MASTER

Modeling and simulating a helpdesk process to research different staffing levels

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Modeling and simulating a helpdesk process to research different staffing levels

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Abstract

This document describes the research to determine and use a framework for improving call center process. The framework has been identified and redesigns and scenarios have been simulated with CPN Tools in the search for better performance. Results of the research are recommendations to anticipate what-if scenarios for a specific helpdesk process and recommendations to develop a model for generic purpose.

Management Summary

The management summary shortly describes problem definition, posed research questions, research methodology, results, conclusions and recommendations that can be found in this report.

Problem definition

It is unknown how the optimal staffing levels can be determined for an inbound call center/helpdesk, occupied by generalists and specialists. Furthermore, the actual staffing levels at the EDS – Vodafone IT Helpdesk are not based on thorough analysis and research, which would substantiate the optimality (in terms of performance measurements) of such staffing levels. Whether it can be significantly improved or not is unknown. Performance of the EDS part of the helpdesk is within the SLA specifications. The impact of the generalist/specialist ratio on this performance is not known. Our literature research did not result in a model generic enough to determine the optimal staffing levels for this (type of) IT Helpdesk process (Stegeman and Jansen-Vullers, 2006).

Research questions

To set the right performance targets to measure optimality, RQ1 has been formulated as:

- What is the definition of process performance at the IT Helpdesk process of EDS – Vodafone?

RQ2 is the main question at the start of the graduation project:

- Is it possible to measure process performance of different staffing level designs and scenarios for a process model of the EDS – Vodafone IT Helpdesk?

Staffing level design deals with numbers of generalists and specialists in the different service groups, their tasks and skills. The second research question calls for the development of an approach towards the determination of optimal staffing levels and inherently contains the practical completion of such an approach for the available business case at EDS – Vodafone. This implies the answering of RQ3:

- Could the EDS – Vodafone IT Helpdesk process perform at the same or a higher level with different staffing levels at equal or lower costs?

An additional research question to RQ2 is RQ4:

- Is it possible to develop a generic model that would make staffing levels, process performance and costs manageable?

Research methodology

Our literature research was performed with the objective of finding techniques or approaches for determining the optimal staffing levels in a multiple skill inbound call center. Scientific literature does not provide a ready-to-use solution for the optimization of call center staffing. The use of some kind of algorithm seemed to be a necessity. It turns out that no single ideal tool exists to solve the problem of determining optimal staffing levels. It turns out that there is always a number of general activities in the (re)design process in this specific research area, when looking at the problem from a managerial perspective. The general approach of (re)design is:

1. The use of historical data to forecast process parameters for future model use.

2. Establish the performance criteria to which the model/process has to perform.
3. Determine the staff requirements, based on either:
    - Queueing Theory,
    - Simulation models or
    - A mix of principles of queueing theory and simulation models.

These three redesign activities have been elaborated into a framework for the research methodology of the graduation project. Figure A represents the phases and the preparation of the phases in terms of practical activities to be performed.

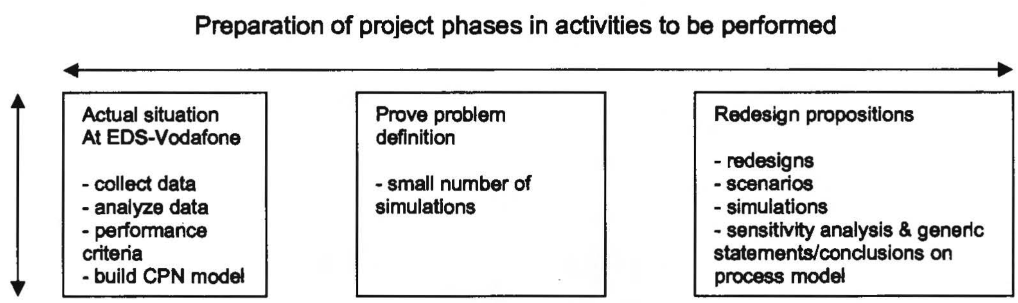

Figure A: representation of phases in the graduation project

Executing the activities from Figure A resulted in:

- The activities in the first phase have the objective to get to know the process at the IT Helpdesk of EDS – Vodafone. The process needs to be described and analyzed for building a process model in CPN Tools.
    - The process description and relevant performance criteria have been defined.
    - Data-analysis has resulted in forecasts of process parameters and a number of demarcations and assumptions.
    - A process model has been designed, based on process description, forecasts and demarcations and assumptions.
- The next phase checks the problem definition. A number of scenarios has been simulated to demonstrate the difference in performance in case the staffing levels are changed.
- The last phase is a proposal of redesigns for the staffing levels, based on simulation results and business objectives. The differences in performance of the redesigns and scenarios are also used to compare the redesigns and to deduce (generic) statements on the sensitivity of the process model.

Conclusions

RQ1: The requirements for the minimum process performance are defined in the SLA between EDS and Vodafone. The identified SLA performance criteria account for specific periods of time and for specific activities that have to do with Incident Management. The criteria are mainly quantitative and related to average speed of answer (ASA), initial resolution rate of front office and target times for solving different types of priorities of incidents. Furthermore, a bi-annual satisfaction survey among Vodafone employees is used as qualitative measurement. For modeling and simulation reasons, the initial resolution rate is assumed to be given and measuring ASA was replaced by measuring the percentage of incoming calls that was lost.

RQ2: The elaboration of the designed framework prove the possibility of building and simulating a process model and measuring performance of redesigns and scenarios with the objective of researching different staffing levels in a process. The process model of the existing situation is valid and verified and has been extended with extra functionalities. This enabled the simulation and comparison of process performance of redesigns and scenarios. The redesigns are different in terms of numbers and types of resources: generalists, specialists and cross-trained workers.

Furthermore, sensitivity analysis substantiates the value of the process model. The reactions on changes of several important helpdesk or call center characteristics in the process model are close to linear. Small changes in inter-arrival rates, service times, abandonment behavior, resource availability and distributions of call types do not cause any extremely sensitive reactions in performance of the process.
The simulation results of redesigns and scenarios have been used to explore the possibilities of the process model and its redesigns. The use of call center redesigns may cause extreme sensitivity of the process performance. A one level redesign (no back office anymore) of the IT Helpdesk process for example, may cause the throughput time of special incidents to decrease by a maximum of 35%. Using other types of resources in the 2nd line (cross-trained workers instead of specialists) also shows the high sensitivity of the process model and its performance to this kind of changes.

RQ3: The need for a redesign to improve performance of the IT Helpdesk process seems to be low, with the assumed settings and circumstances (actual situation). The minimal performance criteria of the SLA are not a problem for the IT Helpdesk in the more general weeks with average (and higher) loads of calls. The actual staffing levels are assumed to be the necessary minimum for the higher loads of calls that can occur at any (unpredictable) time and for the other tasks that have to be performed by resources in the 2nd line. The redesigns though resulted in some interesting findings for different what-if scenarios.

With a simple and almost costless change in the staffing or scheduling of resources, a significant improvement can be reached in terms of ASA and percentage of calls that is lost in particular intervals of the week. Rescheduling compensation periods or temporarily using a specialist from the 2nd line for answering specific types of calls, will increase the process performance significantly.

Another easy and low cost change would be the introduction of 3 or 4 cross-trained workers for some of the support groups in the 2nd line: BO, BO-P&C, MEGA, HQ and ILFIO. The flexibility of the resources in the 2nd line will be increased and this may lead to an improvement of throughput time of special incidents by a few percents.

In case the distribution of standard and special calls remains the same and the number of calls increases to more than 2000 calls, a combination of both the aforementioned redesigns will be capable to handle incoming calls in front and back office and is attractive for implementation. An extra feature could be the simplification of the 1st line activities by just registering and classifying the special calls and immediately referring them to the 2nd line. The costs of such a redesign are estimated at a month work for the front office team leader and the number of 1st line resources could be decreased by at least one.

More radical redesigns are simulated, like one level designs with only generalists or specialists or a mix of specialists and cross-trained workers. Significant improvements have been observed (up to 35%) in throughput time, but the necessary investments in training and higher salaries and in an automated classification menu for calls are considered to be too high for this IT Helpdesk case.

RQ4: This RQ cannot be answered positively, since this should depend on results and conclusions from similar cases to be researched. Our conclusion from this specific case though, is that such a generic model is not inconceivable. Our feasible and realistic redesigns and scenarios, show that a number of important call center characteristics may have a significant impact on the performance of the process (model) in this particular case. Based on a valid and verified process model that offers the flexibility of exploring different redesigns and best practices in BPR, it is possible to directly relate changes in call center characteristics to typical call center performance criteria. The model or framework though is not yet manageable, since it is lacking possibilities and functionality to obtain optimal results for redesigns.

Recommendations

At first sight, no radical changes are necessary to improve the process performance. The simulations of what-if scenarios for different redesigns enable the recommendations of specific redesigns for changed circumstances.

In case the IT Helpdesk is faced with higher workloads and still wants to meet the minimal criteria from the SLA, they can choose from several redesigns options. The actual staffing levels are assumed to be the necessary minimum for the higher loads of calls that can occur at any (unpredictable) time and for the other tasks that have to be performed by resources in the 2nd line. The specific redesigns are attractive for either sporadically (short term) or structurally (long term) higher loads of calls.

- Sporadically busier periods call for simple rescheduling or shifting of resources, depending on the predictability of the peak(s).
- With structurally busier periods the simple rescheduling of resources should be accompanied by cross-trained workers in the 2nd line (for a specific number of resources and support groups) and may be extended with a simplified process in the 1st line. Special calls should all be registered, classified and referred to the 2nd line. Even with less resources in the 1st line, one could obtain better ASA performances.

Illness of resources and (predictable) peaks in loads of calls can be anticipated with a flexible workforce as well. For the IT Helpdesk case this means that fewer (1 or 2) full time resources are needed throughout the week and 1 or 2 generalists from the flexible workforce are scheduled at Mondays and Thursdays, to anticipate the higher loads of calls. For generic purpose of the framework this means that flexible workforce should be introduced as BPR best practice and redesigns with flexible workforce should be developed and simulated as well.

