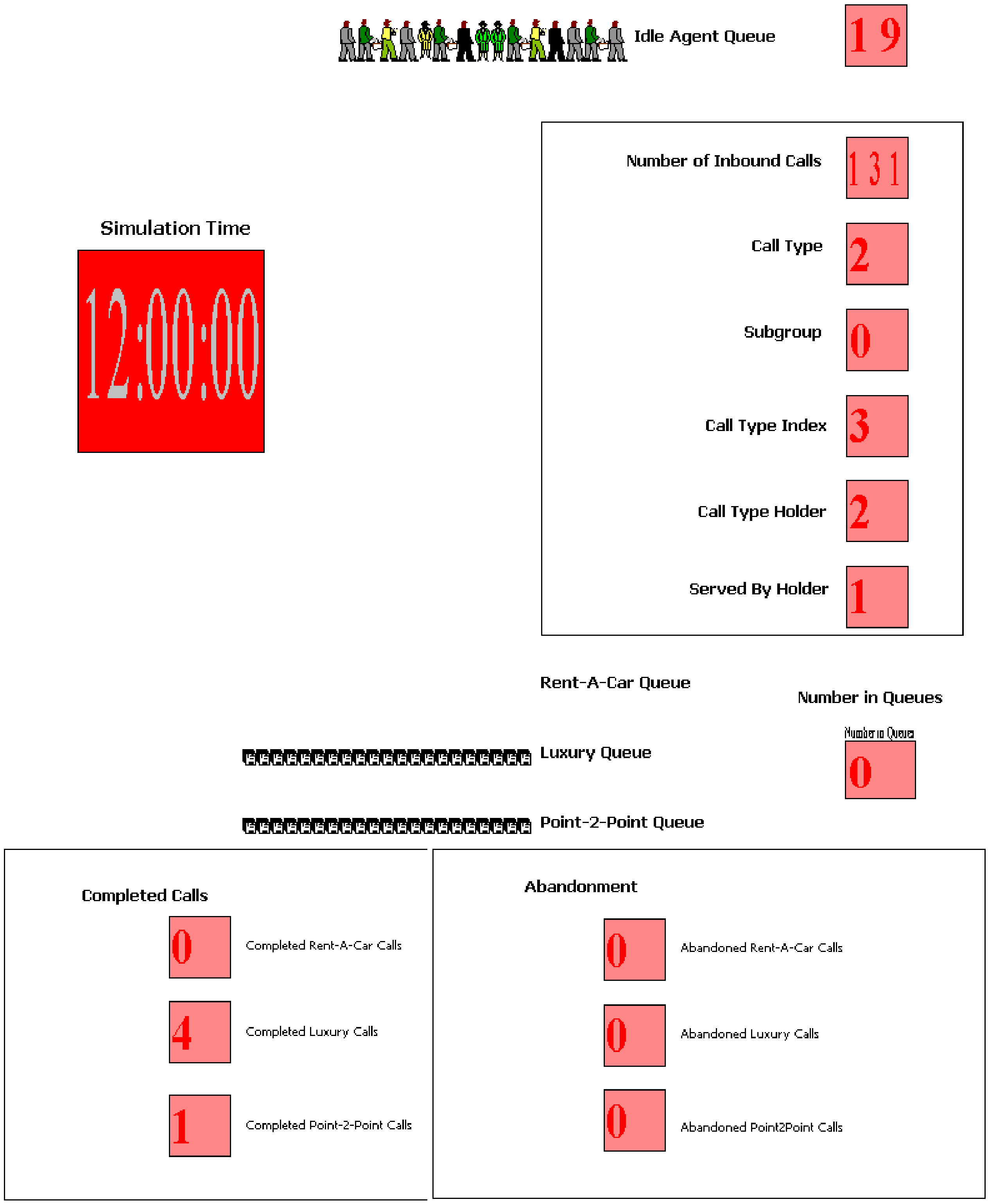
7.1.5 Activity Area 5: Abandonment

Abandonment statistics play a vital role in measuring the performance of the cc. The flowcharts in Appendix 11.3 on page 71 depict the abandonment logic of the three different call types. The Time in Queue attribute of the Call Arrival entity is deducted from the current simulation time to determine the time that a call spent in a queue.

7.2 Model Animation

Dynamic animation describes the cc environment by providing support and graphics for the design and analysis of the simulation study. The animation visually presents the working of queues, completed call and some other variables that assist in model interpretation and scenario analysis. Figure 14 displays the model animations.

Figure 14: Model Animation



7.3 Verification and Validation of the Model

7.3.1 Verification

Verification is the process of ensuring that the model behaves in the way it was intended, according to modelling assumptions that are made. Verification also involve the process of debugging the model. Exploring the extreme regions of the model is an important aspect in verifying more intricate simulation models.

7.3.1.1 Verification Methods

Allow only a single entity to enter the model and follow the entity through the system. Review the results to be sure that the model logic and data are correct.

Animation can also be use as a visual representation of activities performed by the model. By using various colours and assigning different pictures to the status of each of the resources (e.g. idle or busy), entity flow can be followed.

Counters and Discrete-Change Variables are also measures of entity flow. Verification takes place by consulting the Output Analyser. These values should resemble the number of entities through counters or variables.

