Designing a Simulation and Forecast Model for PruHealth's Call Centre

By
Albert Wilhelm Kieser Van der Wat
24220907

Project Leader: Dr. PJ Jacobs

Submitted in partial fulfilment of the requirements for
the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILD ENVIROMENT AND
INFORMATION TECHNOLOGY

University of Pretoria

23 October 2008

Executive Summary

PruHealth was launched in the UK in 2004, in a joint operation with Prudential, UK's leading Health Insurance Provider. PruHealth forms part of Discovery Holdings, its South African counterpart. Its aim is to infiltrate the UK market of health insurance and become a leading competitor. PruHealth's membership base has grown very rapidly in the past year. This growth is starting to effect the operations of the PruHealth call centre. It seems that forecasting the caller volume for the call centre has become a bit of a headache. PruHealth is looking to optimise their call centre by accurately forecasting future caller volume and maintaining a high service level.

Table of Contents

List of Figures

Glossary

PMI	Private Mortgage Insurance
IVR	Interactive Voice Response
ACD	Automatic Call Distributor
SBR	Skill Based Routing
SL	Service Level
AR	Abandonment Ratio
SMA	Simple Moving Average
WMA	Weighted Moving Average
EMA	Exponential Moving Average
WAM	Weighted Average Method
BAU	Business as Usual

1. Introduction

1.1 Discovery

In 1992 Adrian Gore began Discovery Health. His goal was to provide an innovative new provider of health insurance that offers full cover on all medical related relations, especially chronic illnesses like diabetes. Discovery Health grew rapidly with the number of covered lives increasing from 8 000 in 1993, to 2 million in 2006. Recently Discovery broadened their coverage by releasing new health schemes in the US, Destiny Health, and in the UK, PruHealth.

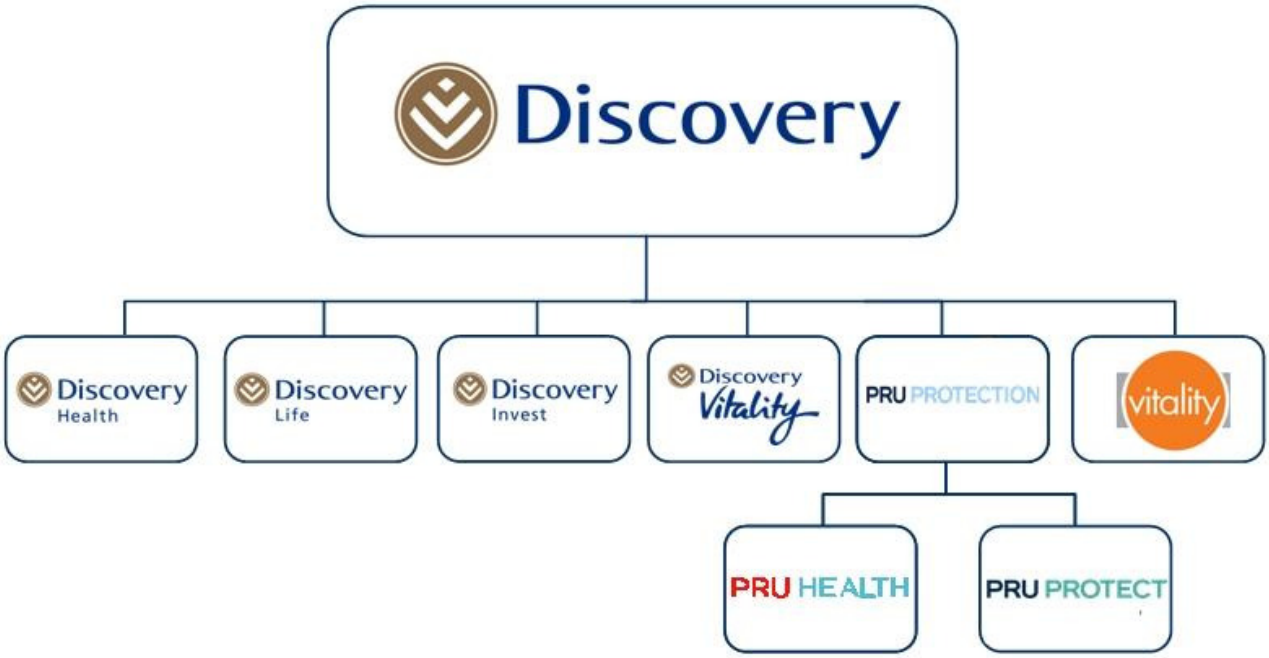
Discovery also holds 70% of the health insurance market in South Africa and it is therefore safe to say that they are in a league of their own. The Private Health Tracker for 2007 rates Discovery's services as the best in the industry, based on healthcare professionals' perception of the service received from medical schemes.

The broadening of Discovery's horizons has increased the strain on their call centres tremendously, especially on PruHealth. Currently Discovery has a call centre for each of their health schemes. All the calls made to Discovery, whether it is from South Africa, America or the UK, are routed to the Discovery call centre in Sandton, Johannesburg.

This project will focus on the PruHealth call centre and optimising the efficiency of the call centre. Building an effective simulation and forecast model will aid the call centre in predicting future trends and determining the effect on the call centre beforehand.

Discovery has a uniquely integrated group management structure which caters for all types of health insurance. Figure 1 below illustrates this structure:

Figure 1: *Group Management structure for Discovery Holdings*



Discovery Holdings consists of 6 main management structures, namely:

- **Discovery Health:** Health Insurance and Health Care Provider.
- **Discovery Life:** Life Insurance
- **Discovery Invest:** Investment Management
- **Discovery Vitality:** Benefit Management
- **PruProtection:** UK Insurance Plan
- **Vitality:** Benefit Management

PruProtection is divided into 2 subsections, namely PruHealth and PruProtect, and form part of Discovery's international sectors. PruHealth consists of Health Insurance Management and PruProtect of Life Insurance Management.

1.2 PruHealth

PruHealth was launched in October 2004 in a joint venture with Prudential, UK's leading life and pension provider. PruHealth uses a different approach when it comes to health care. One of their most successful schemes has recently been launched. The scheme motivates clients to live more healthily, for example: The more you go to the gym, the less you pay on your premium.

Some of the awards that PruHealth has obtained include:

- Health Insurance Company of the Year
- Individual PMI Provider of the Year
- Group PMI Provider of the Year
- Most Innovative New Product
- Best use of Marketing to Intermediaries
- Best PMI Provider

In 2007 PruHealth reached their short term goal of 100 000 lives insured and are now at almost 180 000 lives. In short, the amount of lives covered in the past year is the same as the previous four years.

This has formed a tremendous spike in new members and forced their growth to move from a linear to an almost exponential pattern. This sudden growth in new members and the launch of various new schemes has increased the call volumes on the PruHealth call centre.

Figure 2 and 3 illustrates the growth in lives covered by PruHealth and the increace in caller volume over the past 4 years respectively.

Figure 2: *Graph depicting the rapid growth of PruHealth membership base.*

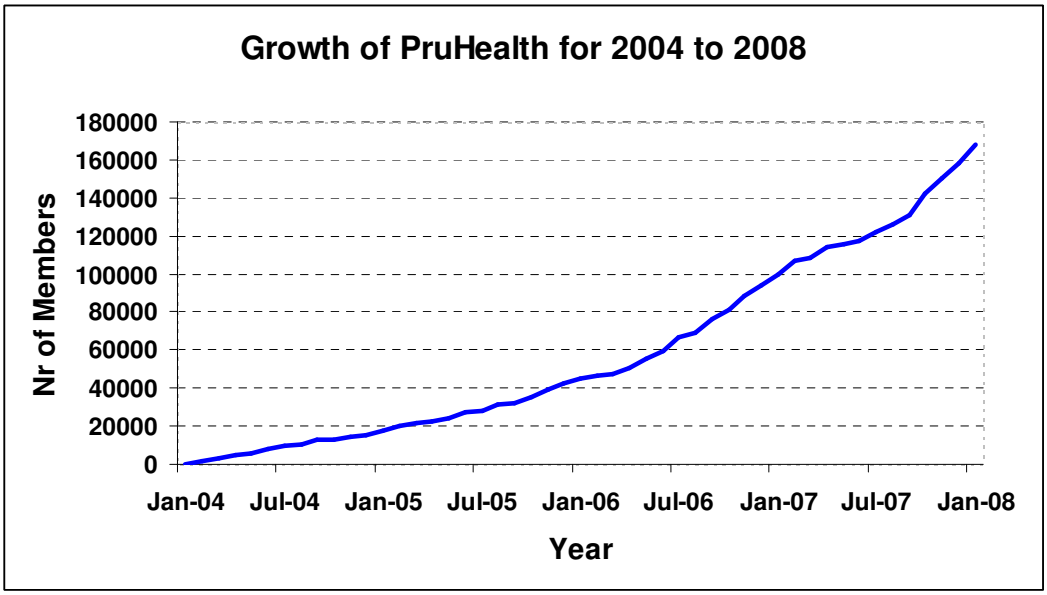
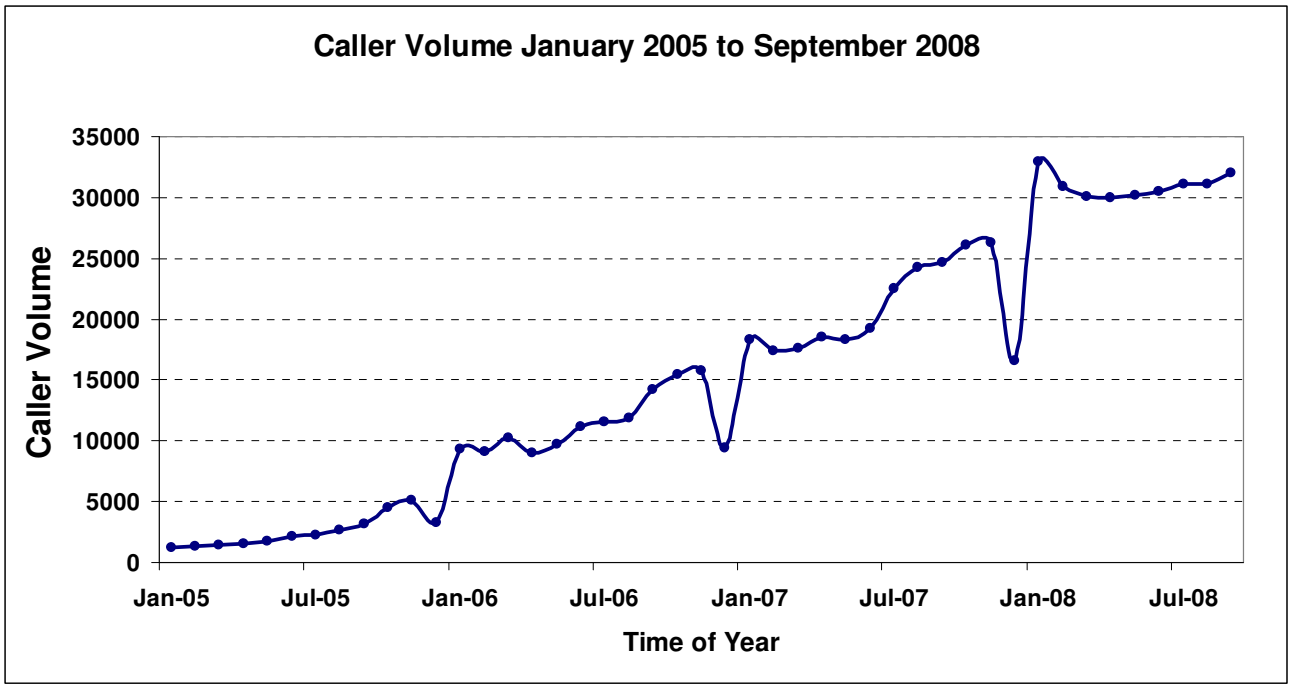


Figure 3: *Graph depicting the growth in Caller Volume over the past 4 years.*



1.3 PruHealth Vitality

PruHealth also utilises the Discovery Vitality Initiative. Vitality rewards clients for living health lives and purchasing products from Discovery Partners. For example, people can see lower-priced motion pictures at Ster-Kinekor, who is a partner with Discovery Health.

In the PruHealth Model people are also rewarded for living healthier lives. At the present moment a person can pay fewer on their premium, depending on how many times they go to the gym. The more frequently you go to the gym the more Vitality Points you earn, this will then determine your *Vitality Status.* The Vitality status is divided into 4 groups, namely Bronze, Silver, Gold and Platinum. Your Vitality status determines what your premium will be, where Bronze represents the normal premium and Platinum the most marked down premium.

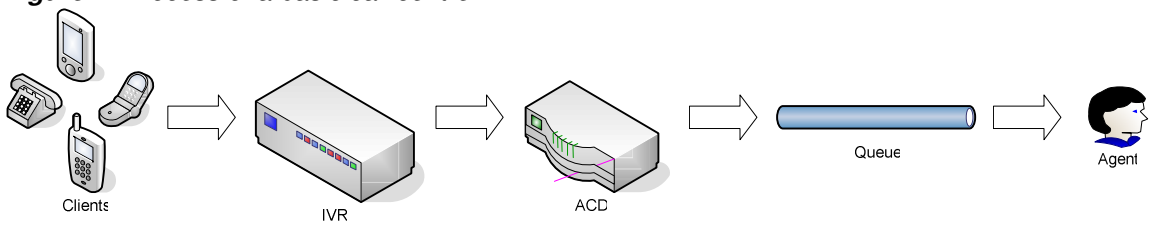
2. Literature Study

2.1 Call Centre Introduction

Telephone call centres are an integral part of any business, and their economic role is significant and growing (Gans, Koole and Mandelbaum, 2003, p.1). A call centre is the assembly point where the customer meets the company. It consists of a set of resources (computers, routers, communication equipment, and employees) which enable the delivery of services via the telephone.

All call centres follow the same basic process of call routing. Once a customer contacts the call centre, the call is connected to an *Interactive Voice Response* (IVR) unit. New advanced technology enables IVRs to use speech-recognition to interpret complex user demands. This enables customers to make use of "self-servicing" i.e. to complete the interaction on the IVR. If an interactive IVR is not present, the call is connected to the *Automatic Call Distributor* (ACD). The ACD is a specialised switch designed to allocate calls to a specific agent. If all agents are busy at the time of the allocation, the call is placed in a queue. Sophisticated ACD's can route calls based on certain routing rules and criteria. Figure 4 depicts the process of a basic call centre.

Figure 4: *Process of a basic call centre.*



Call centres mainly consist of 2 types of routing, namely Single- or Multi-Skill. *Skill-Based Routing* (SBR) consists of rules programmed into the ACD, which controls the agent-to-call and call-to-agent assignments. In multi-skill call centres, calls are distributed to various skill-based agents, depending on the call types (or skill). There is a trend towards multi-skill centres with SBR (Koole and Mandelbaum 2002), according to Mehrotra and Fama (2003), the multi-skill call centre has become ubiquitous.