A rather realistic scenario is the one where the number of special (difficult) calls increases even more or one where the issue of reducing the number of contacts between IT Helpdesk and user (contact reduction) becomes more important. A one level redesign (F) then becomes interestingly enough to calculate the costs for the automated classification menu (and determine its feasibility) for special calls and the costs for resource training and higher salaries.

The answer for RQ2 is for the specific case of the IT Helpdesk process at EDS - Vodafone. The relationships among staffing levels, process performance and costs that have to be managed, are identified. The development of a framework for generic purpose, requires the use of the same approach and framework adopted in this research for other IT helpdesks and call centers. With a few more similar cases it will become clear whether or not the approach, framework and generic model are interesting for future research, possibly in other types of call centers and industries. As described above, the framework is lacking possibilities and functionality to obtain optimal results for redesigns. Therefore, the framework has to be extended with an analytical tool or algorithm to calibrate redesigns and determine an optimal solution. This will improve the manageable part of the framework.

Lack of reliable historical data of service times and availability of resources in the 2nd line has a negative influence on the strength of the conclusions. The ignorance of other tasks that have to be performed by 2nd line resources is not realistic, since the process model that has been developed is a workload model and requires the other tasks to simulate the total workload. Future research should use processes that have recorded historical data of all activities, in front and back office. All activities that influence the service times and availability of resources (utilization rate).
For the EDS – Vodafone case, it is recommended (for future research) to either extend the model with the other tasks of the 2nd line resources or design more detailed functions that determine the (un)availability and utilization rate of 2nd line resources. The best option in terms of reliability and for ease of use in redesigns and simulations is considered to be the first proposition.

In the designs and redesigns, the initial resolution rate of 1st line resources is assumed to be given and is forecasted (from historical data) at about 50%. According to the SLA the rate is preferred to be at least 80%. To provide some direction for a solution or improvement, two options are proposed to increase the initial resolution.

- The 1st line agents should be trained extra to increase their level of skills. This increases the training costs and the salary for each agent.
- The 1st line agents should be allowed and encouraged to spend more time on solving an incident. This requires more agents in the 1st line.

The higher resolution rate of the 1st line agents will decrease the workload from IM on the 2nd line resources. Extra costs (investment) for the 1st line are expected to be lower than the savings that can be made for the 2nd line, which would make the two options mentioned interesting for future research.

Preface

This report is the result of my graduation project that has been performed from April 2005 till April 2006 at the Technical University of Eindhoven and the IT Helpdesk of EDS at Vodafone Maastricht.

The report describes the research and the work I have done to complete the graduation project. The project was part of a new and interesting research area in the Information Systems group of the faculty of Technology Management. This research area covers the development of redesign frameworks for specific domains in industry, based on a set of Business Process Reengineering best-practices and by using a discrete event simulation tool called CPN Tools. The business process has been provided by a call center: the IT Helpdesk at Vodafone Maastricht that has been outsourced to EDS.

There is a number of people I would like to thank for supporting me in finishing my graduation project. My direct supervisor from the University of course, Monique Jansen-Vullers, for a very pleasant cooperation and her positive critical feedback she provided on all of the documents I produced. As some sort of a mutual commitment, she offered me the possibility to assist in a scientific publication and to publish my literature research internally at the University. This speeded up the project in the final phase significantly.
Furthermore, I would like to thank my second supervisor Gergely Mincsovics, for his efforts to join the project in one of the final stages and for his analytical and constructive feedback.
During my visits to Vodafone Maastricht I was greatly supported by my supervisor, Hub Bouwens. Erika Verleysen and Dave Maes have always been available and willing to answer questions and to show me the way at EDS and at Vodafone.
Last but not least, I would like to thank Mariska Netjes, a former student colleague and now a research assistant/doctoral student, for her contributions to the CPN Tools redesigns.

Mark Stegeman
April 2006

Definition of terms

ACD	Automatic Call Distributor; part of the telephony-switch infrastructure (typically hardware-, but recently more software-based) and routes calls to agents, while tracing and capturing the history of each call
Back Office	The 2nd line of the IT Helpdesk, also called support groups
Change	Formal request by user for hardware or software change
Configuration Item	Application type (involved in incident)
CPN Tools	Colored Petri Net Tools; modeling, simulation and analysis tool for colored Petri nets
CTMC	Continuous Time Markov Chains or Markov Processes
Front Office	The 1st line of the IT Helpdesk, where the phone is picked up to answer calls
Generalist	Agent in call center. Generalists usually handle the standard requests dealing with the processing of simple transactions, the modification of customer data or general enterprise or product information; actions where basic knowledge is required
IM	Incident Management
Inbound call center	Call center with incoming service requests or calls
INC	Incident; disturbance of supplied IT service
ITSM	IT Service Management program by HP, registration and management tool for incidents
KA	Office Applications (Kantoor Applicaties)
Outcall	Call to a customer, related to an incident
RFI	Request for Information
SLA	Service Level Agreement; contract between Vodafone and EDS on services and quality of services to be supplied
Specialist	Agent in call center. Specialists with more specific, in-depth knowledge or special skills, deal with the more difficult requests that refer to technical problems, extensive consultations or complaints
Time block	Time interval for which ACD collects data
Trunk	Call center system capacity. Number of available agents to answer calls plus the number of available waiting spots in the queue or buffer
Work order	Order to execute a change request

Table of contents

1 Introduction

1.1 Defining research area

This report is the result of the graduation project for my studies at the Technology Management (TM) department from the Technical University of Eindhoven (TU/e). The project has been partially carried out in the Business Process Management (BPM) research group of the sub-department Information Systems at the department of TM. This research group is, among other things, studying the dilemma of generalists vs. specialists. In short: what staffing levels are optimal for generic and specific business processes in terms of generalists and specialists? The theory behind this dilemma will be explained further on in this report and is a major subject of research in this graduation project. The business case for this graduation project has been provided by Electronic Data Services (EDS) that manages part of the IT automation at Vodafone in Maastricht. The task of the IT Helpdesk of EDS is to control and support the IT processes at Vodafone. The SLA between EDS and Vodafone should guarantee an optimal availability of IT tools and processes.

EDS and especially the BPM research group are interested in determining parameters that affect the performance of staffing levels at a call center or helpdesk. The business case provides a specific process of an inbound call center/helpdesk with multiple types of cases and agents. The agents from EDS - Vodafone can be roughly divided into generalists and specialists who respectively work in the 1st (front office) and 2nd (back office) of the IT Helpdesk. The existing process at EDS - Vodafone and the historical data in two available databases are the input for process analysis, demarcation and modeling.

The research area has been studied by performing a literature research on call centers and approaches towards determining optimal staffing levels in call centers (Stegeman and Jansen-Vullers, 2006). Our literature research has been used as a reference in the graduation project and this report. Additionally, our literature research provides a framework for the necessary activities to be performed in such a research area.

1.2 Research assignment

1.2.1 Problem definition

At the start of the graduation project it is unknown how the optimal staffing levels can be determined for an inbound call center/helpdesk, occupied by generalists and specialists. Furthermore, the actual staffing levels at the EDS – Vodafone IT Helpdesk are not based on thorough analysis and research, which would substantiate the optimality (in terms of performance measurements) of such staffing levels. Whether it can be significantly improved or not is unknown. Performance of the EDS part of the helpdesk is within the SLA specifications. The impact of the generalist/specialist ratio on this performance is not known. Our literature research did not result in a model generic enough to determine the optimal staffing levels for this (type of) IT Helpdesk process.

1.2.2 Goal of the graduation project

The goal of this project is to develop a model of the IT Helpdesk process at EDS – Vodafone for to measuring the process performance of different staffing levels (in terms of numbers of generalists and specialists) and call center designs and to be able to make a comparison with the actual staffing levels. Optimality or process performance for the EDS – Vodafone IT Helpdesk process has to be defined in quantitative or qualitative terms. The definition is used for measuring performance of the process and the model to be developed. Furthermore, the model has to be evaluated in terms of sensitivity and applicability for generic purposes. The sensitivity analysis will deal with changes IT Helpdesk characteristics and its influences on the overall performance of the process.

1.2.3 Research questions

To set the right performance targets to measure optimality, research question number 1 has been formulated as:

RQ1: What is the definition of process performance at the IT Helpdesk process of EDS – Vodafone?

This research question has to be answered in terms of quantitative and/or qualitative performance measurements.

The second research question is the main question at the start of the graduation project:

RQ2: Is it possible to measure process performance of different staffing level designs and scenarios for a process model of the EDS – Vodafone IT Helpdesk?

Staffing level design deals with numbers of generalists and specialists in the different service groups, their tasks and skills. The second research question calls for the development of an approach towards the determination of optimal staffing levels and inherently contains the practical completion of such an approach for the available business case at EDS – Vodafone. This implies the verification, validation and sensitivity analysis of the process model to be developed. The sensitivity analysis provides insight in the impact of changes to important helpdesk characteristics in the process model.

Research question number three is:

RQ3: Could the EDS – Vodafone IT Helpdesk process perform at the same or a higher level with different staffing levels at equal or lower costs?

An additional research question to RQ2 is:

RQ4: Is it possible to develop a generic model that would make staffing levels, process performance and costs manageable?

1.3 Report structure

This report continues with the research methodology (Chapter 2) which discusses the approach towards answering the research questions. Chapter 2 starts with the conclusions from our literature research (Stegeman and Jansen-Vullers, 2006). The research area of our literature research was mainly defined considering the research area of the graduation project. The findings in our literature research have considerably influenced the construction of the framework that has been used in the graduation project. This framework is provided in Chapter 2 and contains phases and activities. The different research questions are linked to one or more of the phases or activities where the answers on the research questions can be found. Furthermore, Chapter 2 goes deeper into some theories and methodologies used in the graduation project: the generalists vs. specialists dilemma, the use of queueing theory in modeling a call center/helpdesk process and the use of a suitable simulation tool (CPN Tools).

Chapter 3 describes and discusses the process to be modeled. A comparison with some findings of our literature research is made to characterize the IT Helpdesk process at EDS – Vodafone. The use of the SLA and the relationship with performance measurements and optimality is subject of discussion. The first part of the demarcation phase of the process to be modeled is described in this chapter as well.