Some of the problems encountered; input data that represent the true call process and assigning the day schedule to the agents.

7.3.2 Validation

Validation is a task of ensuring that the model behaves the same as the real system. Validation can be described as the process of ensuring that the built simulation model is a good portrayal of the physical system.

Validation does not mean that the model mirrors the true physical system. It does mean that the model has been built sufficiently, representing, the true system in order to make decisions concerning the true system by testing them on the built simulation model.

7.4 Scenario Development

Evaluating the different scenarios outlined in figure 15, with changed input parameters and testing decisions is the aim of the project. Several techniques are available to draw the correct conclusions from the changed configurations. Arena® comes with a separate application called the Process Analyzer that greatly eases the scenario analysis process.

The scenario development is in accordance with the level of decision-making. Drawing the correct conclusions based on output measures assist in confident and possible improvements.

The following scenarios outline the analysis of the Avis cc:
Scenario 1: Agent Skill Levels
Scenario 2: Inbound Call Growth
Scenario 3: Call Handling Times

Figure 15: Scenario development with level of decision-making

8 Simulation Results and Recommendations

The Arena Outputs (Appendix 11.5 on page 76) is analysed to determine the areas that require further investigation. The identified scenario situations have unique parameters and determinants. The simulation results and scenario development led to several suggestions to achieve higher service levels at the cc.

8.1 Scenario 1: Agent Skill Levels

Change the agent skill level policy. All agents have one primary skill and can service only one skill type. The agent skill matrix is the key determinant in the scenario development. The tactical decision to change the agent skill levels severely influences strategic decision-making.

The results of the simulation run are given in table 3 below and indicate severe bottlenecks. The development of this scenario led to several policy questions and decision-making, therefore similar scenarios are now in development.

Table 3: Scenario 1 Output Statistics

Statistic	Output Value
Total number of inbound calls	7177
Total number of calls abandoned	3157
Percentage of calls abandoned	43.98%

The high abandonment rate is attributed to the long waiting time in the service queues. The simulation results suggest that agent skill levels should be increased. Training expenses are an important consideration if the agent skill levels is increased.

8.2 Scenario 2: Inbound Call Growth

The Avis cc has experienced high growth rates in the near past. The trends and growth rate pose some interesting question regarding the sensitivity of the cc. Scenarios for both, inbound call increase and decline, is simulated and the results are analysed to measure the sensitivity of the cc.

The year May 2007 to May 2008 showed an overall growth of 30%. This dramatic growth rate of inbound calls is extremely important to analyse, since top-level decision-making is required. Table 4 contains the Arena® output values.

Table 4: Scenario 2 Output Statistics

Statistic	Output Value
Total number of inbound calls	10231
Total number of calls abandoned	2574
Percentage of calls abandoned	25.16%

It is recommended that this particular characteristic of the Avis cc is closely monitored. The recent addition of a trunk line is sufficient to handle the expected growth due to the 2010 FIFA World Cup (South Africa). The growth rate requires that the number of trained agents is considered.

8.3 Scenario 3: Call Handling Times

The First Call Resolution (FCR) methodology was accepted at the end of 2007. FCR requires longer handling times, but at a much higher service level and customer satisfaction. The longer waiting times negatively affect the abandonment rates, higher service levels compensate for the increase in queue length.

Table 5: Scenario 3 Output Statistics

Statistic	Output Value
Total number of inbound calls	8546
Total number of calls abandoned	2399
Percentage of calls abandoned	28.07%

Company policy will determine the priority of abandonment versus customer satisfaction. The FCR methodology remains the optimal call answer policy for the cc.

8.4 Simulation Results Conclusion

The results obtained through the scenario development indicate that the simulation model is a true representation of the Avis cc system. The input parameters influenced the output statistics as predicted. The simulation model may now be used to test several other scenarios that decision makers require.

9 Conclusion

The Avis Call Centre is a dynamic network of activities that is susceptible to internal and external factors. Managing and understanding the intricate processes of the cc will lead to higher service levels, satisfied customers and an efficient workforce.

The simulation modelling is a suitable industrial engineering tool that assists management in controlling the factors that affect the cc performance. The literature study indicates that the Arena® simulation model is the most appropriate method for completing the project.

The conceptual design with the stated input parameters and business decisions ensure that all of the relevant issues are included in the model. The data collection and analysis demand that the simulation model that is constructed in Arena® is a true representation of the real call centre.

The output data retrieved from input parameter configurations illustrated the vulnerability of the call centre to external influences. The unstable demand and growth are some of the considerations that influence the structure of the simulation model. The model accurately represents the real world and after verification and validation several scenarios is tested.

Management can realise the importance of accurate decision-making at every level and may use the simulation model to assist them in short, medium and long-term improvements or to understand the system.