Typically, call centre managers will be concerned with the following performance measures:

1. ***Service Level (SL).*** This is the fraction of calls that wait less than the acceptable waiting time, usually 20 – 30 seconds. In multi-skill call centres, this includes call types.
2. ***Abandonment Ratio (AR).*** The fraction of calls that are abandoned for any reason.
3. ***Expected Waiting Time.*** The expected time a call waits in a queue.
4. ***Calls Completed Successfully.*** The amount of calls that have answered and completed without any problems or complaints.
5. ***Call Durations.*** Most call centres receive thousands of calls per day. Therefore to ensure that the majority of the calls are answered, the calls duration must be kept to a minimum, while still providing quality service.

2.1.1 Decision Making within a Call Centre

There are various decisions that have to be considered when designing or simulating a call centre. These decisions are integral to the performance and efficiency of the call centre, especially with the internal workings of the call centre. The basic hierarchy of call-centres can be recapitulated as follows (Avramidis and L'Ecuyer, 2005, p. 145).

1. ***Strategic Decisions:*** This entitles the main role of the centre in the company and the type of service the centre needs to provide. These decisions are made by upper management.
2. ***Tactical Decisions:*** These decisions entail how the resources should be utilised. Resources include budgeting, human knowledge and the hiring and training of agents
3. ***Planning Decisions:*** Generally a new time table is introduced every week for an employee work schedule. Once the call centre has reached a stable equilibrium, set time tables can be made on a monthly or even yearly basis.
4. ***Daily Control:*** Daily control entitles the monitoring productivity and SL of the call centre on a daily bases.

5. ***Real-Time Control:*** These decisions are mainly programmed into the ACD, and route the calls to the appropriate agent.

The maintaining of these five decision protocols will lead to a healthy and successful call centre.

2.2 Forecasting

The foundation of any good staffing plan is an accurate workload forecast. Without a defined forecast of the work to be expected, the most sophisticated effort to calculate staff number and create complex schedule plans is wasted effort (Reynolds, 2005).

Forecasting has been implemented throughout the world to improve on situations such as planning for new call types, opening a new centre, a merger, implementing new technology, or a change in operating hours.

The forecasting process is both an art and a science (Reynolds, 2005). It is an art due to the reality that we are predicting the future, and a step-by-step mathematical process that uses historical data and utilises it to predict the future.

2.2.1 Types of forecasting

Forecasting can be classified into four types: *Qualitative, Time Series Analysis, Causal Relationship* and *Simulation.*

Qualitative techniques are subjective or judgemental and are based on estimates and opinions. Time series analysis is focused on the idea of past demand being used to predict future demand. Causal assumes that demand is related to factors in the environment. Simulation modelling allows one to run through a range of assumptions about conditions that are applicable to the forecast.

2.2.2 Qualitative Techniques in Forecasting

Qualitative techniques are defined into five subgroups.

Grass Roots

Grass Roots forecasting builds the forecast by compiling input from those at the end of the hierarchy who deal with what is being forecast. The person closest to the customer, or end use of product, knows its future needs best.

Market research

Information is collected by various methods (surveys, interviews, etc.) to test a hypothesis about the market. Market research is usually used for new product launches and long-range product sales.

Panel Consensus

Panel consensus uses the idea that 2 heads are better than one. Typically discussions in a group will produce better forecasts than individually. Participants may be executives, customers or salespeople.

Historical Analogy

Historical analogy is important in planning new products where a forecast may be derived using historical data from a similar product.

Delphi method

A group of experts respond to questionnaires. Results are then compared and a new questionnaire is compiled. New information is therefore received and the influence of group pressure is nullified.

2.2.3 Time series Analysis

Time series forecasting tries to predict the future based on past data. Time series analysis will therefore be the best initial method to use in the problem encountered in the PruHealth Call Centre.

Time series Analysis consists of seven subgroups:

Simple Moving Average

Simple moving average is typically used when a product is neither growing nor declining rapidly. The average of a time period, containing data points, is determined therefore taking each data point into consideration.

Weighted Moving Average

Unambiguous point may be weighted more or less than others as seen fit by experience.

Exponential Smoothing

Recent data points are weighed more with weighing declining exponentially as data become older. In many applications, the most recent events are more indicative of the future than those in a more distant past.

Regression Analysis (Linear)

Regression is defined as a functional relationship between two or more correlated variables. It fits a straight line to past generally relating the data value to time. The relationship is usually developed from observed data.

Box Jenkins Technique

Probably the most accurate statistical technique available but also the most complicated. Relates a class of statistical models to data and fits the model to the time series by using Bayesian posterior distributions.

Shiskin Time Series

Shiskin Time series is a method that decomposes a time series into seasonal, trends and irregular. It is very dependent on historical data and needs at least 3 years of historical data.

Trend Projections

Fits a mathematical trend line to the data point and projects it into the future.

2.2.4 Causal Relationship

Causal relationship tries to understand the system underlying and surrounding the item being forecast. If a causing element is known far enough in advance, it can be used as a basis for forecasting.

Economical Models

Economical models attempts to describe some sector of the economy by a series of interdependent equations.

Input / Output Models

This model focuses on sales of each industry to other firms and government. The model also indicated changes in sales that a producer industry might expect because of purchasing changes by another industry.

Leading indicators

Leading indicators consist of statistics that move in the same direction as the series being forecast, but move in front of the series. For example, an increase in the petrol price will indicate a future drop in sales of large cars.

Forecasting is one of the worlds' most powerful organisational and managerial techniques. Forecasting is the basis of corporate long term planning. Knowing what the market will do, can put one far above your competitors.

2.3 Simulation

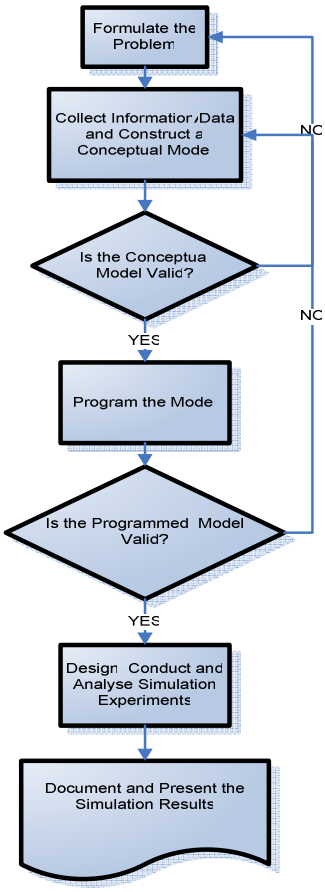
The use of a simulation model is a substitute for experimentation with the actual system, which is usually disruptive, not cost-effective or impossible. Therefore, if the model is not a close representation to the actual system, any conclusions derived from the model are likely to be flawed and may result in costly decisions being made (Law & McComas, 2001, p1). This project will use "The Seven-Step approach for conducting a successful Simulation model" by Law and McComas in building the model.

2.3.1 The Seven-Step Approach for Conducting a Successful Simulation Model

Having a definitive approach for conducting a simulation study is critical to the study's success in general and to develop a valid model in particular.

Figure 5 below portrays a flowchart of the 7 steps.

Figure 5: *The Seven-step Approach*



Step 1: Formulate the problem

All the problem interests are stated by the decision-makers. Informative methods, like meetings, are arranged with critical members of the project to identify the aim and scope of the simulation. Additional information can be obtained including the performance measures that will be used to evaluate the effectiveness of difficult system configuration and the time frame for the study.

Step 2: Collect Information / Data and Construct a Conceptual Model

The collection of information will be a time consuming process. Critical data like system layout, model parameters, probabilities and distributions are integral in constructing a conceptual model.

Step 3: Is the Conceptual Model Valid?

Perform adequate tests on information already known to ensure that the model is working properly. Performing a structured walk-through of the conceptual model before the critical members can provide second opinions about the conceptual model.

Step 4: Program the Model

Program the conceptual model in a commercial simulation-software product. This project will make use of Rockwell Arena Simulation Software.

Step 5: Is the programmed Model Valid?

The results of the programmed model can be compared with performance measures collected from the actual system. The results should be reviewed by a simulation analyst to verify if the results are adequate. Sensitivity analysis can also be performed on the model to see which factors have the greatest effect on the performance measures.

Step 6: Design, Make and Analyse Simulation Experiments.

Run various experiments under deferent situation to analyse the flexibility of the model. Decide on tactical issues such as run length and number replications.
Analysis of the results is crucial in deciding if additional experiments are required.

Step 7: Document and Present the Simulation Results

A detailed description of the computer program and the result should be documented. The flexibility of the model must be discussed to promote the model credibility. Additionally the concept model can be included in the documentation.

Following these simple steps can ensure that the margin of error in the model is completely nullified. It will also guarantee that the process of designing the model does not stray from the initial problem statement.

3. Aim of the Project

Discovery is experiencing some problems with their relatively new, PruHealth call centre. The call centre was opened in 2004 and grew at an extremely rapid rate. In 2007 they achieved their goal of 100 000 members, and 180 000 members in May of 2008. It has taken them one year to obtain the same amount of members, as in the previous four.

The vast increase in their member base has increased the strain on their call centre. The problem is that PruHealth is struggling to forecast what the call volume will be for the coming months. The increase in members is directly linked to an increase in call volume.

PruHealth is also struggling to identify all the variables that have an impact on the call centre. Identifying and determining what the fixed variables are, will have a dramatic effect on the forecasting capabilities of the centre.

The Call centre is also focusing on becoming a more SBR system. PruHealth can only identify what skill each variable requires after all the fixed variables have been defined.

In addition to the forecasting dilemma, PruHealth is aiming to maintain an 85% efficiency ratio on the call centre. The ratio is defined by the amount of calls successfully completed, and the amount of calls abandoned or incomplete.

An effective simulation model will aid in predicting what effect different scenarios will have on the call centre. The model should be able to integrate the different variables and aid in establishing the most optimal solution for the call centre.

4. Project Scope

The scope of the project will focus on gathering information about the call centre and the call centre environment. Adequate information is required to aid in deciding what forecasting models to use. Various forecasting models will be tested to ensure that the most accurate tool is chosen. In the event of more than one effective forecasting model, the 2 models can be coupled together to form a new model.

Simulation has proven to be a highly effective tool in call centres. Companies have resorted to simulation to determine what their call centres are capable of and where they can improve.

This project will use a Simulation tool to effectively determine if the call centre is running on its optimal level. The tool will also be used to identify where improvement can be made. Other approaches are needed to accurately describe the reality of contact centre operations, and modelling these realities can improve contact centre performance significantly.

5. The PruHealth Call Centre

PruHealth is a UK Health Insurance provider that is based in South Africa. All the calls made from the UK are routed to the PruHealth call centre in Sandton, Johannesburg. The calls are then processed by the PruHealth routing system.

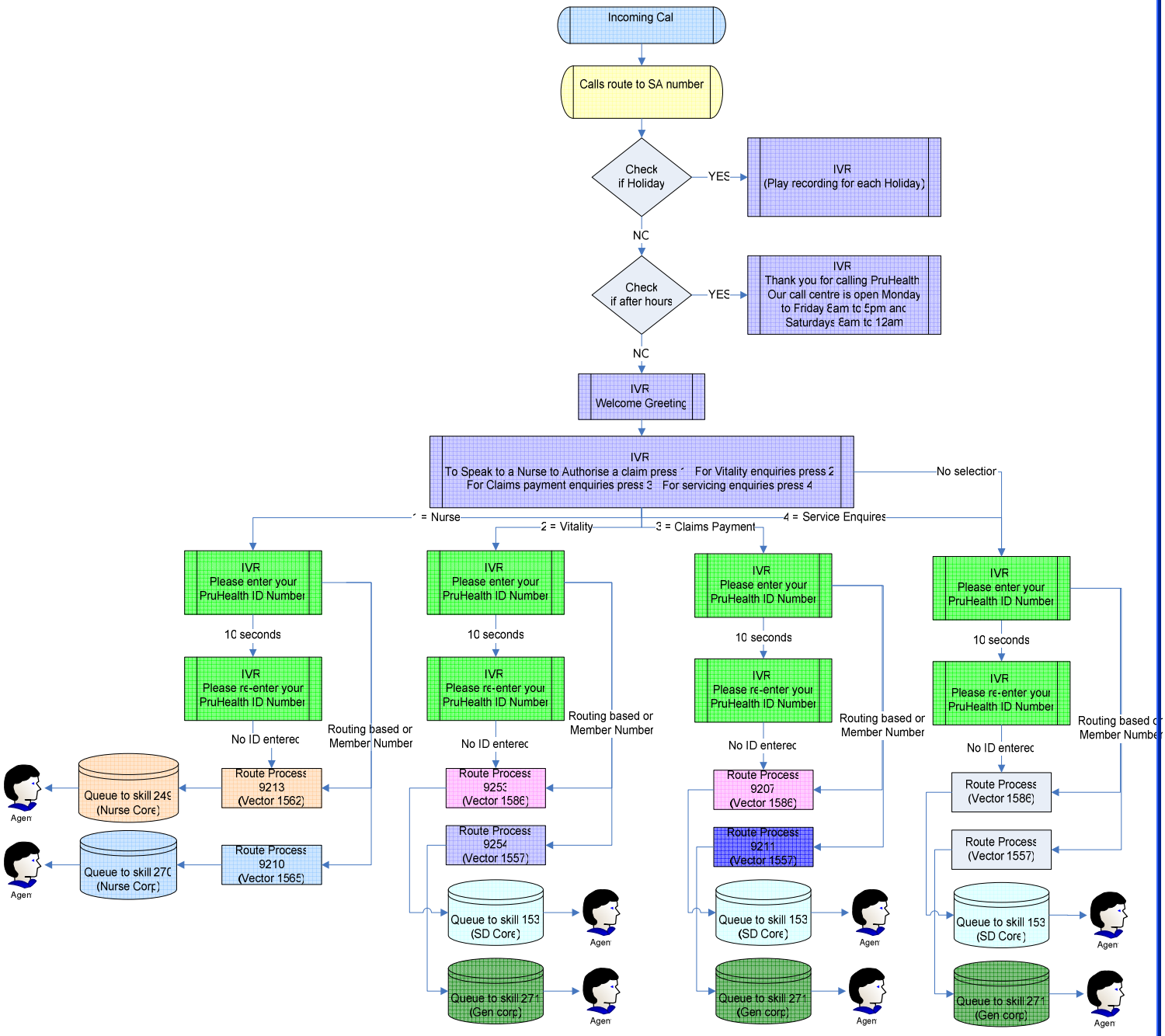
PruHealth consists of 4 types of routing processes, namely: Core, Corporate, Boots and Prudential Corporate. The calls are routed to its allocated process depending on the customer type. SBR is used to route members from different schemes to allocated agents that can handle their type of call.

Difference between the call queues:

- The **Core** queue caters for members on regular health schemes.
- The **Corporate** queue consists of members on elite health schemes. Benefits of the Corporate scheme include higher service levels. Agents that operate in the Corporate queue requires at least 6 months experience and needs to surpass a performance evaluation.
- **Boots** is UK largest pharmacy franchise. They recently joined their whole company to the PruHealth scheme. PruHealth in turn designed an entire call centre process dedicated to Boots employees.
- The **Prudential** queue is dedicated to employees from Prudential.