Chapter 4 deals with the determination of characteristics, input parameters and constants for the process model to be built in the modeling and simulation tool CPN Tools. Data-analysis, forecasting and estimating input parameters, are discussed in this chapter.

After the phases of process description and analysis, demarcation and forecasting and estimating, Chapter 5 describes the actual modeling of the process in CPN Tools. Modeling choices and a process model description are provided. The chapter ends with validation and verification of the model that has been developed.

Chapter 6 discusses the search for a better (re)design of the call center process at the IT Helpdesk of EDS – Vodafone. All redesigns are described and the scenarios for each of the redesigns are elaborated. The chapter also deals with the results of these simulated redesigns and scenarios.

The last chapter (7) deals with the conclusions and recommendations which form the end result of this graduation project.

2 Research Methodology

In this chapter our approach towards answering the posed research questions is discussed and substantiated. Section 2.1 and its sub-sections provide the main findings from our literature research. The framework for the graduation project that is presented in Section 2.2 is based on findings from this literature research and on some typical business process (re)engineering activities.

2.1 Main findings from literature research

In the context of this research project, we first reviewed the existing literature on determining optimal staffing levels in call centers. This literature survey has been published separately (Stegeman and Jansen-Vullers, 2006). In this section we summarize the main findings.

2.1.1 General approach towards determining optimal staffing levels

Part of RQ2 has already been answered in our literature research. The research area of our literature research was mainly defined considering the research area of the graduation project. The research assignment in our literature review was set as follows:

> *Find techniques for determining the optimal staffing levels in a multiple skill inbound call center*

Our literature research is not a summary of different methods of performance evaluation but a search for techniques that support finding an optimal design for call center staffing. Scientific literature does not provide a ready-to-use solution for the optimization of call center staffing. The use of some kind of algorithm seemed to be a necessity. It turns out that no single ideal tool exists to solve the problem of determining optimal staffing levels. Every type of call center demands a specific approach and the studied authors provide different approaches towards solving the problem.

It turns out that there is always a number of general activities in the (re)design process in this specific research area, when looking at the problem from a managerial perspective. The general approach of (re)design is:

4. The use of historical data to forecast process parameters for future model use.
5. Establish the performance criteria to which the model/process has to perform.
6. Determine the staff requirements, based on either:
    - Queueing Theory (leading to CTMC-models),
    - Simulation models or
    - A mix of principles of queueing theory and simulation models.

2.1.2 Forecasting

On forecasting it can be concluded that historical data (of all kinds of types) are a necessity to make reliable estimations and predictions on input parameters for call center modeling. The three main input parameters to determine are:

- the inter-arrival rates,
- service times and
- abandonment behavior of the customers.

An important part of the data analysis is the study of uncertainties. A lot of authors warn for different types of uncertainties, especially for model uncertainty, because any model is an approximation of reality. A number of authors emphasizes the importance of statistical verification of estimates and forecasts.

2.1.3 Setting performance criteria

From the conclusions on optimality and performance criteria, it can be concluded that quantitative performance measures are most widely used, because they are easy to determine and to acquire. Finding a good mix of performance measurements which reflects the characteristics of a specific process the best is difficult. Scientific research has resulted in many techniques to support decisions to be made in the (design of) call center processes where a balance has to be found among different objectives. Generally four main dimensions are distinguished in the effects of (re)design measures:

- time,
- cost,
- quality and
- flexibility.

Brand and Van der Kolk (1995) clarify this with the devil's quadrangle. The trade-off that has to be made between the different dimensions is often difficult and usually the interest of one dimension is at the expense of another one. From this dilemma one can also learn that (re)designing and staffing call centers optimally is not just a matter of looking at costs or flexibility, but calls for an inherently multidisciplinary research for better understanding of customer and Customer Service Representative behavior. Furthermore, literature concludes that human resources often account for 50%-75% of the operating expenses of a call center, which means that human resources act as the most important parameter in call center process (re)design.

2.1.4 Determine staff requirements

The researched approaches to determine optimal staffing levels show the possibility of using a combination of simulation models and the principles of queueing theory to obtain best results for determining optimal staffing levels. A simulation model can be used to model complex processes and to perform what-if redesigns and scenarios, because of high flexibility. The principles of queueing theory are used to approximate the system performance measures. CTMC models are insightful, relatively easier to construct. Simulation models cannot be used to calibrate a system to optimality. Some kind of algorithm is needed. One can run different redesigns and/or scenarios, but it remains unclear whether or not the solution is optimal. By measuring performance of the different simulated redesigns and scenarios one can compare the results of different solutions and find a close to optimal solution through convergence or reaching asymptotically optimal results. An optimal setting (close to optimal) can usually be found with analytical tools, e.g. queueing models and Linear Programming. These tools are considered to be less suitable for the complex process of a call center and for comparing redesigns and scenarios.

To ensure robust modeling it inherently remains important to follow the verification and validation steps necessary to obtain a reliable representation of reality. In our literature research some recommendations concerning model verification and validation have been provided. These are respectively discussed in Sections 5.3 and 5.5.

2.1.5 Generalists vs. specialists dilemma

Our literature research concludes that definitions or qualifications of generalists and specialists are not unambiguous in scientific literature. Every model or author uses a specific qualification for generalists and specialists and usually the two dimensions to which the agents are defined are:

- Type/number of skills an agent has
- The level at which the skills can be performed

In terms of types of calls and required level of skills (provided by Zapf, 2004) one would define generalists and specialists as respectively:

Generalists usually handle the standard requests dealing with the processing of simple transactions, the modification of customer data or general enterprise or product information; actions where basic knowledge is required.

Specialists with more specific, in-depth knowledge or special skills, deal with the more difficult requests that refer to technical problems, extensive consultations or complaints.

2.1.6 Principles of Queueing Theory

For a broad explanation on the relationship between queueing theory and call center processes the reader is referred to Koole and Mandelbaum (2002). They state that call centers can be viewed as queueing systems. A lot of the principles in queueing theory match with the characteristics in call center processes (Figure 1). Queueing models are theoretical models which mathematically define relationships among servers. Queueing analysis of a given model starts with assumptions concerning its parameters and leads to properties of performance measures, such as the waiting time distribution or the abandonment rate.

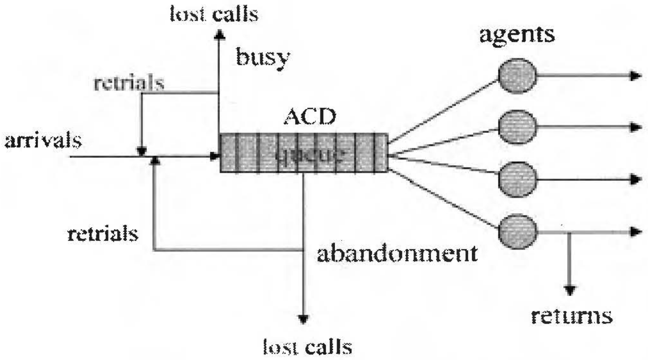

Figure 1: simple representation of a call center process

In a queueing model of a call center, the customers are callers, servers (resources) are telephone agents (operators) or communication equipment, and queues consist of callers that await service by a system resource. The simplest and most-widely used model is the M|M|c queue, also known in call center circles as Erlang C. As already stated before, for most real-world applications Erlang C is an oversimplification. It ignores busy signals, customer's impatience and services spanned over multiple visits.

The basic model of a call center is the M|M|s queue with parameters λ, μ and s:

- the arrival process, assumed Poisson at a constant rate λ
- the service times, assumed exponentially distributed with mean μ
- the number of agents, s

Furthermore, there are implicit assumptions, of which independence between the parameters and FCFS service disciplines are the most important.

2.1.7 CPN Tools

For the modeling and analysis of resource-constrained processes, CPN Tools 2.0.0 is used. This tool supports the construction, simulation and performance analysis of high-level Petri nets (Kristensen et al., 1998). CPN Tools is used, in the first place, because it is becoming the standard tool in the IS research group in many similar projects. The reason for this is that CPN Tools combines the strength of Petri nets with the strength of programming languages. The reasons for using Petri nets to model business processes are stated in Van der Aalst (1998).
The basic behavior of a process is modeled and visualized with Petri nets (Appendix M) and more detailed behavior is added through ML functions. It is possible to debug the model and validate the correct behavior of the model with a step-by-step simulation of the model. Alternatively, the functional correctness of the system can be validated and verified with state space analysis. Once the model is validated, it is easy to make adaptations to it and create alternatives for the original model. The simulation environment in CPN Tools has the capability to perform an automatic sequence of firings to examine the behavior of a model in the long run. The combination of time and simulation in CPN Tools provides the possibility to analyze the performance of the modeled process. For an introduction into high-level Petri nets and CPN Tools the reader is referred to Jensen (1992 and 1995), Kristensen et al. (1998) and Vinter Ratzer (2003).

2.2 Framework for the graduation project

The three identified main activities in the general approach towards (re)design of call center processes in Section 2.1.1 are basically the framework that has been used for the graduation project. The third activity (determine staff requirements) needs extension and more detail to customize the approach for answering the research questions.

Figure 2 represents the phases and the preparation of the phases in terms of practical activities to be performed. The activities identified in Section 2.1.1 are distributed over the first and third phase. The second phase has been added as a check for the problem definition.