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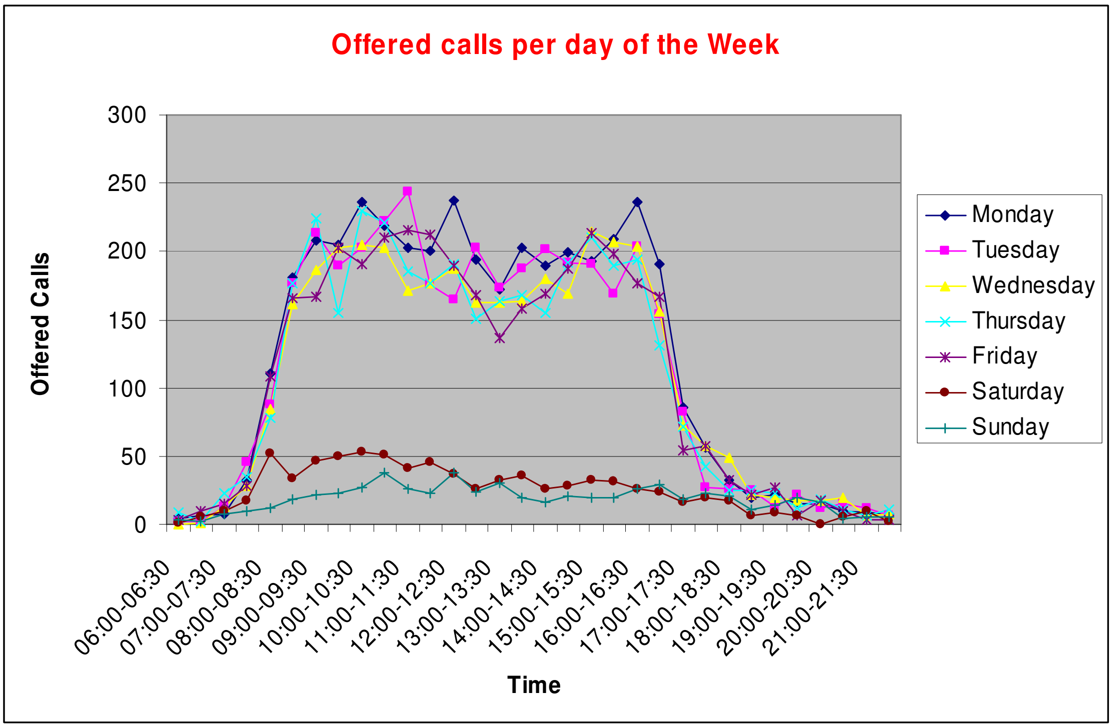
11 Appendices

11.1 Input Data Analysis

Figure 16: The number of offered call per call type for one week



The Agent Skill Matrix

	SKILL SET Matrix		
Agent	**1**	**2**	**3**
Bestina Molangwane	3	2	0
Cedrick Mabogo	1	2	0
Charmaine Maake	1	0	0
Christopher Taulu	1	0	0
Eliott Nhlapho	1	0	0
Gloria Platjies	1	0	0
Godfrey Mbiza	1	0	0
Heath van Biljon	2	3	0
Joseph Mathebula	1	0	0
Juanette Marais	1	0	0
Khanyi Nala	3	2	0
Lerato D	3	0	0
Lerato Magudulela	1	0	0
Lerato Seerane	1	0	0
Linda Msiza	1	0	0

Loretta Kaphioa	3	2	0
Masedi Lonkokile	1	0	0
Melony Muller	3	2	0
Mthokozisi Nzimande	3	2	0
Muzi Buthelezi	3	2	0
Nadia Brooks	1	0	0
Nthabiseng Mothopeng	1	0	0
Oscar Thobegane	1	0	0
Otto Mpodi	1	0	0
Paul Kekane	3	2	0
Peet Appel	1	0	0
Pravesh	1	0	0
Rhoda Diergaardt	3	2	0
Robert Ngobeni	1	0	0
Ronelle Mohamet	3	1	0
Sanele Mthethwa	1	0	0
Shivon Molepo	1	0	0
Sibongile Chirwa	1	0	0
Sibusiso May	1	0	0
Siphokazi Mamase	3	2	0
Siyanda mbatani	3	2	0
Solomon Lethuba	1	0	0
Sonja Grobler	2	3	0
Stephen Molele	3	2	0
Tebogo Moalusi	3	0	0
Thabile	1	0	0
Tshepo Moloi	1	0	0
Tumi Sibeko	3	2	0
Victor Netshifhefhe	1	3	0
Wynand van Rooyen	1	0	0