Figure 6 below illustrates the basic process flow of each queue:

Figure 6: *Basic Process flow of PruHealth Call Centre*



PruHealth consists of a combination of single- and multi-skilled routing. All the calls are routed through the same system. Membership type or Company employee is the decisive element in the routing system. The call will always be routed to an agent skilled enough to handle the call type.

5.1 The Problem

The General Call Centre

There are various problems being encountered at the PruHealth Call Centre.

Problems include:

- Forecasting caller volumes
- Identifying variables
- Predict effect on call centre
- Maintaining an 85% efficiency
- Changing Vitality policies and the impact on the call centre

The eruption of the membership base in 2007 has made forecasting for the call centre rather difficult. Figure 7 illustrates the current minimum and maximum membership predictions from January 2007 to January 2009.

Figure 7: *Predicted Maximum and Minimum Membership from Jan 2007 to Jan 2009*

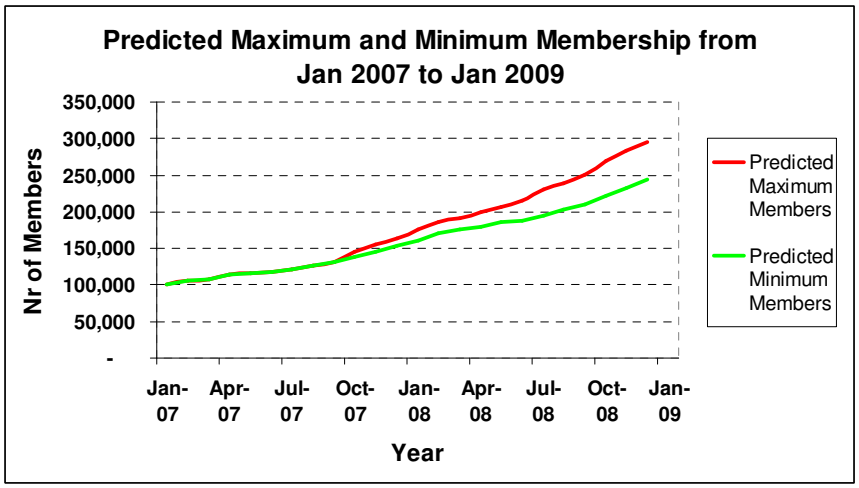
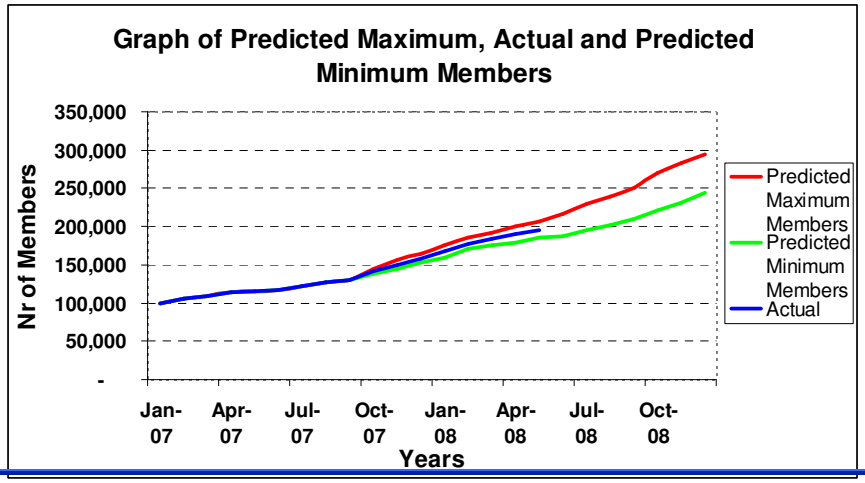


Figure 8 accurately illustrates the Maximum predicted vs. Minimum predicted vs. Actual membership base. Although this graph looks accurate, there is still a difference of up to 50 000 members between minimum, maximum and actual members.

Figure 8: *Predicted Maximum vs. Predicted Minimum vs. Actual Members*



Various forecasting tools will be utilised to determine what tool best suites the current problem. Furthermore, the identification of critical variables is crucial in forecasting techniques. PruHealth has identified a number of fixed variables.
These variables include:

- **Premium collection.** (On the first, 15th and 25th of every month)
- **Claim statement receiving** (Every Thursday)
- **Monthly Newsletters**
- **Corporate schemes joining**
- **Media coverage** (for example, Newspaper Advertising)

These variables are known to have an increase in call volume. PruHealth has identified other non-fixed variables, but are still unable to determine the impact that these variables have on caller volume.

The non-fixed variables include:

- **Policy Age.** (Members are more likely to call within the first 3 months of joining)
- **Sales Channels.** (Members that join PruHealth through their company are not engaged in the product and therefore less likely to call. However, members that buy in their own private capacity are very interested in engaging and therefore call more often.)
- **System Failures**. (For example, a group of members were wrongfully billed)

SBR forms the backbone of any successful call centre. PruHealth have dedicated themselves to ensuring that the right call is routed to the right skill. The split between medically trained and not-medically trained is the most important SBR in the call centre. All calls related to authorisation of claims are routed to a medically trained agent. Members on a Corporate scheme are entitled to better skilled agents, than members on regular schemes. Therefore Corporate members are routed to agents with more than six months experience and surpassed an performance evaluation.

PruHealth has a policy of maintaining 85% efficiency. It has proven that 85% SL is the most effective operating percentage for their call centre. Agent productivity and call volume distribution is successfully achieved at this SL. Unfortunately the increasing growth in caller volume has affected the SL. A direct link can be drawn between the fluctuating SL and the increasing volume.

The Vitality System

PruHealth will also be implementing a new Vitality System. Currently the PruHealth gym Vitality benefits are divided into 3 different groups, namely Infrequent, Occasional and Regular member.

- Infrequent members visit the gym **less than once** a week
- Occasional member visit the gym **less than three** times a week, and
- Regular members visit the gym **more than three** times a week.

Your premium is determined on how frequently you visit the gym. The more frequently a member goes, the less he will pay on his premium.

PruHealth has found that people are misusing the perks of the Vitality points by going to the gym, but not exercising. They will therefore soon be changing the way Vitality Status is determined. The implementation of 6 new criteria's will change the way a member earns points. The new criteria's are: *Exercise, Screening, Nutrition, Education, Personal Goals and Not Smoking.*

In all 6 the criteria, the customer will have to adhere to the following:

Exercise

- Maintain a fitness rating over 6 months
- Improving fitness rating over a 6 month period
- Gym workout
- Attend a organised fitness event

Screening

- Flu vaccination
- Regular check-ups
- Mammogram Glaucoma testing
- Full Health Screen
- Dental check-up

- Pap Smears
- Maintaining blood pressure over 6 month period
- Improving blood pressure over 6 month period

Nutrition

- Maintaining Body Fat target over 6 month period
- Improving Body Fat target over 6 month period
- Creating health meal plan online
- Buying Healthy foods through Sainsbury's

Education

- Personal Health Review
- Reading self-help articles
- Stress education

Personal Goals

- Achieving personal goals
- Maintaining personal goals over 6 month period

Not Smoking

- Being a non-smoker
- Quit smoking and staying clean

All these factors will soon be replacing the current "Gym only"-system. Adhering to most or all of the criteria during the year will result in accumulating Vitality Points and in-turn, improve your Vitality Status. Depending on what your Status is, will determine what your premium will be.

PruHealth has learned from previous occasions not to inform all the members at once. PruHealth fears that a sudden announcement of the new Vitality System will result in a sudden spike in caller volume. They therefore seek to distribute the information over a short period of time. Members will be informed of the change via e-mail or post over a period four weeks.

The overwhelming success of PruHealth might just be its downfall if appropriate and effective measures are not taken immediately.

6. Model Design

The nature of this project has defined the need to utilise techniques from primarily Time Series Analysis forecasting. The PruHealth call centre, much like other call centres, currently relies exclusively on historical data.

6.1 Conceptual Forecasting Design

Focus will be placed on exponential smoothing, regression analysis and trends projections. These forecasting techniques all utilise historical data, especially with data points indicating an increasing growth.

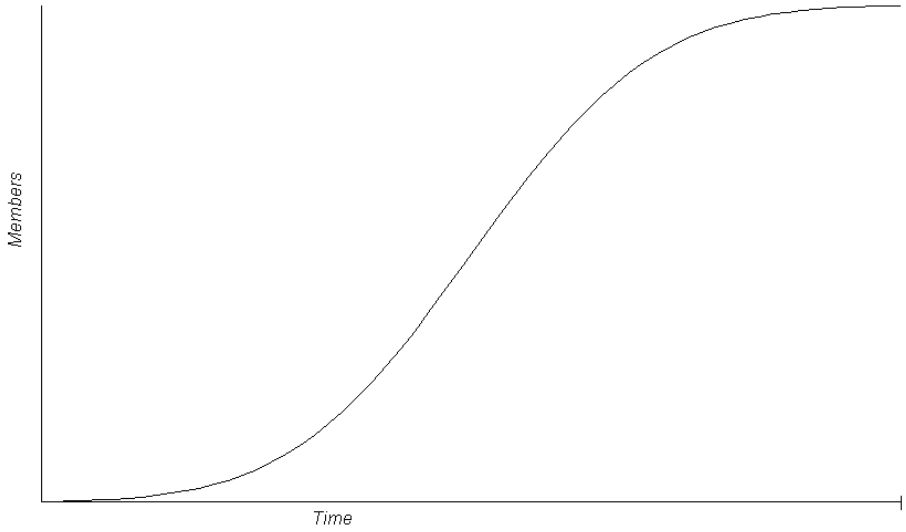


Figure 9: *Predicted trend of membership growth in PruHealth.*

Figure 9 above shows a realistic representation of how the membership growth of PruHealth might be. PruHealth is entering an almost exponential growth rate at the moment, but it is expected that the growth will reach a relative equilibrium.

The expected call volume of the call centre does not necessarily indicate a smooth curve as in Figure 9. Using long and short term forecasting techniques will point out any possible trends and cycles that might occur in the call centre.

The forecasting model will be broken down into 3 different parts, namely, Short-term forecasting, Long-term forecasting and Event forecasting.

6.2 Short-Term Forecasting

Short term forecasting is used to predict what caller volumes might be per week, per day, per hour or even per half an hour. Short term forecasting uses various forecasting techniques, such as Moving Averages and Exponential Smoothing.

Simple Moving Averages

Moving averages are used to smooth out short-term fluctuations, thus highlighting long-term trends and cycles. A Simple Moving Average (SMA) is an un-weighted mean of previous *n* data points. The SMA formula is:

$$SMA_M = \frac{p_{M-1} + p_{M-2} + ... + p_{M-n}}{n}$$

SMA_M = *Forecast for coming period*

p_M = *Occurrence in past period*

Unfortunately, in all cases, a moving average lags behind the latest data point, due to the nature of the smoothing. This can lag to an undesirable extent and disproportionately subjected by older data points dropping out of the average. This problem can fortunately be eliminated by giving extra weight to more recent data points.

Weighted Moving Averages

Whereas the SMA provides equal weight to each component of the moving average, a Weighted Moving Average (WMA) allows any weight to be placed on each element, providing that the sum of all the weights are equal to 1. In relation to this project, the latest data point will have to most weight attached to it. In an *n*-day WMA, the last day has weight *w*, second latest *n-1*, down to zero.

$$WMA_M = \frac{wp_M + (w-1)p_{M-1} + ... + 2p_{M-n+2} + p_{M-n+1}}{n + (n-1) + ... + 2 + 1}$$

The previous formula can be simplified into the following formula:

$$WMA_M = w_1 p_{M-1} + w_2 p_{M-2} + \ldots + w_n p_{M-n}$$

WMA_M = Forecast for coming period *M*

w_n = Weight given to actual occurrence

Values of the weights will differ depending on the time of the year and day of the week. It is sometimes necessary to weigh data points with non-linear weight values, this is known as Exponential Smoothing or Exponential Moving Average (EMA).

Exponential Moving Average

Exponential Moving Average (EMA) applies the weighting for older data point in an exponentially decreasing form. Therefore giving more importance to recent data point and not discarding of older data points. The constant *smoothing factor alpha,* (α), expresses the degree of weighing decrease. The value for the constant is determined both by the nature of the product and by the manager's sense of what constitutes a good response rate. Alternatively, it may be expressed in terms of *N* time periods, where:

$$\alpha = \frac{2}{N+1}$$

Therefore, the formula for calculating the EMA at any time period *M* is designated S_M for any time period $M \geq 2$ is:

$$S_M = \alpha \times p_{M-1} + (1-\alpha) \times S_{M-1}$$

Alternatively, the formula can also be expressed in technical analysis terms as follows, showing how EMA steps towards the latest data point, but only by a proportion of the difference:

$$EMA_{Today} = EMA_{Yesterday} + \alpha \times (p_M - EMA_{Yesterday})$$

The EMA method will be most effective in forecasting what seasonality trends will be on a short-term basis.

Using all the moving average methods will result in an almost near perfect forecast of caller volume on the call centre.

6.2.1 The Short Term Forecast Model

The Short Term Forecast Model utilises monthly historical data and the EMA technique to determine future caller volume and staffing requirements. The model is divided into 5 sections, one for each day of the week. Within each section the user is required to enter the caller volume of the previous 4 weeks, and the caller volume of the previous year for that specified day. Data from the previous year is required to determine the occurrence of trends and to establish the increase in caller volume.

The model determines a caller volume forecast per half-an-hour by weighing the historical data with the value α. Recent data is weighed more highly than data from 4 weeks ago and the year before.

The daily forecast is calculated as follows:

$$\textbf{(1-}\alpha_1\textbf{)}\times\textbf{(Previous weeks' data) +}\ \alpha_2\times\textbf{(Difference between previous 2 weeks' data) +}$$

$$\alpha_3\times\textbf{(Previous third weeks' data) +}\ \alpha_4\times\textbf{(Previous fourth weeks' data) +}$$

$$\alpha_5\times\textbf{(Previous years' data)}$$

With each α weighed at:

Alpha 1	**0.4**
Alpha 2	**0.3**
Alpha 3	**0.2**
Alpha 4	**0.1**
Alpha 5	**0.1**

Once all the historical data has been entered into the model, the staffing requirements can be determined. This is calculated by using the Erlang Add-In of Microsoft Excel. It is calculated by indicating the required SL (85%), the total expected calls forecasted and the average handle time from the previous week.

Appendix A depicts the Short Term Forecast Model for a random day of the week.

Figure 10, below, depicts the graphic output of the historical data vs. the forecasted caller volume for the Short Term Forecast Model in Appendix A.