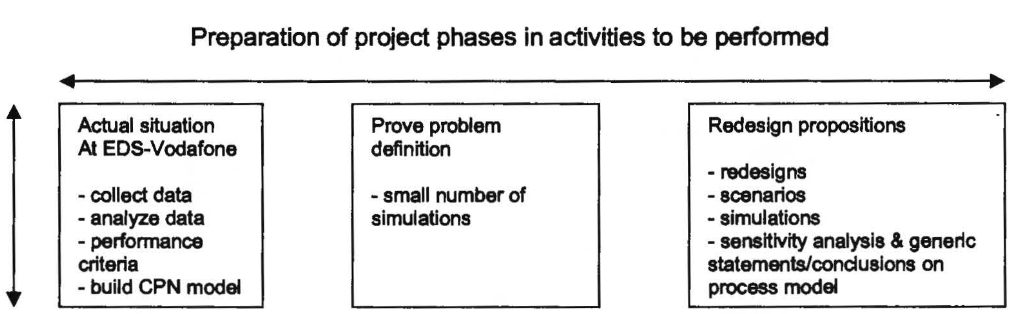

Figure 2: representation of phases in the graduation project

The activities per phase and the concerning chapters of the report are:

- The activities in the first phase have the objective to get to know the process at the IT Helpdesk of EDS – Vodafone. The process needs to be described and analyzed for building a process model in CPN Tools.
    - Chapter 3 describes the process at the IT Helpdesk and provide the performance criteria. RQ1 is answered by providing some details of the SLA.
    - Chapter 4 deals with the data-analysis and contains a number of demarcations and assumptions as well.
    - Chapter 5 uses the findings and results of Chapters 3 and 4 to build the process model in CPN Tools (Section 2.1.7).
- The next phase is, as stated, for checking the problem definition and deals with demonstrating the difference in performance in case the staffing levels are altered. This phase is described in Chapter 6.
- The last phase is a proposal of a redesigns for the staffing levels, based on simulation results and business objectives. This is described in Chapter 6 as well. The differences in performance of the redesigns and scenarios are also used to compare the redesigns and to deduce (generic) statements on the sensitivity of the process model. Other changes in characteristics of the process model will too be used to design scenarios and test the model for sensitivity and robustness. Chapter 6 provides results to answer RQ2, RQ3 and RQ4.

The emphasis is set to the use of a simulation model when determining and evaluating staff requirements. Queueing theory (Section 2.1.6) will not be used to build CTMC models and approximate system performance. Some principles of queueing theory though are used in building the simulation model and in measuring process performance (e.g. utilization rate of resources).

Apart from the phases mentioned above one can generally state that the managerial approach towards a reengineering project implies a couple of necessary phases that need to be executed (Van Aken et al., 2001). This provides a useful guideline and should guarantee the completeness of such a project. Each project and phase can differ in importance and duration.

1. The first phase is orientation and contains the first analysis of the problem. The problem definition will be defined and the demarcation of the process to be researched is being executed. Furthermore, the approach for the project is being formulated in this phase (discussed in Chapters 1 and 2).
2. The second phase consists of research and design. A closer research of the process and problem are being executed for designing different, alternative solutions for the problem. A best solution is chosen for reengineering (Chapters 3 to 6).
3. The third and last phase is implementation of the actual change.

Concerning the fact that the graduation project does not deal with implementation of a solution, the last phase will be left out of the project. The project shows far more characteristics of a diagnostic research. Emphasis in such a project is particularly on the analysis that is performed after the first phase of data collection and first diagnosis.

3 Process description of the EDS – Vodafone IT Helpdesk

This chapter discusses the IT Helpdesk process that is subject of research. Vodafone outsourced its IT Helpdesk and part of the IT services to EDS. At Vodafone and EDS, the process being analyzed is referred to as "Incident Management" (IM). The characterization of the IT Helpdesk process (in call centre terminology) is based on our literature research (Stegeman and Jansen-Vullers, 2006). Furthermore, the SLA in which Vodafone and EDS have contractually agreed upon their mutual commitments, is discussed. Appendix A supports the content of this chapter and provides more detail on the process description and the Service Level Agreements.

This chapter first starts with the main structure of the IT services of EDS to Vodafone. Secondly, some general numbers and characteristics of the EDS IT Helpdesk at Vodafone's are provided. Thirdly, the IM process of a call coming in and being served by the IT Helpdesk is described step by step. The compelled activities at the registration and classification phase are part of this section as well. Fourthly, the specific relevant issues from the SLA that concern the operation and performance measurements of Incident Management are described. Fifthly, the actual performance of the IT Helpdesk process are compared to the performance criteria in the SLA. Some characteristics in numbers of calls, abandonment percentages and percentages of answered calls within the predefined time intervals are discussed as well. The chapter ends with findings and implications.

A strict distinction is made between calls (and service requests) and incidents. Calls are incoming calls to the IT Helpdesk. The call becomes an incident in case it is served and registered in ITSM.

3.1 Main structure of IT services

EDS is responsible for specific IT services that support the business processes of Vodafone. EDS has to take care of an optimal availability of the IT tools for Vodafone NL, as agreed upon in the SLA. Management and support of the IT services are part of the activities of EDS that assure the fast and efficient operation of the tasks and realization of the business objectives of Vodafone. The standard services in the SLA are:

- Customer support: central IT Helpdesk, support for KA.
- Field Support: Deskside support. Install, Move, Add, Change (IMAC) of hardware at the desk of Vodafone employees.
- System Management: management of KA-servers.
- Generic services: IM, Problem Management, Change Management and Configuration Management.

IM is responsible for registering, controlling and repairing the service (Figure 3). From incident control, the reported incident or information about the incident could be transferred to problem management and change management for solving structural problems. The IM process is subject of this research.

IM has to communicate (formally through the front office of the IT Helpdesk) with the reporting person and with the solver of the incident. Furthermore, the IT Helpdesk should register the disturbances in a correct manner to enable proper investigation of the incident or problem. IM (the IT Helpdesk) remains responsible for the reported incident and the progress of solution, although the task may be transferred to a support group for solving or repairing the disturbance. Appendix A provides a more detailed description of the organization of the IT services.

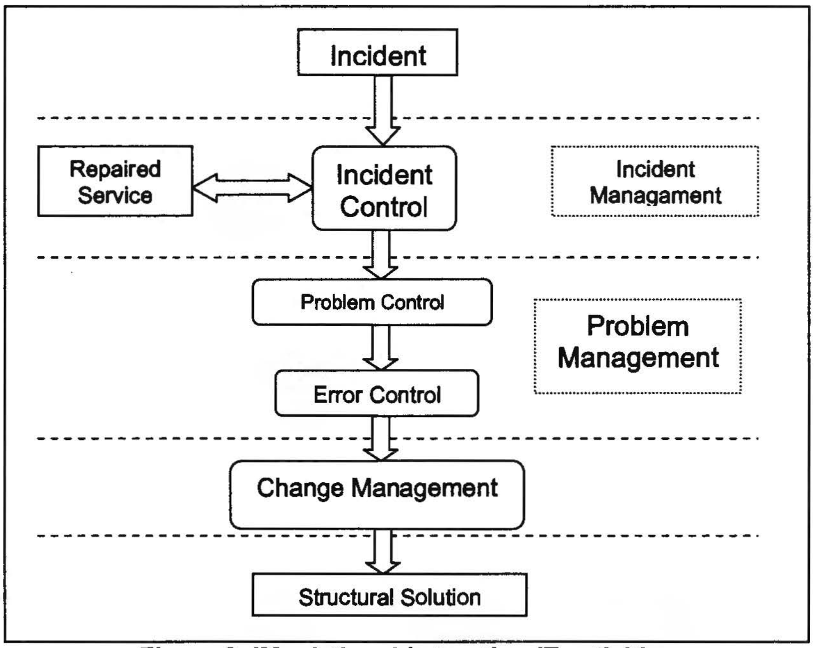

Figure 3: IM relationship to other IT activities

IT Helpdesk
The IT-Helpdesk is thus part of the IM process and is the central support unit for users of the Vodafone ICT infrastructure. The IT Helpdesk is available on a daily (workdays) basis and has the function of an interface between users and the IT organization. The mission of the IT Helpdesk is therefore to support the services and quality of services as agreed upon in the SLA. This implies the guarantee of availability and accessibility of the whole IT organization and the execution of supportive activities in the area of solving incidents and answering questions about incidents.

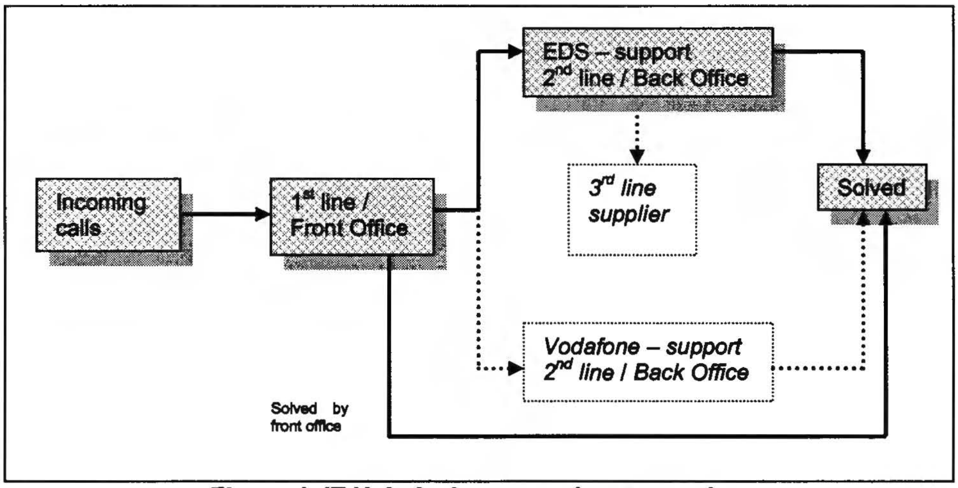

Figure 4: IT Helpdesk process in an overview

Part of the questions and reported incidents can be answered and solved by the front office of the IT Helpdesk at first contact, usually by phone. The rest of the questions and reported incidents require a more profound research or expertise of other persons and departments (2nd and 3rd line support). Figure 4 shows the part of the IT Helpdesk process that is subject of research: the grey blocks and thick lines and arrows are within the SLA between EDS and Vodafone. Table 1 provides an overview of types of incoming questions/incidents at the IT Helpdesk.

Table 1: overview of types of reported incidents/questions

PC hardware problem	Installation, Move and upgrade of PC
PC software problem	Connect to network
Phones and faxes	Connect phones and faxes
Implementation aspects of applications	Change/request for access rights
Content related aspects of applications supported by EDS	Retrieval of data of backup of home drive
Content related aspects of applications not supported by EDS	Retrieval of data of backup of group drive
Network (including Wireless-LAN)	

3.2 Some general numbers and characteristics

This section describes some figures and scientific characterizations of the IT Helpdesk process.