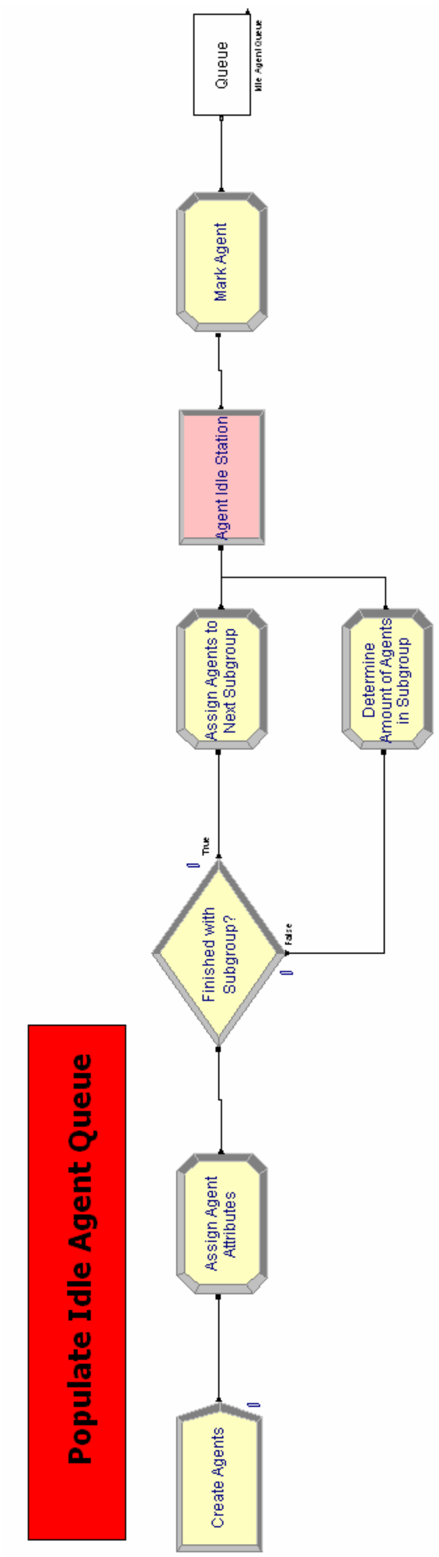
11.2 Key Components of the Model

Variable
Number of Subgroups
Number in Subgroup Counter
Number in Subgroup
Total Number of Agents
p2pProb
racProb
luxProb
Maximum Queue Length
Call Type Index
Call Type Holder
Served By Holder
Max Skill Level
Agents Busy
Skill Level
Agent Skill Matrix
RentACar Abandon
Luxury Abandon
Point2Point Abandon

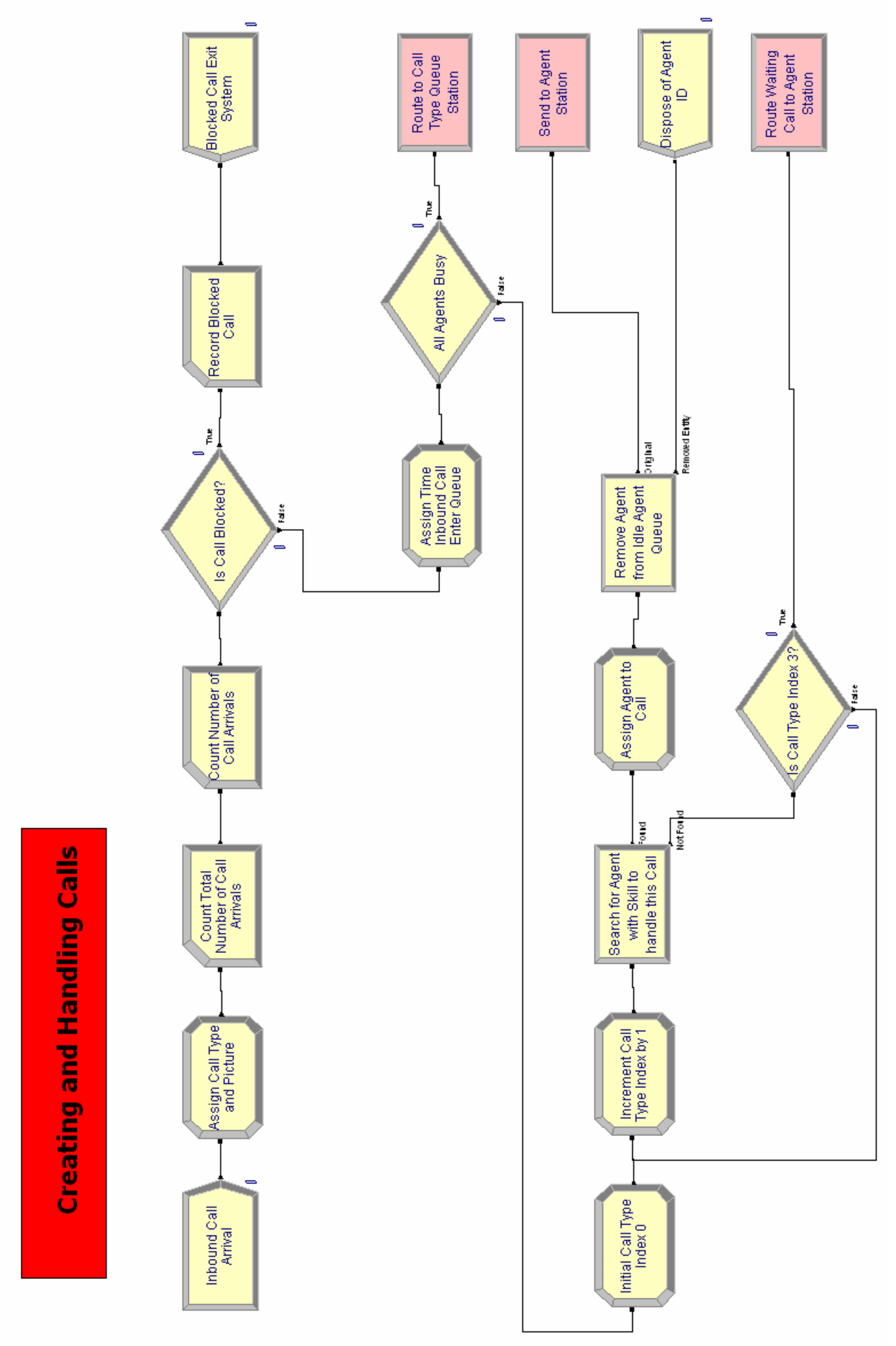
Queues
Idle Agent Queue
Rent-A-Car Queue
Luxury Queue
Point-2-Point Queue