Figure 10: *Graphic output of daily historical data vs. Forecasted caller volume*

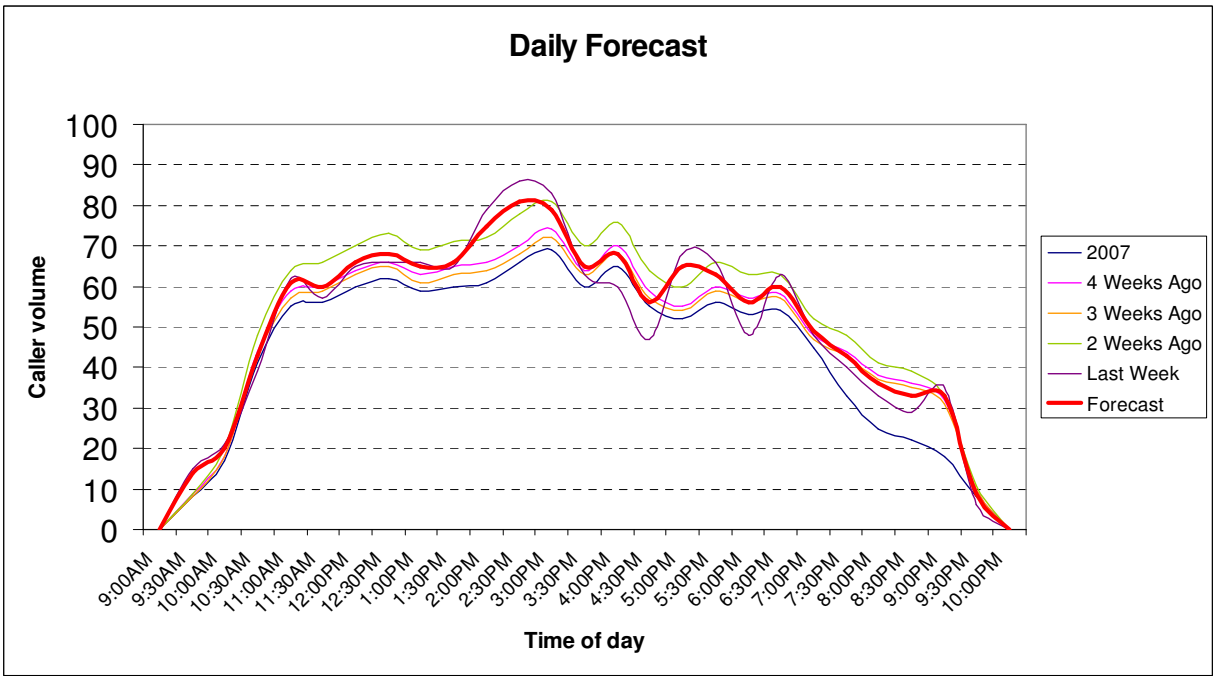
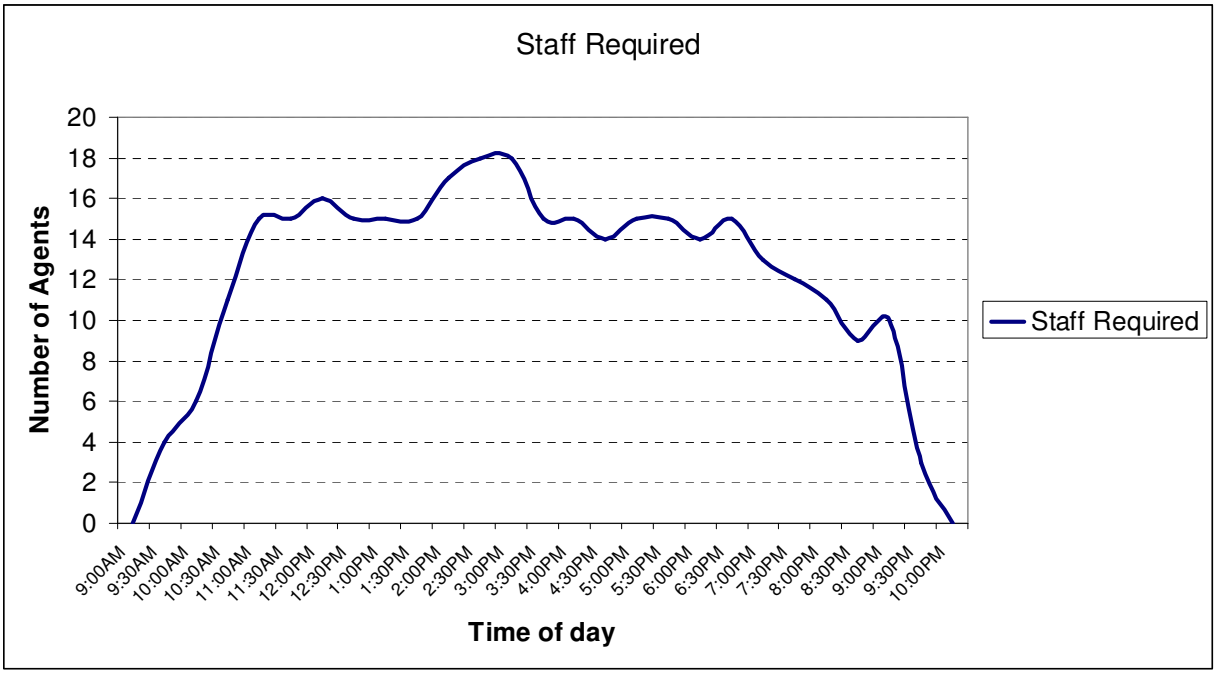


Figure 11 illustrates the expected staffing requirements for the specific day indicated in figure 10.

Figure 11: *Graphic output of daily Staffing requirement*



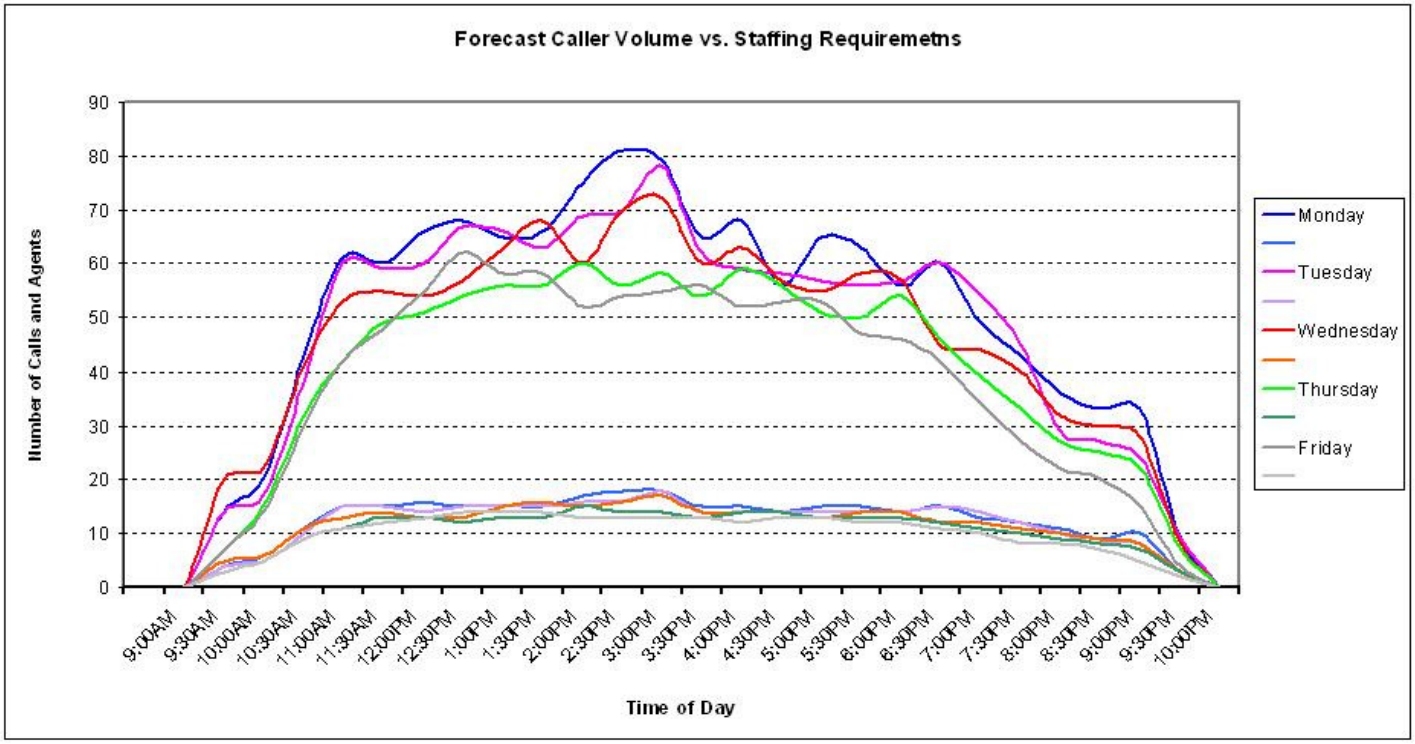
It is clear from the graph in figure 10 that the forecast follows recent data more closely than the other data points. This is due to α being weighed more for recent data points. This will ensure more accurate future forecasts by weighing the growth of caller volume in PruHealth.

This process is then repeated for each day of the week to provide a weekly forecast. *Appendix B* indicates the final weekly forecast of the Short Term Forecast Model

The final weekly forecast indicates the expected caller volume per half-an-hour and the allocated staffing requirements. It also depicts the total caller volume per day and the average staffing requirements per day.

Figure 12 illustrates the forecasted caller volume for the following week vs. the expected staffing requirements for that week.

Figure 12: *Graphic output of weekly Forecasted caller volume vs. Staffing requirements*



Interpreting Results

The use of the Short Term Forecast Model can dramatically improve the daily and weekly forecasts of the call centre. Certain trends can be determined, for example: peak times during the day and the decrease in caller volume as the week progresses.

Figure 12 clearly indicates a decrease in caller volume during the week and a clear daily peak during 1:30pm and 4:00pm. This information is critical in determining a daily and weekly staffing schedule. Furthermore, Figure 10 signifies a growth from 2007 to the present day forecasted information. This proves that PruHealth is on the right path to show considerable growth.

The Short Term Forecasting Model has proven to be an effective tool in determining what the short term caller volume of the call centre will be.

6.3 Long Term Forecasting

Long term forecasting will essentially only consist of Regression Analysis. Using Regression methods will aid in predicting any trends or cycles that may occur and where they might occur next. Long term forecasting will also indicate what effect seasons have on the call centre and also taking into account what effect holidays will have on the call centre.

Linear Regression

Linear regression forms a relationship between one or more independent variables and other variables. A linear regression equation with one independent variable represents a straight line.

The data consists of *n* values $x_{i,1},...,x_{i,n}$ for each of the *m* independent variables $x_i(i=1,...,m))$, and *n* values, $y_1,...,y_n$ of the dependent variable *y.* There are *m* parameters to be determined, $\beta_1,...,\beta_m$.

The model is defined by:

$$y_i = \sum_{j=1}^{m} X_{ij}\beta_j + \varepsilon_i$$

X = a constant

ε = Error term

The simple linear regression model can be represented by a straight line and depicted by:

$$y_i = \beta_1 + x_i\beta_2 + ... + \varepsilon_i$$

A Linear regression model need not be a linear function of the independent variables.

Non-Linear Regression

Non-Linear regression uses observational data to model a function which is a non-linear combination of the model parameters and depends on one or more independent variable. The data consists of *m* values taken from observations, *y* and independent variable, *x.*

The equation is represented as:

$$f(x,\beta)=\frac{\beta_1 x}{\beta_2 + x}$$

β = Non-Linear parameters

This formula is repeated to obtain the optimal required regression.

Combining both linear and non-linear regression will result in an adequate long-term forecasting model. The model should be able to indicate seasonal trends and identify any other unknown variables.

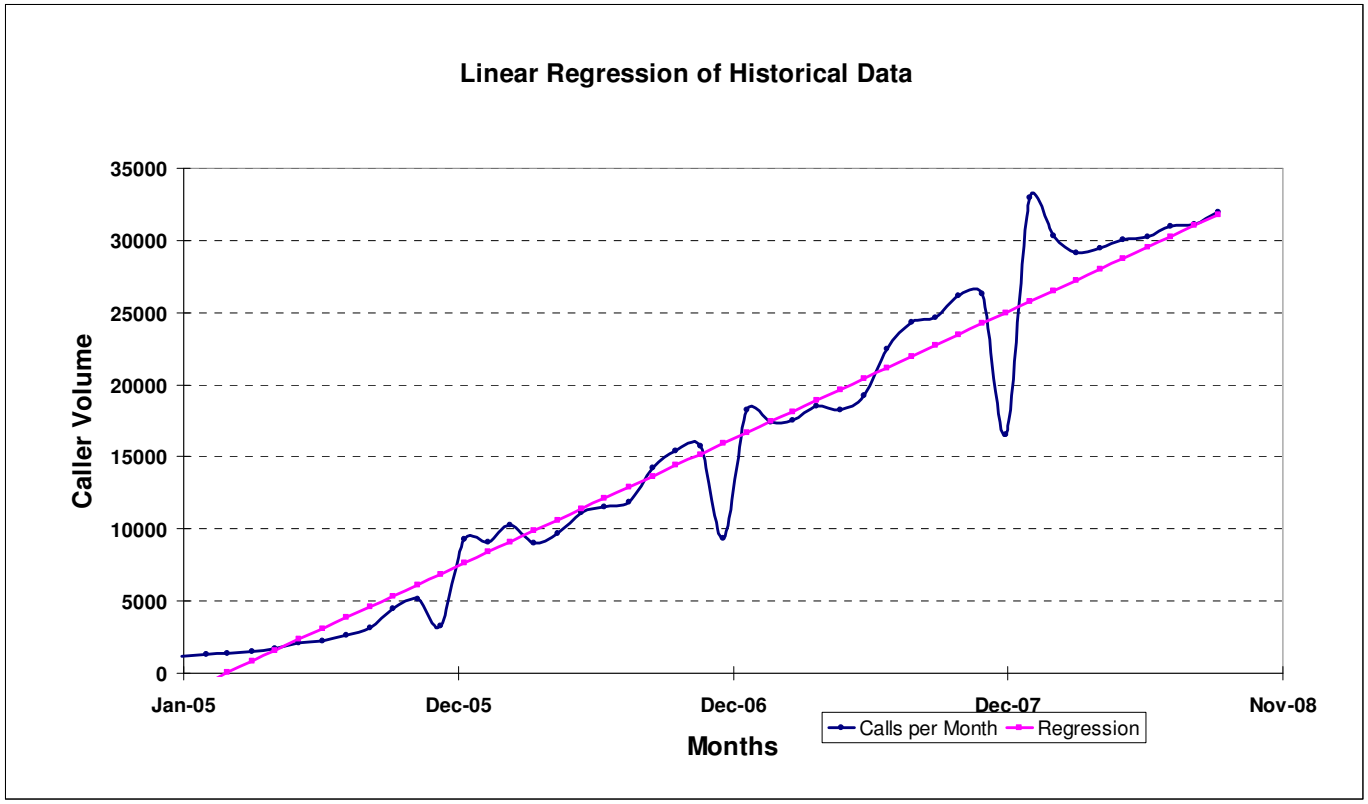
6.3.1 The Long Term Forecasting Model

The Long Term Forecasting Model utilises data from the previous 13 months to forecast caller volumes for the coming months. The model aids in predicting the growth of the call centre and determining what seasonal effect have on the call centre.