3.2.1 Some figures

The number of desks and users at Vodafone for which EDS supports the IT services is about 4000. These desks and users are mainly located in Maastricht. Furthermore, there are some smaller offices in Eindhoven, Den Bosch, Heerlen and Utrecht. Vodafone shops throughout the country can also report their problems to the IT Helpdesk and receive service by EDS or Vodafone support groups. Problems at the (about) 20 switch locations can also be reported to the IT Helpdesk.

EDS and Vodafone agreed upon a point of departure in terms of numbers (Table 2) of incoming (answered) calls, work orders, users and seats for which IT service has to be provided. When the numbers cross one of the thresholds, this will be point of discussion during the monthly reviews and possibly new agreements should be set up for the SLA. Since the start date of the SLA, no adjustments have been made that were caused by crossing one of the thresholds.

Table 2: SLA numbers within scope of SLA

Parameter volume	Agreed	Lower threshold (-10%)	Upper threshold (+10%)
Calls	6000	5400	6600
Workorders	2000	1800	2200
Users	4500	4050	4950
Seats	3650	3285	4015

The EDS employees at Vodafone can be divided into two different "lines". Seven employees of EDS (6 agents, 1 team leader) are occupying the front office (1st line) of the IT Helpdesk. The back office (2nd line) of EDS is divided into 13 different support groups that are described in detail in Appendix I on 2nd line characteristics. The two

larger support groups of EDS are Backoffice (BO) and System Management (SM). Together, all EDS support groups are occupied by approximately 25 employees (2 team leaders included). The rest of the support groups (about 60) in the 2nd line are Vodafone support groups. About 20 to 25% of the incidents (calls classified as such) ends up at the Vodafone support groups. The division of Vodafone employees over these different groups is not known precisely. Furthermore, a couple of EDS employees are part of a Vodafone support group called Specials, which performs all kinds of very specialist tasks. The 3rd line support is formed by some suppliers of hardware and data communication like Oracle and Getronics. The responsibility for incidents that are sent to this 3rd line support remains at EDS and Vodafone support groups. The SLA between EDS and Vodafone is not be applied for these incidents.
Some support groups, like Back Office and Systems Management, have other tasks that are not within IM. Per support group, a description of characteristics is provided in Appendix I.

Full support service, is provided within SLA from Monday to Friday, from 08.00 to 18.00 hours. Availability and accessibility has to be within the levels set in the SLA.

3.2.2 Characterization of the IT Helpdesk

The IT Helpdesk of EDS will be described by some typologies or terminologies that are used in scientific literature to characterize call centers. These terminologies have been formulated in a literature research (Stegeman and Jansen-Vullers, 2005).

3.2.2.1 ACD and Agents

The call center is mainly reached by phone, which means that a caller (user) enters an Automated Call Distributor (ACD) before speaking to an agent. The ACD offers the opportunity for the caller to choose a type of problem (Table 3) from a menu, after which the ACD leads the call to a suitable (with the right skills) agent. The agents are logged on to the ACD. The front office of the IT Helpdesk (1st line) is occupied by agents that handle all ACD options from the menu. A skills matrix for the resources/agents in the 1st line has been provided in Appendix A.5. In this case, the ACD is just used as a part of the communications infrastructure and as a recording tool for history data of calls and agents. The ACD database is called AVAYA, which allows for access to the database and designing all kinds of ACD and call reports.

Table 3: ACD types and description

ACD type	Description
62	IT Helpdesk (general option)
207	IT Helpdesk NT Password
281	IT Helpdesk Incidents
282	IT Helpdesk Workorders
283	IT Helpdesk Complaints and Service

An incoming call will be classified (incident) by the 1st line agent and served and solved right away if possible. If the incident turns out to be too difficult, it will be forwarded to a specialist in the 2nd line. Since the agents in the 2nd line are called specialists and can only handle specific tasks or problems, the agents in the 1st line could be called generalists. They handle the more standard incidents that come in. The name "generalists" for 1st line agents though, is not used in general at EDS and Vodafone. The definition from our literature research on generalists and specialists can be applied to the agents in the EDS IT Helpdesk process very well. These definitions have already been provided in Section 2.4. The 1st line agents (more skills on basic level) could be seen as generalists and the 2nd line agents (fewer skills on advanced level) are qualified as specialists.

The agents in the 1st and the 2nd line may have different sets of skills. The accompanying (distribution of) service times per skill are assumed to be the same for each agent. The level of experience or knowledge has no influence. This assumption has been made due to the fact that available data summarizes all service times of different agents. Data analysis did not allow for determining agent-specific service times. The assumption results in the (modeling) fact that each agent serves calls according to an average service time distribution, as will be further explained in upcoming chapters and sections.

3.2.2.2 Categorization of the IT Helpdesk as a call center

For categorizing some characteristics of the IT Helpdesk as a call center, our literature research identified some useful dimensions defined by three different authors:

- The functionality can be defined as helpdesk. The nature of the call center is to serve service requests based on IT problems.
- The size of the (EDS part of the) IT helpdesk is about 30 agent seats and the same number of employees/resources/agents.
- The geography can be defined as multi-location. The buildings in which several agents of different support groups (EDS-HQ and EDS-ILFIO) are seated, are not that far apart from each other, but not at the same location. Furthermore, the support group EDS-SWITCH+DB is very flexible and covers all switch locations in the Netherlands. EDS-SM uses the services and resources of a server location abroad.
- The agents characteristics have been described before and can be defined in terms of low-skilled vs. highly trained and single- vs. multi-skilled.
- The different agents imply a multi-layered call center as well. The generalists are in the front-office or 1st line. The specialists can be found in the back-office or 2nd and 3rd line.
- The call center only handles inbound calls, which means that the workload at the IT Helpdesk depends on reported problems and service requests.
- There is a difference in level of difficulty of calls (standard vs. specialized or easy vs. difficult). This includes multiple types of calls as well. In the ACD menu, callers can choose an ACD type (Table 3). When a call is registered, it is assigned with an ITSM type (Table 4).
- Other distinctive attributes of the incident can be incident code (part of infrastructure) and configuration item (application type).
- The communication channels can be synchronous (phone, personal contact) as well as a-synchronous (mail, fax).
- Furthermore, the call center or IT Helpdesk process is complicated by varying arrival rates (depending on time of day and week), abandonment of callers due to impatience, different priorities of incidents and users/groups and of course a varying number of available agents per half an hour (due to breaks, meetings, other tasks, etc).

The ITSM type (Table 4) represents the type of request. There are 5 different ITSM types. Generally, a call that is served is referred to as an incident, no matter what ITSM type is assigned to the call. All ITSM types will be referred to as incident in the report, for ease of writing and comprehensibility.

Table 4: Different ITSM types

ACD type	Description
62	IT Helpdesk (general option)
207	IT Helpdesk NT Password
281	IT Helpdesk Incidents
282	IT Helpdesk Workorders
283	IT Helpdesk Complaints and Service

3.2.2.3 Resemblance with representations of call centers in scientific literature

Figure 5 represents a call center model that uses the principles of gatekeepers and referrals to characterize the difference between generalists and specialists. According to the authors that designed the model, the performance of a call center and the behavior of an agent (gatekeeper) mainly depend on the prescribed referral rate (the rate at which work is routed from generalists to specialists). If an incident is too difficult to be handled and solved by the gatekeeper, he or she refers the incident to a specialist. The authors call it a triaging system, because customers first interact with a generalist who determines if the customer requires the attention of a specialist or not.

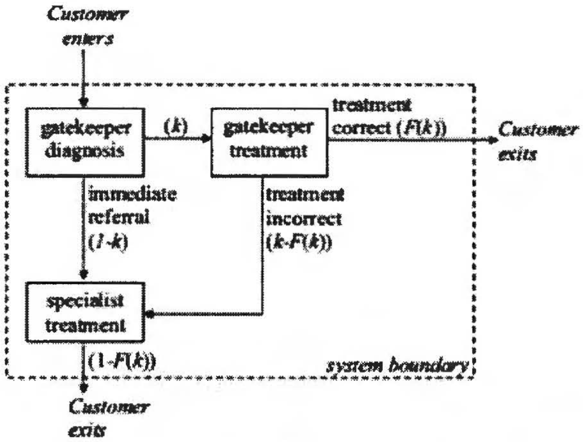

Figure 5: gatekeeper and referral configuration of a call center

At the IT Helpdesk, the fraction of incidents that is referred to the 2nd line specialists is known. This fraction can be extracted from the available historic call data. Unfortunately, no distinction is made between immediate referral rate and the incorrect treatment in recording the call data.

A kind of Petri-net way of representing the process in a call center is presented in Figure 6. The difference with the previous representation of a call center process is the distinction between two types of request (standard and special) which are handled both in a different way. The difficulty of a service request is known upfront in this case. Standard requests are classified and handled by generalists and special requests are first classified by generalist and then handled by specialists. The Petri-net principles are used, which means that a call can only be classified (and possibly handled) when a requests arrives and a generalist is free.

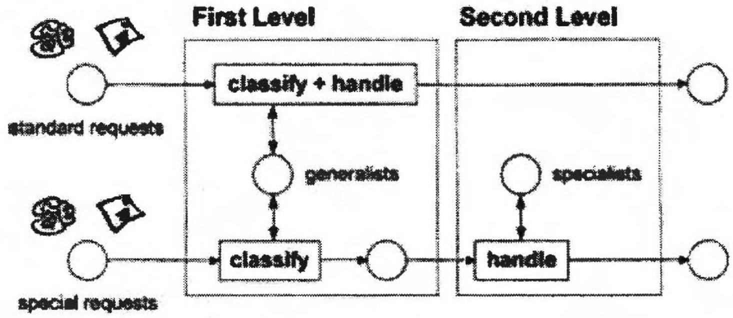

Figure 6: Two-level design of a call center process

The distinction between standard and special requests is not that strict for the incoming calls at the IT Helpdesk of EDS and is not known upfront. Some calls can be classified as standard calls because they are relatively easy to solve by the generalists in the 1st line. Some calls are sent straight away to the 2nd line support groups. Furthermore, a call may also look like a standard request at first sight and turn out to be of another nature and requiring more specialized knowledge.