11.3 The Simulation Model Parts

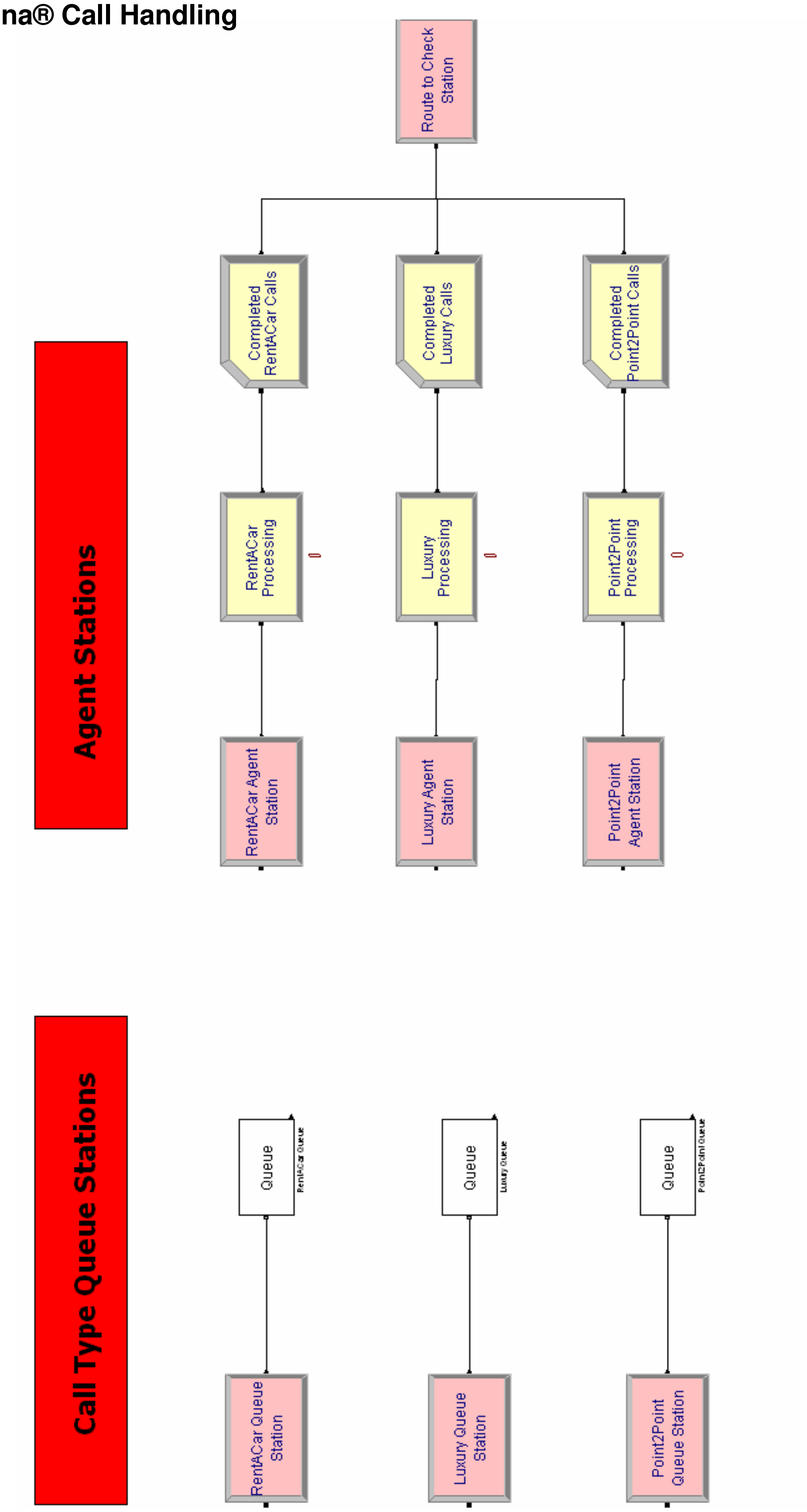
11.3.1 Arena ® Agent generation



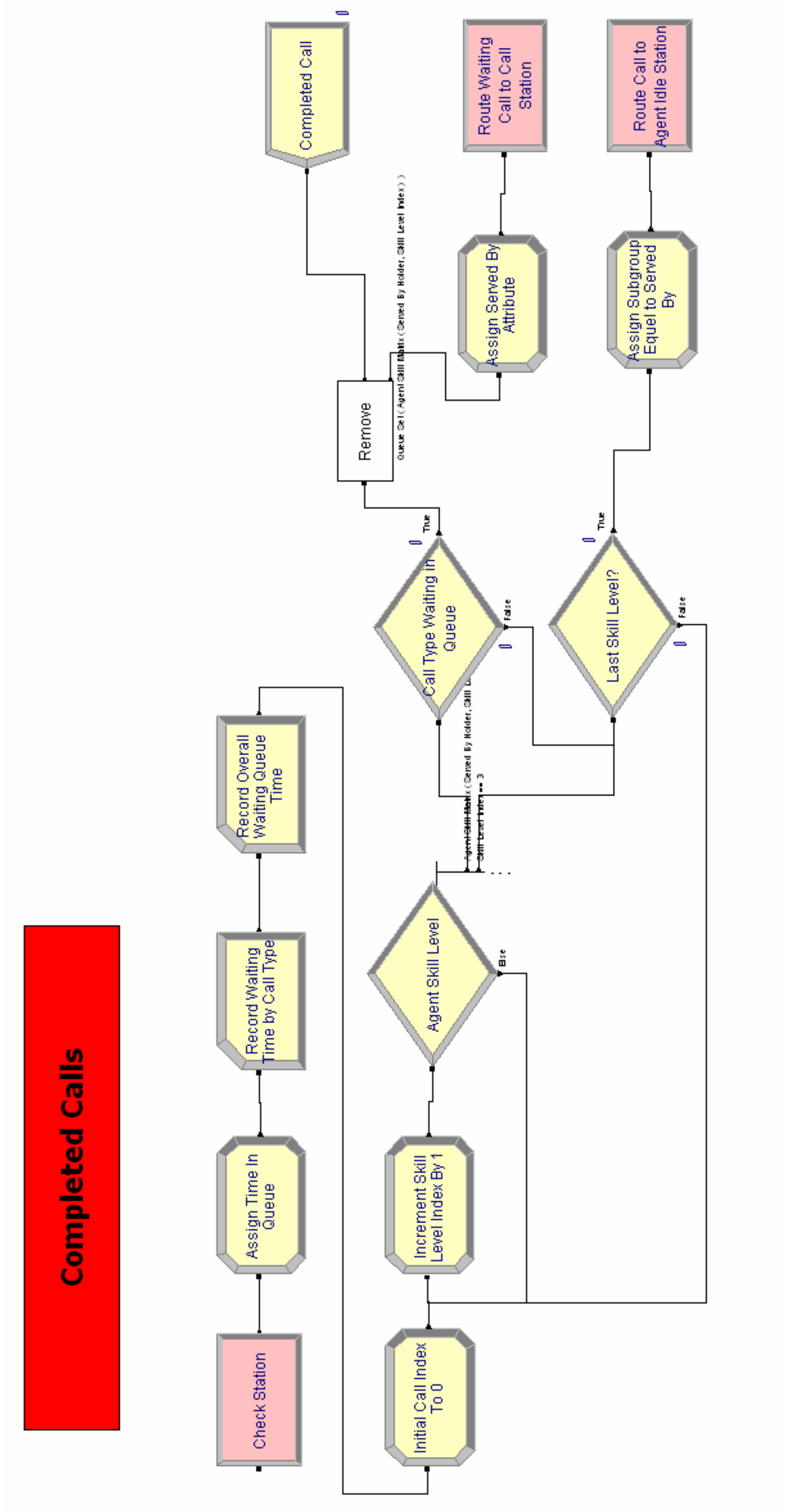
11.3.2 Arena ® Populate incoming calls



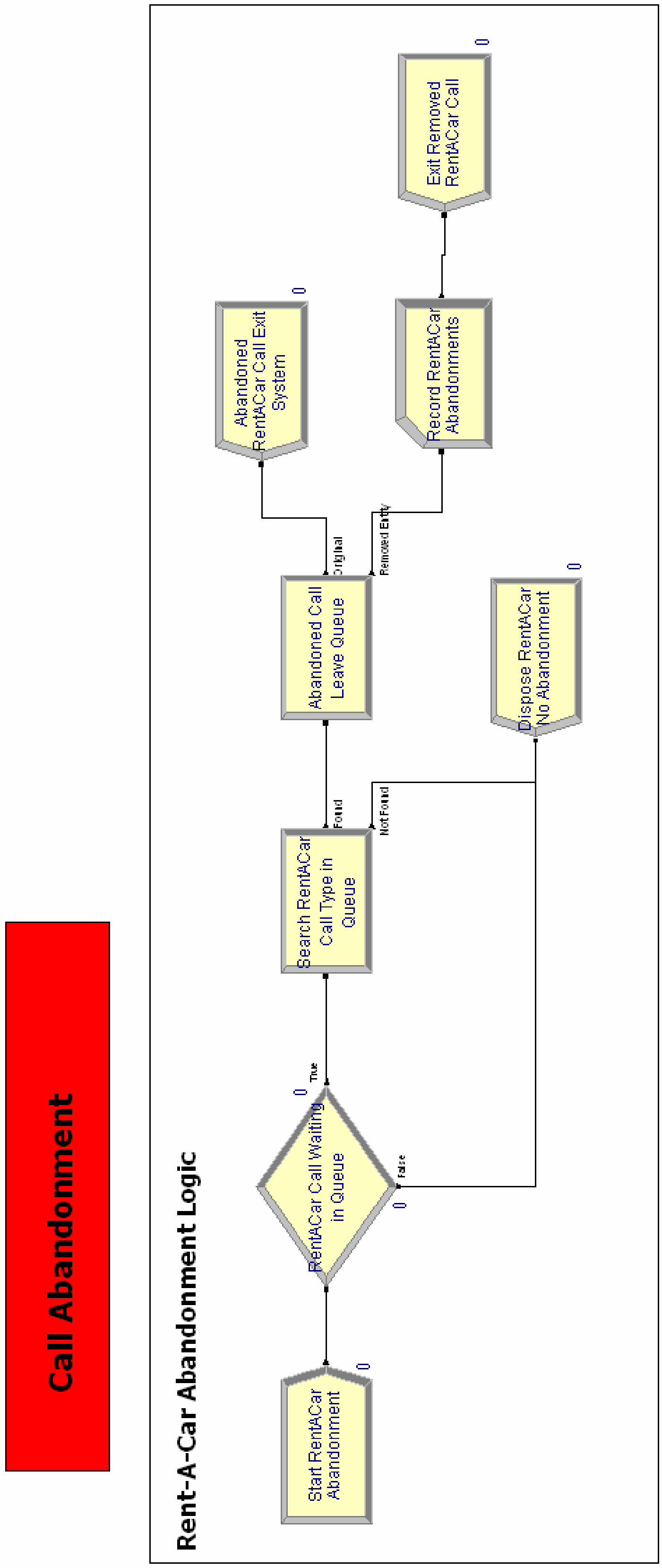
11.3.3 Arena® Call Handling



11.3.4 Arena® Completed Calls