From figure 3, on page 4, it is clear that the PruHealth call centre has an increasing growth in call volume each year. The effect of seasonality is noticeable during the month of December and January. December shows a hefty decrease in caller volume followed by a large increase, in January, of almost double the December caller volume. The growth then grows steadily during the year and peaks again in the months before December.

Applying linear regression on the historical data indicates a stable growth in the caller volume. This is illustrated in Figure 13:

Figure 13: *Linear Regression Growth of Caller Volume*



The Long Term Forecast Model aims to include the influence of seasonality when predicting monthly volumes. This is done by "deseasonalising" the data.

When a time series displays repeating seasonal fluctuations, the data should be "deseasonalised" or seasonally adjusted before other forecasting techniques are applied. The "deseasonalised" data can then forecasted using exponential smoothing. Once this is completed, the forecast is "reseasonalised" to get the desired result. "Deseasonalisation" is usually not performed unless you have at least three full seasons of data. Luckily the PruHealth call centre just about falls within the criteria.

"Deseasonalising" and "reseasonilising" is accomplished as follows:

1. Calculate seasonality factors for each month, indicating that month's percentage of the average monthly total for the series, as follows:

$$S_j = \frac{12}{N}\sum_{i=1}^{N}\frac{Y_{ij}}{A_i}, j = 1...12$$

Where N is the number of complete years worth of data, Y_{ij} is the value of the time series $Y(t)$ in the month *j* of year *i*, and A_i is the annual total of the series in year *i*.

2. Calculate the "deseasonalised" data by dividing the data in each month by its corresponding seasonality factor. This is accomplished by using the following formula:

$$D_{ij} = \frac{Y_{ij}}{S_j}, i = 1...N, j = 1...12$$

3. A 12-month forecast, f_j is made of the $D's$, using one- or two-parameter exponential smoothing.

4. Finally the final forecast, F_j, is calculated by multiplying each month of the future forecast by its corresponding seasonality factor. This is indicated in the following formula:

$$F_j = S_j f_j, j = 1...12$$

Error in the Model

The model can unfortunately not forecast too far in the future. This is due to the rapid and irregular growth of caller volume. The call centre has not yet reached a stable seasonal trend and rather shows a rapid and fluctuating growth of caller volume per month. This produces an error in the forecasting model. Figure 14 illustrates the affect of this error.

Figure 14: *Error in Long Term Forecasting Model*

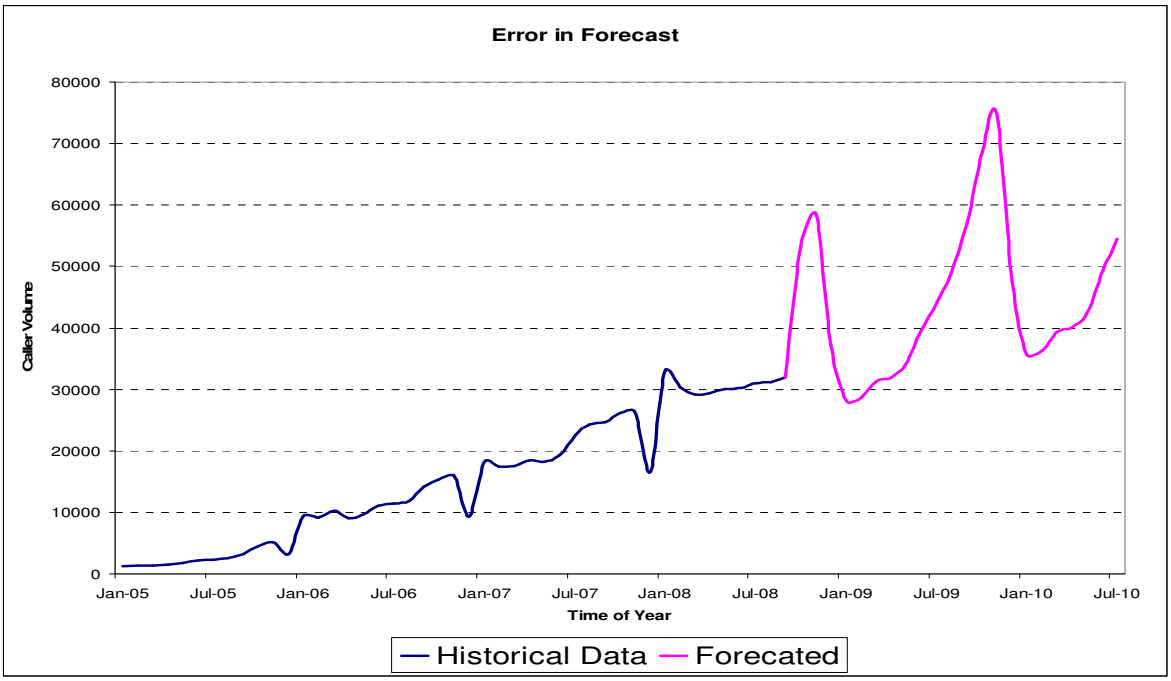


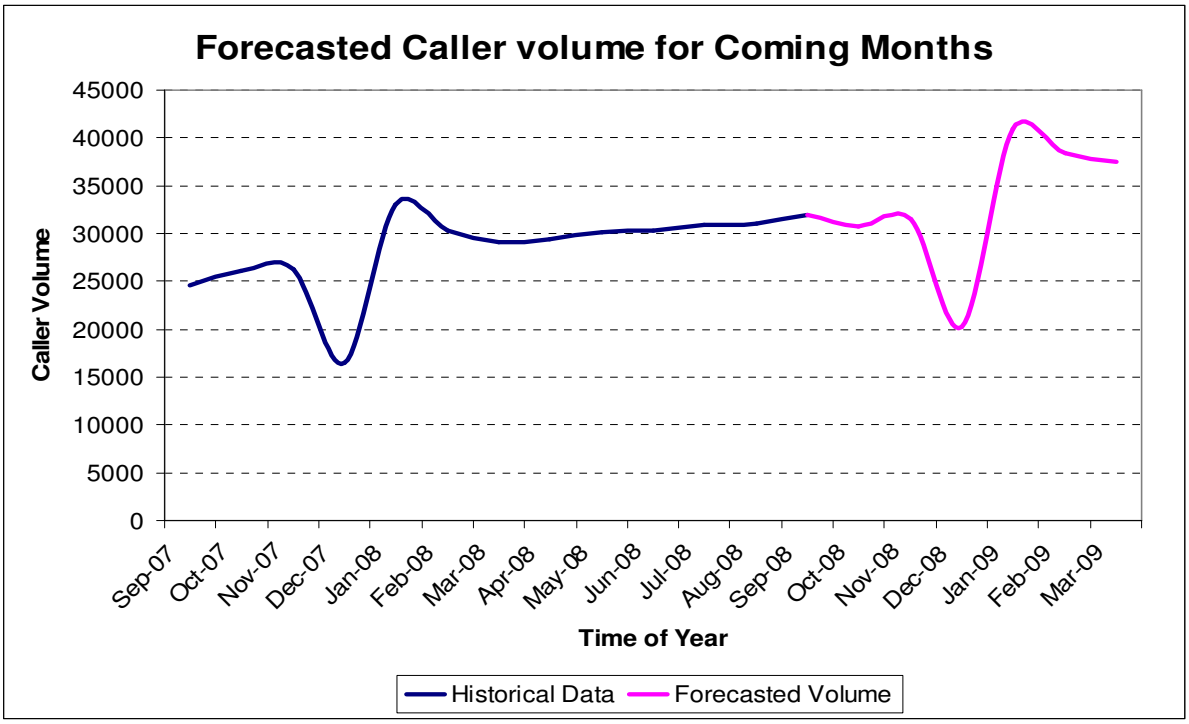
Figure 14 visibly indicates a sudden rapid growth from end September 2008 to January 2009 and completely ignores the seasonal decrease that should occur during December of 2008. The December decrease has now moved to February 2009 and transpires once more in February 2010. The origin of the error lays in the historical data. The seasonality factor becomes "corrupted" by the sudden growth in the caller volume between January 2007 and September 2008.

Overcoming the error can only be achieved by reducing the amount of historical data used in the model. Using a maximum of 13 data periods, 13 months, will eliminate the error and provide an effective seasonality factor.

How the model works

Only data form the previous 13 months needs to be entered into the model. The model will then determine the seasonality factor of each month and "deseasonlise" the data. This is followed by applying exponential smoothing to the data. Finally the forecast is completed by "reseasonalising" the data. *Appendix C* illustrates the calculation of the seasonality factor and "deseasonalising" the historical data. Figure 15 demonstrates the results of the forecast model:

Figure 15: *Results of Long Term Forecasting Model*



Interpreting Results

We can undoubtedly observe the nullification of the error that occurred in figure 14. The graph above illustrates the seasonal decrease in caller volume over the month of December 2008 and rapid increase in January 2009. Furthermore, we can notice the steady growth from the previous year. Unfortunately the margin of error will increase if we desire to forecast beyond the indicated months.

Forecasting for more than the indicated months can only happen once the call centre reaches a stable seasonal trend. Alas, this will only occur once PruHealth reaches a stable membership base.

6.4 Event Forecasting / New Vitality System Model

Identifying what variables have an impact on the call centre and how these variables can be controlled, forms part of the most important aspects of forecasting. PruHealth is a fairly new health insurance provider in the UK. These innovative ideas made a huge impact on the market and the way people looked at health insurance. Unfortunately people found certain loopholes in their system. For example, people went to the gym and eat at the cafeteria without exercising, but still claimed their Vitality Points.

PruHealth realised they had to broaden the system of Vitality Point earnings to close the loopholes and any other anomalies. By introducing their new Vitality Status system (Mentioned section 5.1) will insure that members live healthier lives and work harder to earn Vitality Points and ultimately pay less on their premium.

The Events Forecasting Model provides a day-by-day breakdown of when certain members will be notified of the changing Vitality System and the impact it might have on the call centre. This model can also be used to determine any other future transformations and the effect it will have on the Call Centre.

Model Break-Down

Figure 16:*:Illustrated Break-Down of Events Model*

	Time Period of Event
Event Description	**Distribution of E-mails and Post to members**
Total Additional Calls per Day	
Business as Usual (BAU) Forecasted Calls	
Total Calls	
Current Capacity	
Difference	
Additional Agents	
Call Response Rate	

For the Problem at hand, the model will notify members according a priority list. The priority list was designed by PruHealth to indicate which members will be largely affected

by the change. Member largely effected will be notified first and members least effected, last. Table 1 indicates how the priority groups work:

Table 1: *Priority list of members*

Priority	Description
1	Individual Regular: Bronze, Silver, Gold < 3 Months to Renewal
2	Individual Occasional: Bronze, Silver < 3 Months To Renewal
3	Individual Regular: Bronze, Silver, Gold > 3 Months To Renewal
4	Individual Occasional: Bronze, Silver > 3 Months To Renewal
5	Individual Regular: Platinum
6	Individual All Others
7	All Protect Members
8	Group Regular: Bronze, Silver, Gold < 3 months To Renewal
9	Group Occasional: Bronze, Silver < 3 Months To Renewal
10	Group Regular: Bronze, Silver, Gold > 3 Months To Renewal
11	Group Occasional: Bronze, Silver > 3 months To Renewal
12	Group Regular: Platinum
13	Group All Other

The use of different colours is used to avoid confusion and better analyse the segments in the final model.

The priority list is divided into the following segments:

- **Individual**

This includes members that joined PruHealth privately. Privately joined members are more interactive with their policy and more aware of changes in the policy.

- **Group**

Group members joined PruHealth through their company or business. These members are generally not as interactive with their policy.

- **Gym Usage**

Indicates what Vitality status the members are on (Bronze, Silver, Gold or Platinum)

- **Months to Renewal**

People who are less than 3 months to the renewal of their contract will be affected sooner that people who are more than 3 months to renewal.

Take note, Regular gym members can still be on a Bronze status, as the upgrading to a next level only occurs every 3 months.

Priorities 1 through 7 include all individual members. Individual members are more involved with their policy and changes that influence them directly. They will therefore be notified first.

The detail of the Priorities will be discussed as follows:

Priority 1

All individual members who are Regular gym users, on a Bronze, Silver or Gold Status and have less than 3 months to renewal will be largely effected by the change. This is due to how regularly they visit the gym. They will therefore have to adhere to the new changes to stay on their status.

Priority 2

All individual members who are Occasional gym users, on a Bronze or Silver Status and have less than 3 months to renewal will also be effected by the change. Priority 1 and 2 are divided, due to the large amount of members within the segments.

Priority 3 and 4

These priorities are the same as priority 1 and 2, except these members are more than 3 months to their next renewal. Hence these members will only be affected later.

Priority 5

Members on a Platinum status are known to frequently visit the gym and are healthy individuals. These members are consideration to keep on living healthily regardless of the change, and will therefore not be greatly affected by the system change.

Priority 6 and 7

Individual members who are Infrequent gym users will probably not be bothered by the Vitality system change. Protect Members are members on the Life Insurance policy.

Priorities 8 through 13

Priorities 8 through 13 follow the same criteria as priorities 1 through 6. The difference occurs with the Group members being notified. Group members joined PruHealth via their business and company. They are therefore not particularly active with the policy and prefer that the company attend to the administration of the policy.

How the model works

The Events Forecast Model was build to determine how the different priority segments should be distributed through the indicated notification period and what effect it will have on the call centre. In this case, the notification period extends through the month of July. It also indicates the total amount of additional calls per day, additional agents required and the call response rate.

PruHealth notifies their members using e-mail or post, depending on what the member prefers. The priority segments are therefore divided into 2 sections, E-mail and Post indicated in *Appendix D*. The values entered in the "Total" column, indicates the total amount of members for the segment, i.e. Segment 1 has 1663 members. This amount is then multiplied with the Weighted Average (WA) of expected calls to determine the amount of additional calls expected from that segment.

The weighted average value is a single amount of expected calls using the Weighted Average Method (WAM).
The WAM equation is:

$$\overline{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

w = *Weight per Member Segment*

x = *Amount of Members*

Each WA value, in Appendix D, is determined by multiplying the amount of members per segment with the likelihood that they would contact the call centre, indicated in *Appendix E.* For Example: The expected amount of calls form e-mail distribution for segment 1 (yellow), is defined by multiplying the sum of total e-mails sent with the WA of their likelihood to contact PruHealth. Therefore:

$$1663 \times 54.4\% = 904 \text{ expected calls}$$

Appendix E depicts the amount of members per Status group, whether they are Regular, Occasional or Infrequent Gym users and if they are more, or less than 3 months to renewal. It also indicates the segment likelihood of a member contacting PruHealth.