The process at the IT Helpdesk seems to be a mix of the two representations of a call center that have just been discussed.

3.3 The Incident Management process

This section describes the IM process step by step. First, the report and registration of an incident are described. Secondly, the service and solution of an incident are described. In Appendix A accompanying this chapter, a process flow diagram can be found, which represents the handling of an incident at the IT Helpdesk. The steps that are referred to in the upcoming sections are distinguished and described in detail in the appendix.

3.3.1 Reporting and registering the incident

As stated before, all Vodafone employees and IT specialists can report incidents to the IT Helpdesk. Mainly by phone or by e-mail. The IT Helpdesk is the single point of contact for communication about the incidents and has the exclusive right to register the calls.
The registration of the incident requires as much information as possible, among other things:

- Data of the reporting user.
- IT service concerned.
- Configuration Item, part of the IT infrastructure involved.
- Description and information of the incident.
- Impact and priority determination.
- Reporting medium type (phone, mail, etc) and incident type classification (incident, request for information, etc)

3.3.2 Serving and solving an incident

Sometimes, the 1st line of the IT Helpdesk is able to serve and solve the incident directly (step 2). The user that reported the incident should accept the solution in order to assign the status CLOSED to the incident (step 14). A description of the solution should also be added to the incident.

From data analysis (Section 4.5) it will be concluded that Extension Outbound calls are made as well after registering a call. These calls are made for gathering extra information and are related to an incoming call. Figure iii (Appendix A) and the process description in Appendix A do not mention this operating procedure.

If the problem cannot be solved by the 1st line (front office) of the IT Helpdesk, the incident will be distributed to a support group in the 2nd line of the IT Helpdesk. The 1st line of the IT Helpdesk will have to assign the incident (step 3) to a support group, which has to analyze and solve the incident. The incident with the highest priority has to be served first. This also could imply the interruption of treatment of an incident with a lower priority.

Steps 4, 5 and 6 are performed by a specialist and are required to determine whether or not the incident has been sufficiently registered and has been assigned to the right support group.

- If this is the case, the specialist will accept (step 7) the incident and start analysis and possibly solution of the incident.
- If the incident is not sufficiently registered, the incident will be assigned with status HD-INFO and sent back to the 1st line of the IT Helpdesk for further registration (step 2 again).
- If the incident is not assigned to the right support group, the incident will be assigned with status REJECTED and sent back to the 1st line of the IT Helpdesk where another support group needs to be assigned to the incident.

The analysis of an incident and the possible solution of an incident should be registered in detail by the specialist in order to inform the reporting user when he or she calls the IT Helpdesk for an update.

In case the specialist thinks that a solution or workaround has repaired the disturbed IT service, the incident will be assigned with status SOLVED (step 8). According to the procedure, the incident will be sent back to the 1st line of the IT Helpdesk (step 11). The 1st line of the IT Helpdesk has to verify the solution with the reporting user and check whether or not the user accepts the solution or workaround (steps 12 and 13). If the latter is the case, the incident will be assigned with status CLOSED (step 14). Otherwise, the incident will be sent to a support group in the 2nd line again (step 3) for further analysis and solution. The status of the incident will then be set to REOPEN.
In reality, the prescribed procedure is not followed that strictly. Usually, the specialist verifies the solution with the reporting user and decides whether or not more service or analysis is needed. The specialist can close an incident as well. In other cases, the solution is not verified together with the reporting user. If the solution is not satisfying for the user, the incident will be re-opened after another call of the user and the status of the incident will be set to REOPEN.

Each incident is assigned with a priority implying a target time for the solution to be found and implemented. If a specialist expects that the throughput time of the incident is going to be longer than the target time set, the specialist will have to add the reason for delay to the incident and define a new target time for the incident to be solved (step 9). This happens a lot and is mainly caused by the accessibility of the reporting users. In many cases, the user is required to implement the solution for the reported problem.

In case the reason for delay can be explained by the need of 3rd support (of external service suppliers), the status of the incident will be set to WAIT (step 10). The solution of the incident continues after reaction by the 3rd line service supplier.

3.4 Specific relevant issues from the SLA

The SLA contains the performance levels and targets that EDS has to meet. The larger part of the SLA has already been described in the previous sections on supported services and IM. Measurements of the quality of operations in the IT Helpdesk are defined as well in the SLA between EDS and Vodafone. These measurements are mainly of a quantitative nature and measure ASA (average speed of answer) and the percentages of incidents that are solved within the target time. The SLA specifies a lot of quality levels. Here, only the relevant service levels for the IT Helpdesk and for the EDS support groups in the 2nd line will be mentioned. The service levels have to be met during the full support opening hours (08.00 – 18.00 hours), from Monday to Friday (working days).

The priority is determined by the 1st line agent that registers and classifies the call or incident. The priority is based on the numbers of users involved and degree of functionality (IT services) that is unavailable. Table iii of Appendix A is used in determining the priority. The target times for the different priorities of the incidents concerning applications and hardware for which EDS provides support to Vodafone are:

- TOP: 90% of the incidents should be solved within 30 minutes
- HIGH: 90% of the incidents should be solved within 2 hours
- MEDIUM: 90% of the incidents should be solved within 8 hours
- LOW: 90% of the incidents should be solved within 4 working days
- NONE: Not specified, preferably solved within a month (20 working days)

Since ITSM (the incident registration tool) can only measure in hours and does not distinguish 30 minute blocks, the target time (for measurements) for incidents with priority TOP is set to 1 hour. The service level reports are based on the numbers extracted from ITSM as well. If a lot of users are involved in an (major) IT disturbance, the number of calls will be high. In that case, all registered incidents are gathered or related to one incident and the priority will be set to HIGH or TOP.

Furthermore, 90% of the incoming calls should be answered within 45 seconds. This service level indirectly covers the (maximum) number of abandoned calls as well.

In the SLA, the percentage of incidents (initial resolution rate) that should be solved by the 1st line is defined as well (50 to 80%, different per type of application). In this research, the rate of incidents that is solved at first attempt is assumed to be a given fact and not a decision variable that can be influenced. Therefore, this rate does not need measuring in the model to be built. The rate depends on the levels of different skills required to solve an incident and on a maximum time allowed to solve an incident. As stated before, the assumption has been made that there is no difference in level of skills. Thus, there are no differences in the distributions of service times per agent and per skill.

Customer satisfaction surveys are used as well, two times a year, as a qualitative measurement for the operations of the IT Helpdesk.

3.5 Actual performance of the IT Helpdesk

EDS produces monthly and yearly reports to provide insight into its performances of the concerning period. As just stated, two times a year, a customer satisfactory survey is performed and the results of recent surveys are all positive and within the set targets. Some results of the monthly SLA reports have been summarized in Table x of Appendix A. The most important service level measurements are mentioned for the first 4 months of 2005. The ASA for the requests (calls coming in at the IT Helpdesk) is not really satisfying in the months January to March, which were very busy months in terms of numbers of incoming calls. The overall rates for solving incidents (in the IM process) within the set target times are good for all months (>90%). The number of calls handled stays within the predefined thresholds (Table 2).

In 2004, 8 out of 12 months showed an ASA that was within the service level requirements (>90%). The other 4 months showed rates between 80 and 90%. For the incidents in the IM process, in 7 out of 12 months the percentage of incidents solved within the set target time is above 90%. For the rest of the months, this percentage is between 80 and 90%. Eight months of historical data that is of more recent date, showed only positive monthly SLA reports. These historical data have been collected after the data-analysis and are therefore not used for forecasting.

3.6 Findings and implications

The process of IM as part of the total package of IT services provided by EDS to Vodafone has been described. The IT Helpdesk is part of IM and has been outsourced to EDS. The process in front and back office of the IT Helpdesk has been described in detail. This process description can now be used to determine the input parameters that need to be forecasted for the process model and for the modeling of the process itself. The process of the IT Helpdesk has been described by means of call center terminology that has been extracted from literature research (Stegeman and Jansen-Vullers, 2006). Some demarcations and assumptions have already been made due to the scope of the project and the specifications of the SLA.

The process description provided in this chapter is a formal one. In reality, the procedures might be performed a little bit different. For example, the specialist himself will check whether or not a solution is satisfying for a user. The front office of the IT Helpdesk does not have to verify every specific solution for every incident with the reporting user.

The initial resolution rate of the front office that has been identified by literature research, is assumed to be a given fact for the process model of the IT Helpdesk. In reality, the initial resolution rate differs per type of problem and incident and depends on decision variables that are outside the scope of the project.

Section 3.4 answered RQ1.

4 Determination of model input parameters and constants

The IT Helpdesk process has been described and some assumptions and demarcations on the process parts to be modeled have been made. The data analysis for determining characteristics and input parameters for the process model is subject of this chapter. The specific characteristics and input parameters required have been (in)directly provided by the findings of Chapter 3. Literature research (Stegeman and Jansen-Vullers, 2006) concluded that forecasting with historical data is a necessity to make reliable estimations and predictions on input parameters for call center modeling. The three main input parameters to forecast are:

- the arrival rates,
- service times and
- abandonment behavior by customers.

Furthermore, analysis of numbers of call types and of routes of incidents through the IT Helpdesk, should result in characteristics of and constants in the process that are used for modeling the IT Helpdesk process. Objective of this chapter thus, is to analyze and present the input parameters and constants in a way that they are suitable for use in the process model that has to be built.

An important part of data analysis is to study uncertainties. When modeling the call center process it is important to make sure the model represents the business process as realistic as possible. Assumptions and simplifications can be made, but not too rigorously. Estimates and distributions may be used for input parameters, but should be statistically derived from reliable historical data.

The characteristics and input parameters to be forecasted and the results of the analyses from the accompanying appendices are discussed in the upcoming sections:

- 4.1 Characteristics of incoming calls and distributed incidents.
- 4.2 distribution in inter-arrival rates for the incoming calls.
- 4.3 abandonment behavior of callers
- 4.4 distribution in service times at the 1st line
- 4.5 characteristics of outbound extension calls in the 1st line
- 4.6 skills and availability of 1st line resources
- 4.7 characteristics of the 2nd line support groups to be modeled
- 4.8 distribution of incidents to 2nd line support groups
- 4.9 implications of this chapter for the model to be built.