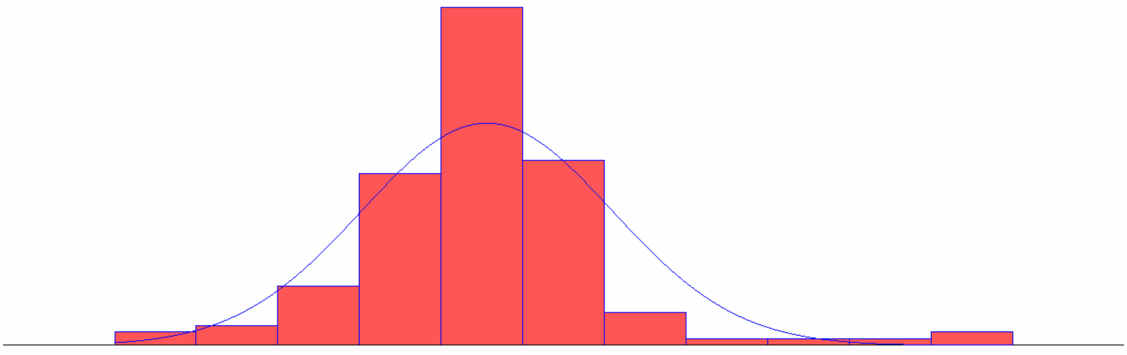


11.3.5 Arena® Abandonment



11.4 Probability Distributions

11.4.1 Rent-A-Car Distribution



Distribution Summary

Distribution: Normal

Expression: NORM(161, 49.2)

Square Error: 0.029012

Data Summary

Number of Data Points = 129

Min Data Value = 15.3