The main body of the model will use the WA value and determine what amount of emails and post must be sent per day, based on the amount of expected calls from that segment. The criteria to constrain the maximum amount of calls per day include:

- **Total Additional calls per day**

Additional expected calls determined by the WA value

- **Business As Usual (BAU) Forecasted calls**

Expected calls forecasted for that day

- **Current Capacity**

The current management capacity of the call centre is approximately 1500 calls per day.

- **Capacity Difference**

The difference in the current capacity of the call centre and the additional calls expected.

- **Additional Agents**

The Erlang Add-In in Excel will assist in predicting the number of additional agents required to uphold the service level.

- **Call Response Rate**

Call response rate indicates the percentage of additional calls received per day, divided by the total amount of e-mails and post received.

The Erlang equations consists of combining required SL, expected response time, additional expected calls, the percentage of calls in busiest hour of the day and average call time. Simplified, the equation materialises into:

(Required SL, Response Time(Additional Calls×Calls in Busiest Hour)Average Call time)

Substituting fixed values into the equation provides the following:

(85%, 15 (Additional Calls × 12.5%)320 seconds)

A Service Level of 85% has to be maintained for calls answered within 15 seconds and maintaining an average call time to 320 seconds. The 85% SL forms and integral part of the model as PruHealth strives to maintain their high quality of service.

Appendix F depicts the main body of the model as it was used. This model was used to determine the amount of additional calls induced by the informing the members of the changes.

The model depicts the most effective distribution of e-mails and post to be distributed during the given informing period. The amount of e-mails and post sent is directly linked to the amount of additional calls expected. The model only works on the following assumptions:

- The members will contact the call centre on the same day they receive the e-mail or post
- The post has to be sent out 3 days before the members are scheduled to receive it.
- The second week has to obtain the most additional agents.
- Members are most likely to contact in the afternoon when they return from work.

With effective use this model, we can determine the following:

- ✓ Total expected additional calls
- ✓ Number of additional agents required
- ✓ Expected Call Response Rate

We can hereby effectively determine how the distribution of e-mails and post should be allocated to utilise the full potential of the call centre.

The Events Model has proven to be a highly effective forecasting tool. It utilises all the PruHealth requirements, including maintaining an 85% Service Level. The Model is depicted with the effect of the new Vitality System change, but can be used for any future alterations implemented. PruHealth can hereby monitor the effect on the call centre and when to inform certain members.

Figure 17 displays the additional calls expected over the period of the Event.

Figure 17::*Expected additional calls per day*

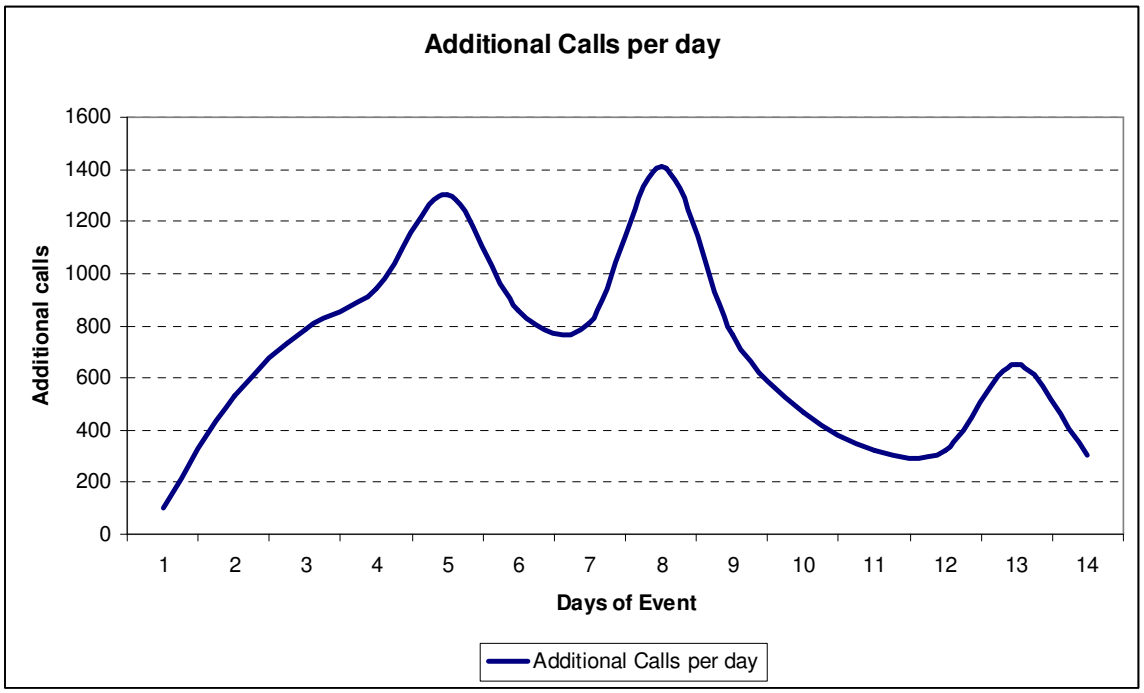
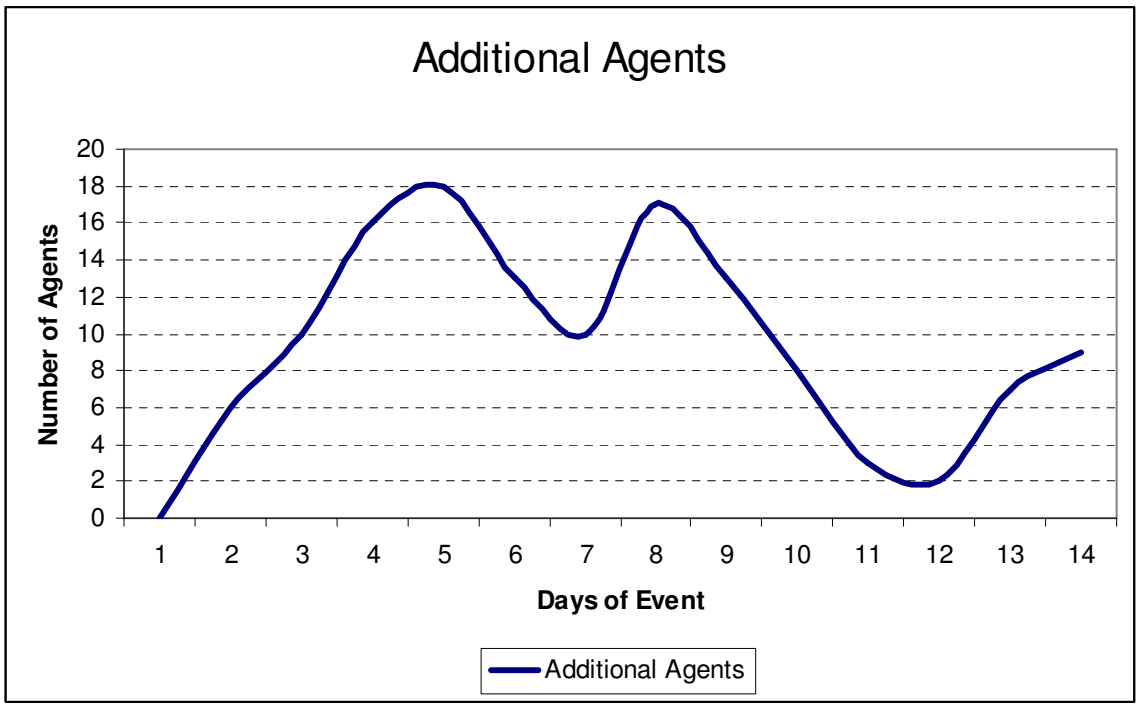


Figure 18 displays the additional agents required to handle the additional calls.

Figure 18::*Expected additional agents per day*



7. Simulation Design

Arena Simulation, by Rockwell Software, will be used to simulate the call centre. Arena has proven to be the best simulation program in the world. It is extremely easy to use and has all the features required to simulate the problem at hand.

Figure 19, represent the most popular simulation programs used at the annual Winter Simulation Conference.

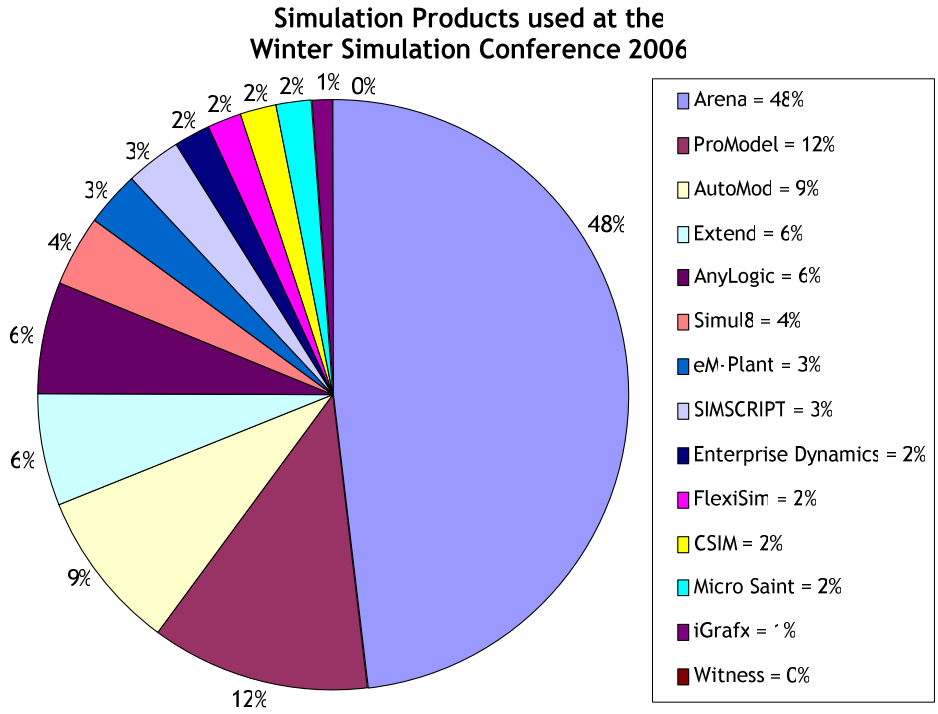


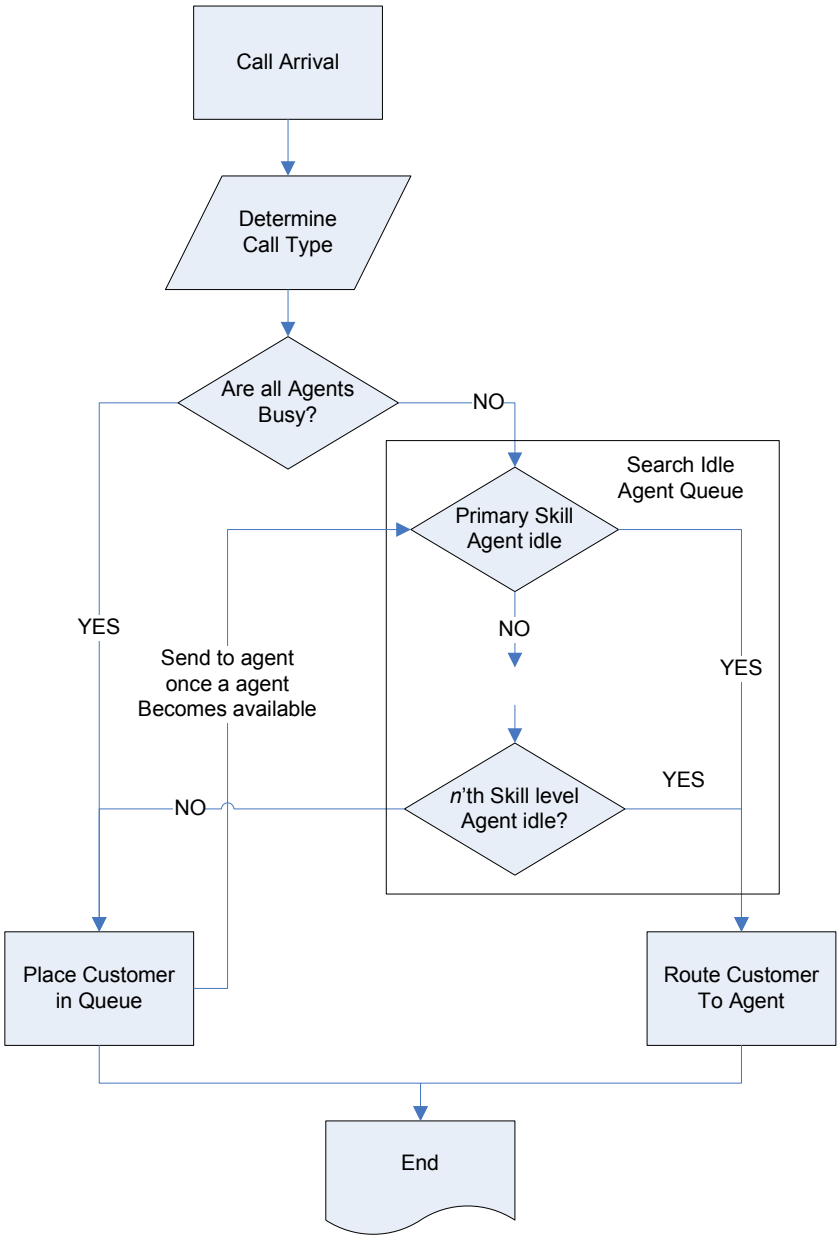
Figure 19: *Popular simulation programs used at the annual Winter Simulation Conference*

The simulation model will follow a basic call centre SBR system. Calls received will be identified and placed in their adequate queue. The model is built to maintain the high quality of SBR currently at PruHealth.

The model will simulate the 4 main queues of PruHealth, namely Core, Corporate, Boots and Prudential. The aim of the model is to determine the effects on the various queues.

Figure 20 demonstrates the inner workings of receiving a call and placing it in a SBR queue.

Figure 20: *SBR system*



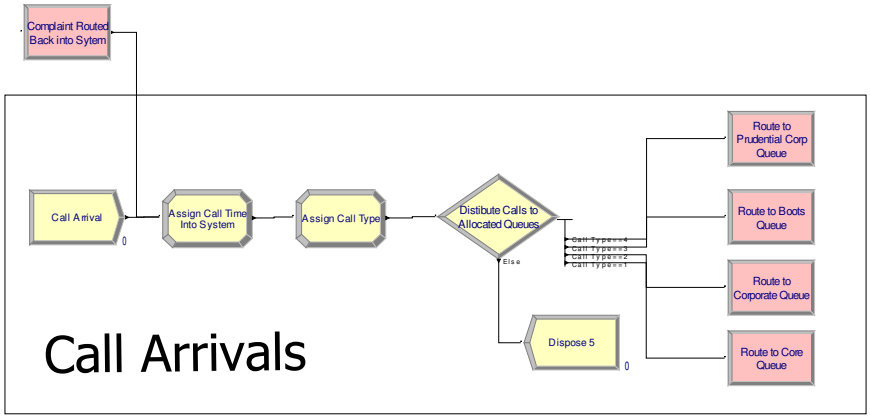
7.1 Model Breakdown

The model has been broken down into 4 sections, namely: Call Arrivals, Skill Routing, Process Queue and Probability of Complaint.