The tools used to collect the available data are HP ITSM, AVAYA, interviews and measurements by hand. Microsoft ACCESS & EXCEL, SPSS and Statgraphics are used to perform analyses of the available data.

4.1 Characteristics of incoming calls and distributed incidents

The findings and results of the analyses that are mentioned in this section, are obtained from Appendix B on process characteristics and ITSM numbers. One whole year of historical data from the AVAYA and ITSM databases are available for the analyses.

4.1.1 Classification of incoming calls

The calls that arrive at the IT Helpdesk are, to a large extent, registered in ITSM. Either as solved incident or as an incident that needs further service in the 2nd line by specialized support groups. The registration data per incident (in ITSM) are used to forecast a number of process characteristics of the call center process. An incident that is served by the 1st line, will be assigned with a specific ITSM type, priority and support group name. The assignment of a support group name to an incident is described in Section 4.8. More characteristics of the incident are available in the ITSM database, but have not been used for modeling due to the maximum scale of detail that has been chosen. This demarcation is mainly related to scope. For example, incident codes and configuration items have been left out. These respectively refer to the related cause (hardware, software, network, etc) and the specific application.

4.1.2 Abandonment and unregistered calls

From first analysis (Appendix B.4) of the available ITSM data of one year it turned out that the larger part of the ITSM registrations was a follow-up of calls and mails. In one year, 67339 registrations in ITSM were made. 75296 calls and mails did come in at the call center (IT Helpdesk). 3340 Calls were abandoned and another 4617 (6.42% of 67339) calls and mails were not registered in ITSM. Abandonment characteristics are assumed to be a result of the performance of the process at the IT Helpdesk and will be further discussed in Section 4.3.

4.1.3 INC and RFI incidents and initial resolution rates by 1st line IT Helpdesk

Furthermore, the percentage of INC incidents that was registered in ITSM is forecasted at 71.60%. This percentage also includes the ITSM types EVENT, COM and SR, due to demarcation and modeling reasons (Appendix B.3.2). These types of incidents end up at Vodafone support groups. The percentage of RFI incidents logically was forecasted at 28.40%. Part of the INC (30.10%) and RFI (93.14%) incidents is solved at first attempt by a 1st line resource, directly on the phone (Appendix B.5). The total initial resolution rate therefore is calculated at 48%. 52% Of the calls is referred to the back office.

4.1.4 Priority distributions for INC and RFI incidents

The incidents (INC and RFI) that are sent through for service in the 2nd line are assigned with a priority. The distributions for the priorities are different for each ITSM type and can be found in Appendix B.6. For INC incidents, about 90% of the incidents has a priority of LOW or MEDIUM. RFI incidents have a higher probability of having no priority (NONE) at all and are rarely assigned with priority HIGH (0.5%). Priority TOP does not occur at RFI incidents. Due to the demarcation choice in Section 4.1.3, the INC incidents that actually are of ITSM types EVENT, COM and SR will have to be assigned with a specific priority (otherITSM = 5.7%, Appendix B.6.1).

4.2 Inter-arrival rates of incoming calls and mails at the IT Helpdesk

Available data of interval, weekly and monthly reports, extracted from the AVAYA database, have been used to forecast the necessary parameters for the process model to be built. The determination of the inter-arrival rates is described in more detail in Appendix C on inter-arrival rates of calls. SLA considerations and analysis of data demarcated the opening (and operating) hours of the call center process model to 08.00 to 18.00 hours on weekdays. This implies analysis of the concerning time intervals only.

4.2.1 Inter-arrival rates, time blocks and Poisson

The call center process to be modeled, starts with the incoming calls that arrive with an intensity that is called the inter-arrival rate of calls: number of seconds between each call (a stochastic rate or variable). These rates will be used as input parameters to the model and therefore need to be forecasted from the available call center data. These rates are

simulating the load on the call center, the IT Helpdesk. The more calls come in, the busier the 1st line resources will be, and eventually the 2nd line resources too.
From literature research (Stegeman and Jansen-Vullers, 2006) some findings can be used to provide direction to the analysis of inter-arrival rates. The use of time blocks with detailed aggregated data (from the ACD - AVAYA database) may be used for forecasting matters. The length of the time blocks at the IT Helpdesk is 30 minutes. Time-of-the-day and day-of-the-week dependent input parameters can and should be estimated, since the inter-arrival rates turn out to be dependent on the interval of the week. The process of arrival rates can usually be very well represented by a Poisson process. Therefore, the average number of incoming calls per interval should be the result of the analysis. The assumption of differing inter-arrival rates per interval of the week was made in Appendix C.3 and proven in Appendix C.5.3.

4.2.2 Absence of trends or patterns over time

There are no patterns or trends over the months or the years in terms of incoming calls (Appendix C.3). The number of calls for every day (Figure vii in Appendix C.3.1) and interval (Figure x in Appendix C.5.3) in the week though is different. The time of the day is not influencing the division of ACD types over the calls. The division of ACD types over the calls seems to be independent of time of the day and thus always has the same distribution.

Extreme values were removed from the available data (Appendix C.4.2) for forecasting a regular week pattern, which would be representative for most part of the year. Disturbances, like holidays, huge peaks in numbers of incoming calls were removed. Findings from literature research (Stegeman and Jansen-Vullers, 2006) recommend this procedure. Furthermore, in scientific literature on call center analysis, some warnings are provided about estimations and determinations of call center parameters based on historical data. Gans et al. (2003) make the important distinction between estimation and prediction. These are two closely related, but different, statistical tasks. Estimation concerns the use of existing (historical) data to make interferences about the parameter values of a statistical model. Prediction concerns the use of the estimated parameters to forecast the behavior of a sample outside of the original data set (used to make the estimation). Predictions are "noisier" than estimates because, in addition to uncertainty concerning the estimated parameters, they contain additional sources of potential errors. Uncertainty has already been decreased by searching for the regular week pattern.

4.2.3 Number of calls per week, day and interval

The following method (Appendix C.5) has been adopted to forecast the average number of calls that come in at every interval of the week:

1. First of all, the weekly totals are obtained from the weekly ACD reports. Numbers for the defined opening hours are calculated and extreme values are removed for forecasting the average number of calls that arrives at the call center in a regular week. The week load in absolute numbers of calls is forecasted at 1426 (Appendix C.5.1).
2. Second, the cumulated daily numbers of ACD calls (all ACD types) are used to forecast the average fractions of calls per day (related to the weekly total of calls). These numbers are for opening hours and include the numbers of abandoned calls. The daily fractions of week load of incoming calls can be found in Appendix C.5.2. Mondays (350 calls) turn out to be most busy, Fridays (240 calls) are the most easy days (Figure 7).

3. Third, the cumulated interval numbers of ACD calls (all ACD types) are used to forecast the average fractions of calls per interval (related to the daily total of calls). The interval fractions of daily load in incoming calls for each interval of the day can be found in Appendix C.5.3. The busiest intervals (Figure 8) are in the mornings of each day.
4. With these parameters and the number of seconds in an interval (1800), the inter-arrival times for each interval of the week have been calculated. These results can be found in Appendix C.5.4.

4.2.4 Distribution of ACD types over the incoming calls and mails

The incoming call will (in reality) go through the ACD menu, where the caller will choose an ACD menu option. In the process model this will be modeled as well. The call will be assigned with an ACD type. The determination of the distribution of the different ACD types over the calls has been performed as well and can be found in Appendix C.6. The larger part of the calls, about 77%, has a general type (62 = IT Helpdesk). ACD type 300 has been created for the incoming mail at the call center (IT Helpdesk). These mails are part of the inter-arrival rates of calls at the call center too.

4.3 Abandonment behavior of callers

Callers do not have an infinite patience to wait before their call is answered. The probability that a call will leave the waiting queue in the call center process before receiving service by a 1st line agent, does influence the abandoned number of calls.

4.3.1 Abandonment as a result of process performance

The number of abandoning calls will depend on the way the process performs. It is not a given parameter. The only parameter that somehow can be forecasted, is the patience of the caller. In the SLA Reports that are printed each month, the number of abandoned calls can be found per time interval (Table i, Appendix D.2).
Maximum waiting times have been forecasted for each ACD type that can be chosen in the ACD menu. The available (13) monthly reports contain the number of abandoned calls per ACD type and per waiting time interval. The ACD records the numbers of calls that abandon in one of the above mentioned time intervals. Detailed analysis and determination of abandonment probabilities can be found in Appendix D.
Data from the ACD can be pretty censored when it is used to analyze and forecast abandonment parameters. Since the data of served customers who did not abandon the system is not available, patience is not fully observed. Only the maximum patience times of those customers who abandon are observed. Literature research (Stegeman and Jansen-Vullers, 2006) mentions these findings as well.

4.3.2 Probability distribution of maximum waiting times

The distributions of maximum waiting times over the time intervals of the different ACD types that have been forecasted, are compared in Table 5. It is obvious that there is a significant difference between the distinct ACD types. The abandoned calls of ACD types 281, 282 and 283 are pretty much distributed the same way over the different time intervals. The distributions of abandoned calls over the time intervals of ACD types 62 and 207 are quite different from each other and the other three ACD types. ACD type 300 (mails) is assumed to have an infinite waiting time and calls with this ACD type do not abandon the waiting queue. Therefore they are always assigned with a waiting time of almost one day (35999 seconds), which is assumed never to occur in reality.

Table 5: distribution of percentages of maximum waiting times (in seconds) per ACD type

ACD	Name	0 - 10	20	25	30	45	>45	35999	AVG_t>45s
62	Helpdesk	41.33	11.87	3.08	4.17	7.36	32.19	0	116
207	NT Password	28.89	15.56	6.67	2.22	4.44	42.22	0	141
281	Incidents	18.70	6.30	0.84	3.57	5.04	65.55	0	191
282	Workorders	21.29	4.52	1.29	4.52	3.87	64.52	0	219
283	KLES	19.44	2.78	2.78	0.00	5.56	69.44	0	280
300	Mail	0	0	0	0	0	0	100	3599

In the different columns of Table 3, one can find the percentages of abandoned calls in the concerning time intervals. The last column contains the mean of the last interval. Determination of these mean values is explained in Appendix D.2.1.