Max Data Value = 368

Sample Mean = 161

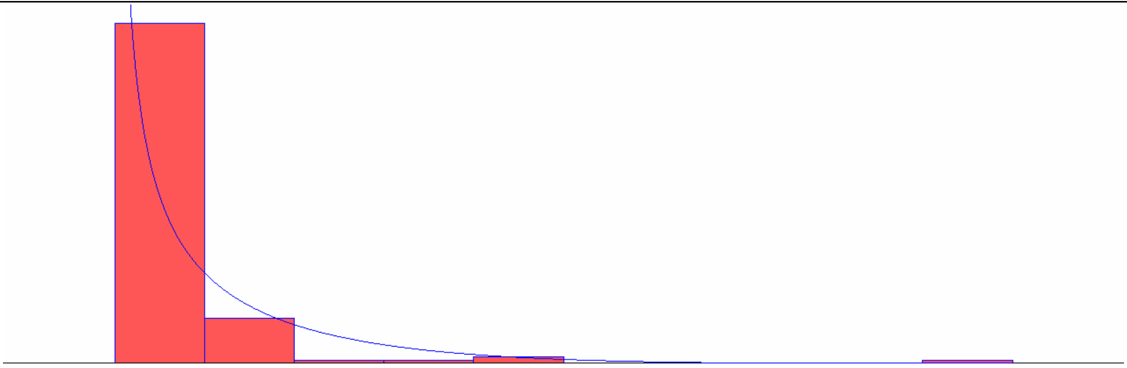
Sample Std Dev = 49.4

Histogram Summary

Histogram Range = 15 to 368

Number of Intervals = 11

11.4.2 Luxury Distribution



Distribution Summary

Distribution: Beta

Expression: 14 + 1.65e+003 * BETA(0.401, 4.68)