Call Arrivals

The call arrival generates calls for the call centre. Once a call is received it is assigned a Call Type. The call type is a discrete probability distribution of the type of call that can be received. Call types include: Core, Corporate, Boots and Prudential. The calls are then distributed to their allocated queues.

Call Arrivals



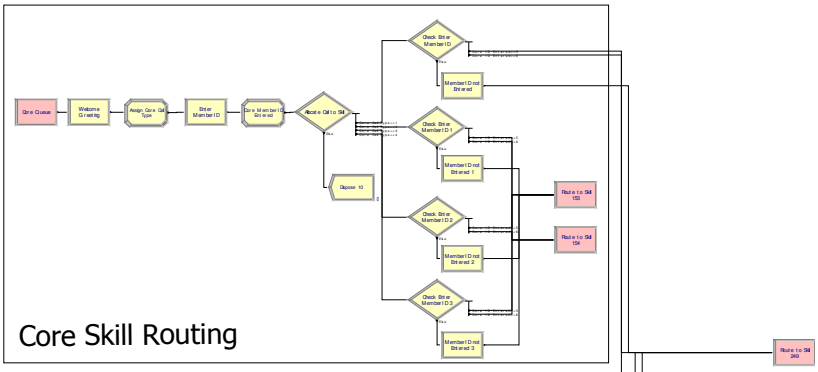
Skill Routing

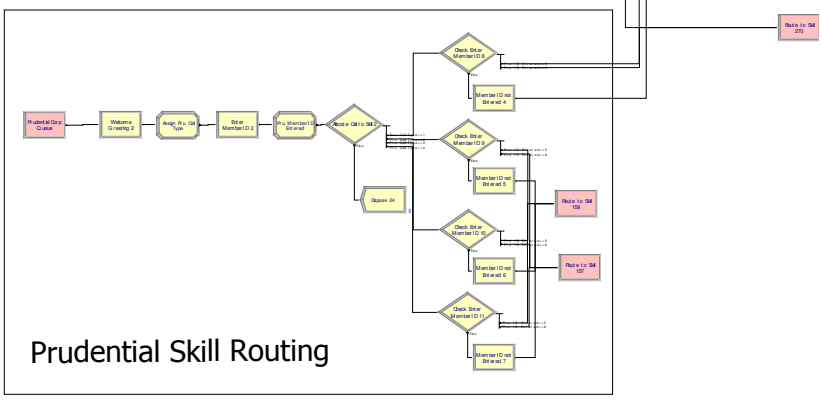
When a call reaches its allocated queue it is met by an IVR greeting and delayed for 10 seconds. The call is then assigned a type, or nature of call. The nature of the call will determine what skill the call requires. Allocation of the nature of the call is also determined by a discrete probability.

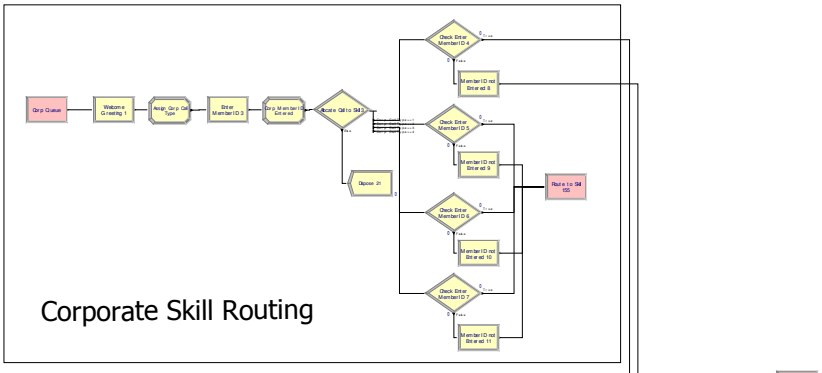
After the nature of the call is assigned it is assigned an additional membership ID. Some calls will not be assigned membership ID's.

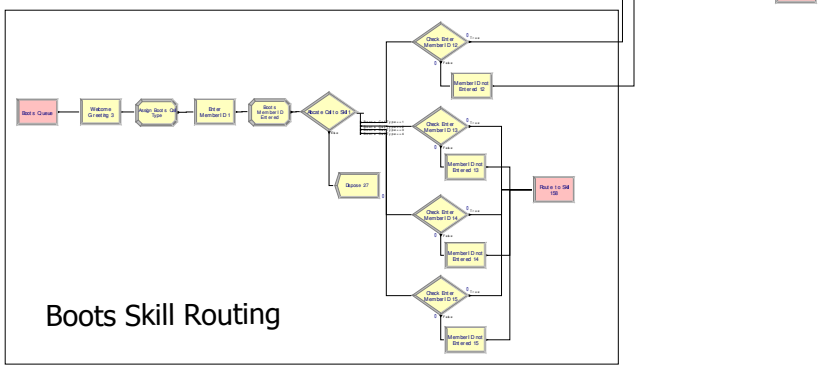
The calls are then requested to provide their membership ID's. Calls without membership ID's will be distributed differently to calls with membership ID's.

Finally the calls are distributed to their allocated skill queues depending on the nature of the call.





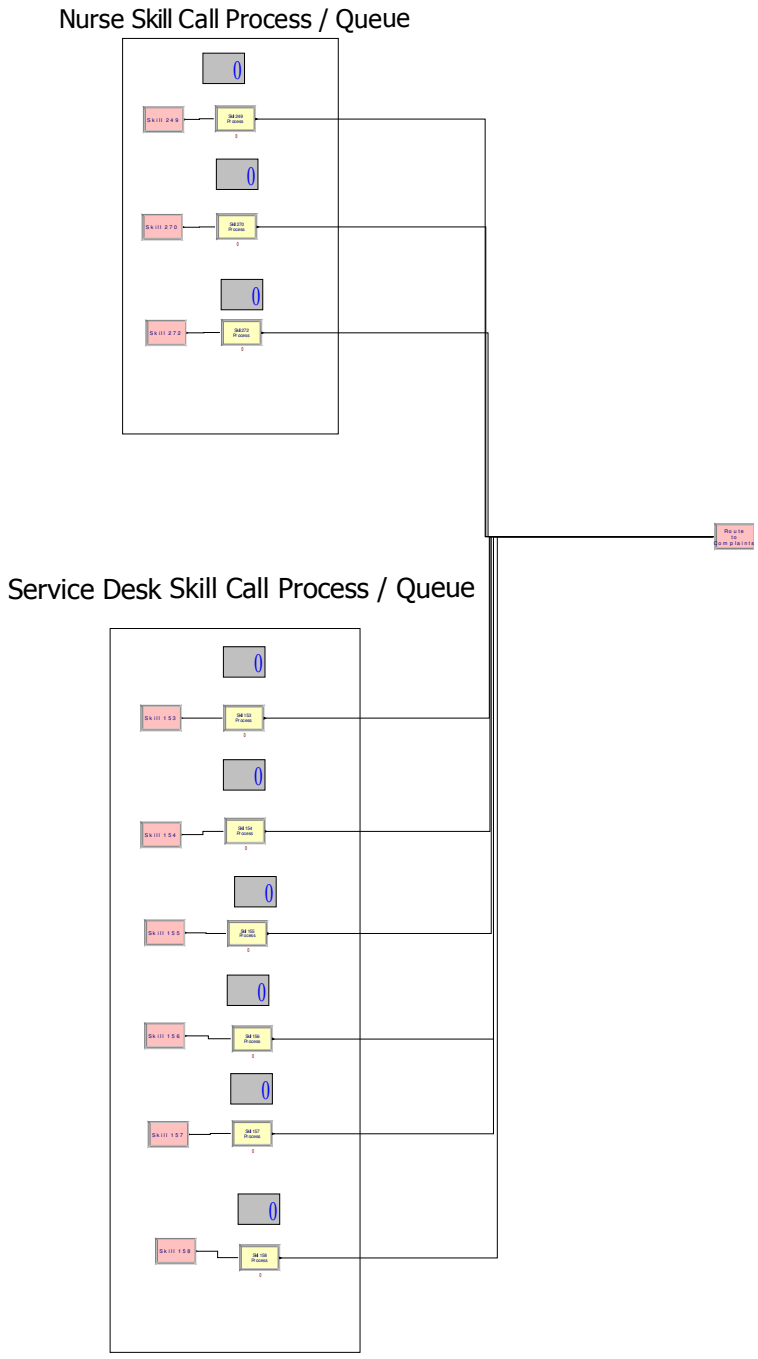




The images above illustrate the different skill routings.

Process Queue

The process queue represents an agent handling a call for an expected amount of time. If a call arrives while another is still being processed, the arriving call will be put in the queue. As soon as the processed call is completed, it is released and the waiting call is removed from the queue and processed.



After a call is processed it is sent to the complaints probability. There is a 1% probability of a complaint occurring. If a complaint does occur, it is routed back to the Call Arrival routing where it will be routed to an allocated agent skill. Calls that do not appear as a complaint are successfully ended. *Appendix G* illustrates the model as a whole.

Using the Model

Staffing managers in the call centre will only have to change 2 variables within the simulation model. These variables are: The call arrival rate, in the call arrival section, and the average handling time, in the process queue.

Currently calls arrive at an exponential distribution with a mean of ten. By simply changing the mean of the arrival rate will either increase or decrease the volume of calls.

Furthermore, the changing of the average handle time will either increase or decrease the processing time of a call. The model processes calls at a minimum rate of 60 seconds, a maximum rate of 360 seconds and a “most likely” rate of 120 seconds. A change in the handle time of a call will directly impact the waiting time of the queues.

Interpreting results

Therefore, by merely changing these two variables will result in calls being processed faster or waiting time in queues increasing and directly impacting the efficiency or the call centre.

Manager can hereby simulate what effect an increase in caller volume will have on the call centre. Or what a lack of agents will have on the efficiency of the call centre.

8. Conclusion

Call centres form one of the most important parts of any major company. The service levels of a call centre can have a direct impact on the success of the business. PruHealth wishes to successfully forecast future trends and cycles in their Call Centre.

The implementation of the Short Term, Long Term and Event Forecasting Model will significantly improve the efficiency of the call centre. By accurately predicting what future caller volumes will be and identifying seasonal trends will ensure that PruHealth has the upper-hand in maintaining their 85% Service level.

Simulation has proven to be a powerful tool for understanding the performance of complex systems under various conditions. Companies all over the world use simulation to aid in predicting what different circumstances will have on their company. Simulation has almost no costs involved and does not entail any risk to the company.

The use of the Simulation model will aid PruHealth in defining what effect different criteria will have on the call centre. Successfully defining PruHealth's variables, implementing a suitable forecasting tool and construction an appropriate simulating model, will maintain their service levels and aid them in predicting what the future holds.

In the end, none of us can truly predict the future, we can only try and come as close as we possibly can. What the future truly holds will forever remain a mystery.

9. References

AVRAMIDIS, A.N. and L'ECUYER, P., 2005. *Modelling and Simulation of Call Centres,* Proceedings of the 2005 Winter Simulation Conference, pp. 144 – 152. Edited by M.E. Kuhl, N.M. Steigre, F.B. Armstrong and J.A. Joines.

CHASE, R.B., JACOBS, F.R. and AQUILANO, N.J., 2005. *Operations Management for Competitive Advantages,* 11th edn, McGraw-Hill Irwin, New York.

DISCOVERY, 2008. *Discovery Health,* Viewed 20 May 2008, https://www.discovery.co.za/index_login.jhtml

GANS, N., KOOLE, G. and MANDELBAUM, A., 2003. *Telephone Call Centres: Tutorial, Review and Research Prospects,* Manufacturing & Service Operations Management 5, pp.79-141.

GITLOW, H.S., OPPENHEIM, A.J., OPPENHEIM, R. and LEVINE, D.M., 2005. *Quality Management,* 3rd edn, McGraw-Hill Irwin, New York.

KELTON, W.D., SADOWSKI, R.P. and STURROCK, D.T., 2007. *Simulation with Arena,* 4th edn, McGraw-Hill, New York.

KOOLE, G. and MANDELBAUM, A., 2002. *Queuing Models of Call Centres: An Introduction.* Annals of Operations Research 113, pp.41-59.

LARSON, O.C., 2007. *Development of a Strategic Management Tool for Vodacom Customer Care,* Academic Dissertation, University of Pretoria.

LAW, A.M. and MCCOMAS, M.G., 2001. *How to Build Valid and Credible Simulation Models,* Proceedings of the 2001 Winter Simulation Conference, pp. 22 – 29. Edited by B.A. Peters, J.S. Smith, D.J. Medeiros & M.W. Rohrer.

NETER, J., KUTNER, M.H., NACHTSHEIM, C.J., and WASSERMAN, W., 1996. *Applied Linear Regression Models,* 3rd edn, Irwin, Chicago.

PRUHEALTH, 2008. *PruHealth,* Viewed 22 May 2008, https://www.pruhealth.co.uk/

PRUPROTECT, 2008. *PruProtect,* Viewed 23 May 2008. https://www.pruprotect.co.uk/

REYNOLDS, P., 2005. *Forecasting Fundamentals: The Art and Science of Predicting Call Centre Workload,* Viewed 27 May 2008, http://www.tmcnet.com/channels/workforce-optimization/workforce-optimization-articles/forecasting-call-center-workload.htm.

ROBBINS, T.R. and HARRISON T.P., 2007. *Partial Cross Training in Call Centres with Uncertain Arrivals and Global Service Level Agreements,* Proceedings of the 2007 Winter Simulation Conference, pp. 2252 – 2258. Edited by S.G. Henderson, B Biller, M.H. Hsieh, J. Shortle, J.D. Tew and R.R. Barton.

ROCKWELL SOFTWARE, 2000. *Call Centre, Simulation and Arena Contact Centre Edition*, Arena Contact Centre Edition, Rockwell Automation.

SAVAGE, A.L., 2005. *Decision Making with Insight,* 1st edn, Thomson Brooks/Cole, Belmont

WALLACE R.B. and SALTZMAN, R.M., 2005. *Comparing Skill-Based Routing Call Centre Simulations using C programming and Arena Models.* Proceedings of the 2005 Winter Simulation Conference, pp. 2636-2644. Edited by M.E. Kuhl, N.M. Steiger, F.B. Armstrong and J.A. Joines.

WIKIPEDIA, 2008. *Exponential Smoothing,* Viewed 28 May 2008, http://en.wikipedia.org/wiki/Exponential_smoothing

WIKIPEDIA, 2008, *Forecasting,* Viewed 28 May 2008, http://en.wikipedia.org/wiki/Forecasting

WIKIPEDIA, 2008, *Moving Average,* Viewed on 18 Augustus 2008, http://en.wikipedia.org/wiki/Moving_Average

WIKIPEDIA, 2008. *Linear Regression,* Viewed 28 May 2008, http://en.wikipedia.org/wiki/Linear_regression

Appendix A: Short Term Forecast Model for a Random day of the week

Data	Previous Year	Previous 4 weeks				Today		
Time Of Call	2007	4 weeks ago	3 weeks ago	2 weeks ago	Last week	Forecasted	Average Handle Time	Staff Required
9:00AM	0	0	0	0	0	**0**	0	**0**
9:30AM	8	9	8	9	15	**14**	215.11	**4**
10:00AM	17	18	18	20	21	**20**	270.71	**6**
10:30AM	41	44	43	48	39	**43**	311.92	**11**
11:00AM	55	59	57	64	62	**61**	302.78	**15**
11:30AM	56	60	59	66	57	**60**	308.26	**15**
12:00PM	60	64	63	70	65	**66**	300.52	**16**
12:30PM	62	66	65	73	66	**68**	273.57	**15**
1:00PM	59	63	61	69	66	**65**	292.34	**15**
1:30PM	60	65	63	71	65	**66**	292.84	**15**
2:00PM	61	66	64	72	79	**75**	304.27	**17**
2:30PM	66	70	68	78	86	**81**	297.27	**18**
3:00PM	69	74	72	81	83	**79**	301.25	**18**
3:30PM	60	64	63	70	63	**65**	280.49	**15**
4:00PM	65	70	68	76	60	**68**	282.04	**15**
4:30PM	55	59	57	64	47	**56**	308.08	**14**
5:00PM	52	55	54	60	68	**65**	297.33	**15**
5:30PM	56	60	59	66	66	**63**	309.89	**15**
6:00PM	53	57	56	63	48	**56**	303.61	**14**
6:30PM	54	58	57	63	63	**60**	314.43	**15**
7:00PM	45	48	47	52	48	**49**	315.49	**13**
7:30PM	33	44	43	48	20	**37**	323.13	**10**
8:00PM	25	38	37	41	33	**36**	372.94	**11**
8:30PM	22	36	35	39	29	**33**	313.6	**9**
9:00PM	18	32	31	33	35	**33**	321	**10**
9:30PM	8	10	10	11	6	**9**	224.61	**3**
10:00PM	0	0	0	0	0	**0**	0	**0**
	1160	1289	1258	1407	1290	**1328**	275.4622222	**12**

Appendix B: Weekly Short Term Forecast Model

	Weekly Forecast									
	Monday		Tuesday		Wednesday		Thursday		Friday	
Time of day	Forecasted	Staff Required	Forecasted	Staff Required	Forecasted	Staff Required	Forecasted	Staff Required	Forecasted	Staff Required
9:00AM	0	0	0	0	0	0	0	0	0	0
9:30AM	14	4	14	4	20	5	7	3	7	3
10:00AM	20	6	17	5	22	6	15	5	14	5
10:30AM	43	11	38	10	41	11	32	9	30	9
11:00AM	61	15	60	15	53	13	42	11	42	11
11:30AM	60	15	59	15	55	14	49	13	48	12
12:00PM	66	16	60	14	54	13	51	13	55	13
12:30PM	68	15	67	15	57	13	54	12	62	14
1:00PM	65	15	66	15	63	15	56	13	58	14
1:30PM	66	15	63	15	68	16	56	13	58	14
2:00PM	75	17	69	16	60	15	60	15	52	13
2:30PM	81	18	70	16	70	16	56	14	54	13
3:00PM	79	18	78	18	72	17	58	14	55	13
3:30PM	65	15	62	14	60	14	54	13	56	13
4:00PM	68	15	59	14	63	14	59	14	52	12
4:30PM	56	14	58	14	57	14	56	14	53	13
5:00PM	65	15	57	14	55	13	51	13	53	13
5:30PM	63	15	56	14	58	14	50	13	47	12
6:00PM	56	14	57	14	57	14	54	13	46	12
6:30PM	60	15	60	15	45	12	46	12	42	11
7:00PM	49	13	54	14	44	12	39	11	34	10
7:30PM	43	12	45	12	40	11	33	10	27	8
8:00PM	36	11	29	10	32	10	27	9	22	8
8:30PM	33	9	27	8	30	9	25	8	20	7
9:00PM	33	10	24	8	28	8	22	7	15	5
9:30PM	9	3	9	3	8	3	7	3	4	2
10:00PM	0	0	0	0	0	0	0	0	0	0
	1334	12.07407407	1258	11.55555556	1212	11.18518519	1059	10.18518519	1006	9.62962963

Appendix C: Long Term Forecasting Model Calculations

	Original Data	Seasoned Data		Deseasoned Data		Deseasoned Model		Seasoned Model	
		Warmup	Holdout	Warmup	Holdout	Fitted	Forecast	Fitted	Forecast
1	24632	24632	#N/A	28155.2	#N/A	24417.37	#N/A	21361.87	#N/A
2	26139	26139	#N/A	28155.3	#N/A	25500.68	#N/A	23674.53	#N/A
3	26273	26273	#N/A	28155.3	#N/A	26502.21	#N/A	24730.47	#N/A
4	16566	16566	#N/A	28155.2	#N/A	27420.11	#N/A	16133.46	#N/A
5	32940	32940	#N/A	28155.2	#N/A	28253.57	#N/A	33055.03	#N/A
6	30313	30313	#N/A	28155.2	#N/A	29002.71	#N/A	31225.4	#N/A
7	29117	29117	#N/A	28155.2	#N/A	29668.45	#N/A	30681.89	#N/A
8	29456	29456	#N/A	28155.2	#N/A	30252.49	#N/A	31650.13	#N/A
9	30088	30088	#N/A	28155.2	#N/A	30757.15	#N/A	32868.51	#N/A
10	30246	30246	#N/A	28155.3	#N/A	31185.33	#N/A	33501.09	#N/A
11	30975	30975	#N/A	28155.2	#N/A	31540.39	#N/A	34699.16	#N/A
12	31118	31118	#N/A	28155.3	#N/A	31826.09	#N/A	35175.12	#N/A
13	31990	31990	#N/A	36565.7	#N/A	32046.51	#N/A	28036.33	#N/A

	Season Factors
1	0.874863505
2	0.928388119
3	0.93314743
4	0.588380516
5	1.169941664
6	1.076637626
7	1.034158826
8	1.046199203
9	1.068646193
10	1.074257851
11	1.100150108
12	1.10522902

Time Period	Forecast
14	30758.55
15	31506.633
16	20238.249
17	40982.156
18	38394.975
19	37534.41

Appendix D: Expected Number of Calls per Segment

E-mail			WAM		Expected Number of Calls	
Segment	**Total**	**Description**	**Segment**	**WA**	**Segment**	**Calls**
1	1663	Individual Regular: Bronze, Silver, Gold < 3 Months to Renewal	1	54.4%	1	904
2	824	Individual Occasional: Bronze, Silver < 3 Months To Renewal	2	47.0%	2	387
3	4389	Individual Regular: Bronze, Silver, Gold > 3 Months To Renewal	3	40.2%	3	1766
4	6240	Individual Occasional: Bronze, Silver > 3 Months To Renewal	4	29.1%	4	1819
5	235	Individual Regular: Platinum	5	10.0%	5	24
6	9361	Individual All Others	6	13.7%	6	1284
7	15	All Protect Members	7	30.0%	7	5
8	198	Group Regular: Bronze, Silver, Gold < 3 months To Renewal	8	34.9%	8	69
9	269	Group Occasional: Bronze, Silver < 3 Months To Renewal	9	29.4%	9	79
10	835	Group Regular: Bronze, Silver, Gold > 3 Months To Renewal	10	23.3%	10	195
11	1561	Group Occasional: Bronze, Silver > 3 months To Renewal	11	19.6%	11	306
12	67	Group Regular: Platinum	12	0.0%	12	0
13	2336	Group All Other	13	12.9%	13	302

Post			WAM		Expected Number of Calls	
Segment	**Total**	**Description**	**Segment**	**WA**	**Segment**	**Calls**
1	287	Individual Regular: Bronze, Silver, Gold < 3 Months To Renewal	1	65.3%	1	187
2	166	Individual Occasional: Bronze, Silver < 3 Months To Renewal	2	56.4%	2	94
3	769	Individual Regular: Bronze, Silver, Gold > 3 Months To Renewal	3	48.3%	3	371
4	1174	Individual Occasional: Bronze, Silver > 3 Months To Renewal	4	35.0%	4	411
5	47	Individual Regular: Platinum	5	12.0%	5	6
6	1984	Individual All Others	6	16.5%	6	327
7	207	All Protect Members	7	30.0%	7	62
8	202	Group Regular: Bronze, Silver, Gold < 3 months To Renewal	8	41.9%	8	85
9	326	Group Occasional: Bronze, Silver < 3 Months To Renewal	9	35.3%	9	115
10	737	Group Regular: Bronze, Silver, Gold > 3 Months To Renewal	10	28.0%	10	206
11	1885	Group Occasional: Bronze, Silver > 3 months To Renewal	11	23.5%	11	443
12	14	Group Regular: Platinum	12	0.0%	12	0
13	2322	Group All Other	13	10.7%	13	249

Appendix E: Individual Distribution and Likelihood to Call

	Individual Distribution - Email						Individual E-mail Distribution - Likelihood to Call					
	Infrequent		Occasional		Regular		Infrequent		Occasional		Regular	
	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal
Bronze	1030	2684	544	6177	364	2877	20%	15%	50%	30%	80%	50%
Silver	532	654	280	63	747	1200	15%	10%	40%	20%	60%	30%
Gold	498	542	534	687	554	313	5%	2%	15%	5%	30%	20%
Platinum	495	535	519	658	129	106	2%	1%	10%	2%	10%	10%

	Individual Distribution - Post						Individual Post Distribution - Likelihood to Call					
	Infrequent		Occasional		Regular		Infrequent		Occasional		Regular	
	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal
Bronze	756	945	139	607	48	256	24%	18%	60%	36%	96%	60%
Silver	22	75	27	567	144	262	18%	12%	48%	24%	72%	36%
Gold	8	26	23	89	96	250	6%	2%	18%	6%	36%	24%
Platinum	6	24	17	76	23	24	2%	1%	12%	2%	12%	12%

Appendix E Continued: Group Distribution and Likelihood to Call

	Group Distribution - Email						Group E-mail Distribution - Likelihood to Call					
	Infrequent		Occasional		Regular		Infrequent		Occasional		Regular	
	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal
Bronze	479	1413	192	1303	116	436	20%	15%	30%	20%	50%	30%
Silver	29	90	77	258	74	222	10%	5%	25%	15%	30%	20%
Gold	5	32	22	80	9	177	0%	0%	0%	0%	0%	0%
Platinum	8	46	34	98	33	34	0%	0%	0%	0%	0%	0%

	Group Distribution - Post						Group Post Distribution - Likelihood to Call					
	Infrequent		Occasional		Regular		Infrequent		Occasional		Regular	
	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal	≤ 3 months to Renewal	> 3 months to Renewal
Bronze	828	1306	234	1774	88	351	18%	12%	36%	24%	60%	36%
Silver	12	38	33	111	70	310	12%	6%	30%	18%	36%	24%
Gold	2	14	10	34	43	76	0%	0%	0%	0%	0%	0%
Platinum	4	20	15	42	4	10	0%	0%	0%	0%	0%	0%

PRU HEALTH
It pays to be healthy

Appendix F: Events Forecast Model

Segment	Description	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul	11-Jul	12-Jul	13-Jul	14-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul	20-Jul	21-Jul
1	Individual Regular: Bronze, Silver, Gold < 3 Months E-mail	100	469	335																	
1	Individual Regular: Bronze, Silver, Gold < 3 Months Post		62	62			62														
2	Individual Occasional: Bronze, Silver < 3 Months E-mail			387																	
2	Individual Occasional: Bronze, Silver < 3 Months Post							47	47												
3	Individual Regular: Bronze, Silver, Gold > 3 Months E-mail						883	883													
3	Individual Regular: Bronze, Silver, Gold > 3 Months Post							371													
4	Individual Occasional: Bronze, Silver > 3 Months E-mail								606	606	606										
4	Individual Occasional: Bronze, Silver > 3 Months Post								206	206											
5	Individual Regular: Platinum E-mail														24						
5	Individual Regular: Platinum Post										6										
6	Individual All Others Email													321	321	321	321				
6	Individual All Others Post										327										
7	All Protect members																	5			
7	All Protect members										62										
8	Group Regular: Bronze, Silver, Gold < 3 months E-mail																	69			
8	Group Regular: Bronze, Silver, Gold < 3 months Post										85										
9	Group Occasional: Bronze, Silver < 3 Months E-mail																	79			
9	Group Occasional: Bronze, Silver < 3 Months Post										115										
10	Group Regular: Bronze, Silver, Gold > 3 Months E-mail																	195			
10	Group Regular: Bronze, Silver, Gold > 3 Months Post										206										
11	Group Occasional: Bronze, Silver > 3 months E-mail																	306			
11	Group Occasional: Bronze, Silver > 3 months Post													443							
12	Group Regular: Platinum E-mail																				0
12	Group Regular: Platinum Post													0							
13	Group All Other E-mail																				302
13	Group All Other Post														125	0					
Total E-mails																					
1	E-mails to be sent	180	862	616																	
2				824																	
3							2195	2195													
4									2080	2080	2080										
5															235						
6														2340	2340	2340	2340				
7																		15			
8																		198			
9																		269			
10																		835			
11																		1561			
12																					67
13																					2336
	Total E-mails per day	180	862	1440			2195	2195	2080	2080	2080			2340	2575	2340	2340	2878			2403
Total Post																					
1	Post to be Received		96	96			96														
2	Post must be sent 3 days prior to Received							83	83												
3								769													
4									587	587											
5											47										
6											1984										
7											207										
8											202										
9											326										
10											737										
11																					
12														1885							
13														14							
															1161	1161					
	Total Post Per Day	0	96	96			96	852	670	587	3503			1899	1161	1161	0	0			0
	Total E-mails and Post	180	958	1536			2290	3047	2750	2667	5583			4239	3736	3501	2340	2878			2403
Expected Calls																					
	Total Additional Calls per Day	100	531	784			945	1301	859	812	1407			764	470	321	321	654			302
	BAU Forecasted Calls	1375	1356	1225			1571	1517	1423	1248	1173			1515	1430	1286	1206	1182			1653
	Total Calls	1475	1887	2009			2516	2818	2282	2060	2580			2279	1899	1607	1527	1836			1955
	Current Capacity	1500	1500	1500			1500	1500	1500	1500	1500			1500	1500	1500	1500	1500			1500
	Difference	-25	387	509			1016	1318	782	560	1080			779	399	107	27	336			455
	Additional Agents	0	6	10			16	18	13	10	17			13	8	3	2	7			9
	Call Response Rate	56%	55%	51%			41%	43%	31%	30%	25%			18%	13%	9%	14%	23%			13%

PRU HEALTH
It pays to be healthy

Appendix G: Arena Model