Square Error: 0.010696

Data Summary

Number of Data Points = 115

Min Data Value = 14

Max Data Value = 1.67e+003

Sample Mean = 145

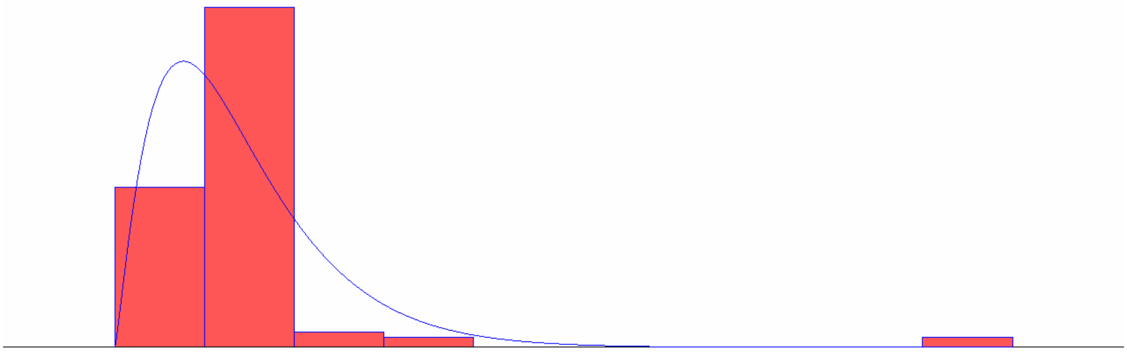
Sample Std Dev = 181

Histogram Summary

Histogram Range = 14 to 1.67e+003

Number of Intervals = 10

11.4.3 Point-to-Point Distribution



Distribution Summary

Distribution: Gamma

Expression: 15 + GAMM(105, 2.22)

Square Error: 0.094223

Data Summary

Number of Data Points = 107

Min Data Value = 15

Max Data Value = 1.69e+003

Sample Mean = 248

Sample Std Dev = 212

Histogram Summary

Histogram Range = 15 to 1.69e+003

Number of Intervals = 10

11.5 Arena® Output Reports

AVIS

Replications: 1 Time Units: Hours

Entity

Other

Group #3 Name (String)

Number In

	Value
Agents	45.0000
Control Entity	69782.00
Inbound Call	2000.00

Number Out

	Value
Agents	45.0000
Control Entity	69782.00
Inbound Call	1955.00

WIP

	Average	Half Width	Minimum Value	Maximum Value
Agents	0.2157	(Insufficient)	0.00	45.0000
Control Entity	0.00	0.000000000	0.00	1.0000
Inbound Call	72.7167	(Correlated)	0.00	412.00

AVIS

Replications: 1 Time Units: Hours

Queue

Time

Waiting Time

	Average	Half Width	Minimum Value	Maximum Value
Idle Agent Queue	0.01910740	(Insufficient)	0.00	0.08643058
Luxury Queue	0.1058	(Correlated)	0.00346670	0.2565
Point2Point Queue	0.1000	(Correlated)	0.00233167	0.1985
RentACar Queue	0.00098791	(Insufficient)	0.00016924	0.00180658

Other

Number Waiting

	Average	Half Width	Minimum Value	Maximum Value
Idle Agent Queue	41.2050	(Correlated)	0.00	45.0000
Luxury Queue	12.8163	(Correlated)	0.00	165.00
Point2Point Queue	15.1159	(Correlated)	0.00	205.00
RentACar Queue	0.00030580	(Insufficient)	0.00	1.0000

AVIS

AVIS

Replications: 1 Time Units: Hours

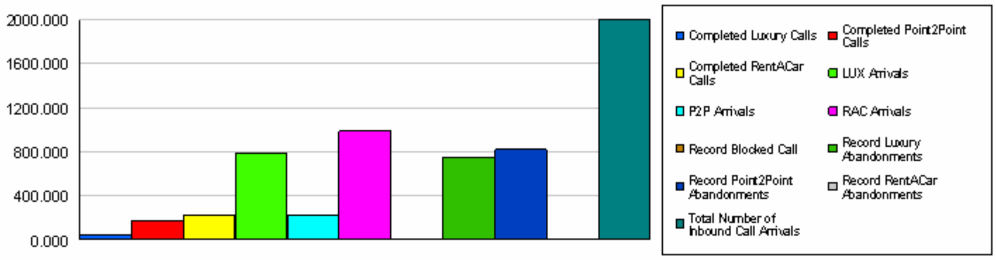
User Specified

Tally

Interval	Average	Half Width	Minimum Value	Maximum Value
Record overall Waiting Queue Time	0.1205	(Correlated)	0.01120664	0.5049

Counter

Count	Value
Completed Luxury Calls	43.0000
Completed Point2Point Calls	171.00
Completed RentACar Calls	222.00
LUX Arrivals	789.00
P2P Arrivals	222.00
RAC Arrivals	989.00
Record Blocked Call	0.00
Record Luxury Abandonments	746.00
Record Point2Point Abandonments	818.00
Record RentACar Abandonments	0.00
Total Number of Inbound Call Arrivals	2000.00



Usage

None	Average	Half Width	Minimum Value	Maximum Value
LUX Tally	0.1968	(Insufficient)	0.01120664	0.5049
P2P Tally	0.1966	(Insufficient)	0.02571557	0.3709
RAC Tally	0.04710930	(Insufficient)	0.01209477	0.08087416