From the table, one can conclude that about 70 to 90% of the abandoned calls fall in the first and the last interval. Either callers are not patient at all or are very willing to wait for service. Especially callers for ACD type 62 (Helpdesk) are least patient. This could be explained by the fact that this ACD type is actually the general option. Callers that are in a hurry and not listen to the menu options, might pick this ACD type as their first (random) choice.
This explanation can be further substantiated with the fact that for the more specialized ACD types, callers are significantly more patient. The percentages of callers that abandon in the last time interval prove this.

4.4 Distribution of service times in the 1st line of the IT Helpdesk

The service time in the 1st line of the IT Helpdesk, is the time that an agent needs to answer a call, register some data in ITSM and possibly solve the problem. The service time stops at the moment that an agent closes the call or sends the call through for further service in the 2nd line. The concerning data has been extracted from 10 weeks of detailed interval data from the AVAYA database (for the ACD menu, ACD types 62, 207, 281, 282 and 283) and from the ITSM database (ACD type 300, mails).

The distribution of service time over the intervals seems to be random. The number of available measurements per interval though, strongly differs (Appendix E.1). This is of course related to the different inter-arrival rates of calls and mails per interval.

The samples of service times per ACD type have been analyzed (Appendix E.2) with statistical tools (Statgraphics and SPSS) and it turns out that roughly 90% of all calls (ACD types 62, 207 and 281) do not have a particular probability distribution for their service time in the 1st line. No probability distributed fitted the available data. Statistical analysis of the other 10% of the calls (ACD types 282 and 283) and mails (ACD type 300) could not reject the idea that the distribution comes from a Gamma or Lognormal distribution, which is partly confirmed by literature (Stegeman and Jansen-Vullers, 2006). For the time being all service times are assumed not to have a certain probability distribution. Mainly because the functions for Gamma and Lognormal probability distributions are not yet available in the standard version of CPN Tools. A consistent approach towards estimating the particular service times per ACD type has therefore been chosen. The data samples from the statistical analysis itself may be used as a list from which a discrete uniform distribution may pick a value. The sample size of the tests for ACD type is N. Per ACD type, the findings from data analysis are presented in Table

6. The mean value and the value range for the service times can be found in columns 3 and 4.

Table 6: summary of results from analysis of ACD type service times

ACD type	N=	Mean [s]	Std [s]	Values ranging from [s]
62	10837	150	42	4 – 424
207	297	106	87	14 – 750
281	1297	133	83	1 - 782
282	646	160	120	6 – 1061
283	125	158	127	11 – 656
300	208	191	164	22 – 991

In the AVAYA database one can also find the time an agent spends on registering or working on a call after he or she has put down the phone. This is called ACW and means After Call Work. Since the average ACW Time values are very low or even 0, ACW is considered to have little impact on the service times of the 1st line and is therefore neglected.

4.5 Outbound extension calls

When a call of a specific ACD type is hung up or served, it might be necessary to make a call out for extra research or information. This is called an "outbound extension call" and is always related to the incoming call (and thus ACD type) for which service has just been performed. As stated, not all calls are followed up by an outbound extension call. Analysis of the available data shows that the number and percentage of outbound extension calls differs per ACD type of calls. Furthermore, it can be assumed that the number of outbound extension calls depends on the number of incoming calls and thus on the inter-arrival rates that have been forecasted before. Trend or pattern analysis is therefore redundant. Appendix F presents the detailed analysis and forecast of characteristics of outbound extension calls.

4.6 Skills and availability of 1st line resources

Appendix A.5 describes the formal or predefined skills per resource in the 1st line. There are 6 resources, which can serve all ACD types of calls (Table 4). Mail reports are handled by two resources every week. Appendix H.4 provides the skills of resources operating in the support groups of the 2nd line. The support groups HD and GWE are occupied by 1st line resources, as can be seen in Table x in Appendix A: the columns of the SG (support group) skills.

Every interval of the day and week may have a different number of available resources. Resources can start between 08.00hrs and 09.30hrs, may have breaks in between and could be doing other activities: like meetings, consultation/feedback, administration and other things. Again, ten weeks of detailed interval data was collected for analysis purposes from the AVAYA database. Per day and per interval, the number of available resources has been used to forecast averages for every interval in the week. That is a total number of 100 intervals.
Results of the analysis of available numbers of 1st line resources are discussed in detail in Appendix G, Appendix G.3. The average numbers of available resources are forecasted and can be used to build availability or unavailability functions for the model to be used. From analysis, it could be concluded that the average available number of

resources follows a logical (related to shifts and breaks) pattern over the intervals of one day. The average number of available resources is usually between 3 and 5, for one whole day, between 08.00 and 18.00 hours. The average of available resources in the 1st line (to take calls) is forecasted to be 3.8 resources.

Pichitlamken et al. (2003) mention the fact that the time an agent is available to take a call is very likely to be less than the time for which they are scheduled, because of coffee breaks, trips to restrooms, absenteeism, etc. The detailed data of the ACD reports though, shows the average number of resources that has been logged on the ACD during the time intervals.

4.7 Support group characteristics

In the 2nd line, the resources are called specialists and can handle incidents that are not solved in the 1st line of the IT Helpdesk. The 2nd line consists of many different support groups. Each has its own capabilities and skills to solve different types/kinds of problems. There are 13 EDS support groups to which incidents can be distributed. Furthermore, there are over 50 Vodafone support groups to which specific incidents can be distributed. The subsequent sections are the result of analysis in Appendix H.

4.7.1 Researching service times of INCs and availability of resources

The data and information from the ITSM database was lacking specific service and waiting times for handling INC's due to infirm registration. With INC's it often happens that the ITSM screen is closed during service of an incident. The registration time stops and is being registered in ITSM. Either another program is then being opened to solve the problem or another incident is being opened that needs service too. The specialist can multitask when the service of an incident needs quite a lot of time. Therefore the handling of incidents at the different EDS support groups in the 2nd line had to be researched by observation and asking questions. Furthermore, the availability of resources is not recorded as thorough as in the 1st line by the ACD – AVAYA database. Some numbers and information are needed to be able to dimension the availability of resources and the service times for INC's, groups and specialists in the 2nd line support groups:

1. The time spent on an incident by a resource in a support group. What are the average, minimum, maximum and most often occurring service times?
2. What are the priorities of each group and resource to handle incidents, work orders, changes and systems management? In other words: what is the availability of the resources to spend time on the incidents? Also work schedules, pauses and available time to handle incidents are important.

Every support group was researched to get the necessary information. At some groups a few measurements could be performed for service times or throughput times. At other groups I could only ask a few questions to substantiate the assumptions to be made. The result of the analysis can be found in Appendix H. For each support group a distribution in of service times (for INC incidents) and an overview of availability of resources has been defined. The availability of resources has been identified by times of presence and absence (due to other priorities, breaks and end of shifts). The service times for RFI incidents are discussed in the next Section 4.7.2. Furthermore, a short task description and possible special characteristics (Section 4.7.3) of the support groups are provided. Other tasks of the resources in the support groups may deal with problem management and change management, as described in Section 3.1. These tasks are not part of IM and therefore out of the scope of the research.

4.7.2 RFI service times at the different support groups

Service times for RFI's can be obtained from the ITSM database and are being forecasted per priority. For RFI service times, the registration times of ITSM can be used, because of the kind of tasks that are being performed when handling a RFI incident. The time registered in ITSM is the real time spent on service of the incident. No other programs or incidents are being opened at the same time that disturb the registered service time. As happens with INC's. The results of the analysis are probability distributions of service times of RFI's per incident priority and per support group. The results are gathered in Appendix L.
The sample of measurements is being analyzed for occurring frequencies. With SPSS one can forecast the percentage of measurements that falls into a specific interval. Per sample of measurements, the number and divisions of percentiles can differ, because of number of measurements or differences in the distribution of service times of RFI's at a certain support group - priority combination.

Not all support groups serve RFI incidents. Usually, RFI incidents are sent to the support groups: HD, BO-P&C and ILFIO. The combination of some priorities and support groups showed only a few RFI incidents. Due to the lack of available data, no estimates could be made on the distribution of the service times of RFI incidents. The assumption has been made that these support groups therefore do not serve RFI incidents. The number (at least 6) of support groups that is not serving RFI incidents is different per priority. The affect on the process model of leaving out these RFI incidents is assumed to be negligible because of the low numbers observed.

4.7.3 Specialist skills

Appendix H.4 summarizes the skills of the resources in the 2nd line. These findings are obtained from the descriptions per support group. Some resources have more than one skill and thus can serve incidents that are sent to different support groups (Table i, Appendix H.4). These specialists are assumed to operate on the same level as specialists with only one skill. The resource first checks whether or not he has tasks to perform related to his primary skill before accepting incidents requiring (one of his) secondary skills.

4.7.4 Demarcation issues and special characteristics found

During the research of the 2nd line the decision had to be made whether each of the support groups had to be modeled or not. Several support groups are hardly or not at all used for service. Some types of incidents (INC's and RFI's with different types of priorities) have been observed at all support groups. The modeling demarcation could be substantiated with measurements and analysis. Part of the demarcation activities has just been described in the previous section. Furthermore, one support group (EDS-OD) will be left out of the process model, because only a few INC and RFI incidents were observed and this particular support group is actually not a part of IM.

A couple of other support groups (REPAIR, AM and SWITCH+DB) need to be modeled with an extra delay in the throughput times, mainly due to dependency on 3rd line suppliers. The analysis and determination of these delay times can be found in Appendix K. As stated before in Chapter 3, these incidents are not within the SLA between EDS and Vodafone. Detailed analysis of these incidents has therefore not been performed.

For several reasons the Vodafone support groups will have to be modeled as one big support group where incidents (about 20 to 25% of the total number of incidents) leave the system without receiving specific service.

1. These support groups are not in the SLA between EDS and Vodafone. EDS is not responsible for the performance of the Vodafone support groups.
2. A significant part (>83%) of incidents that is sent to the Vodafone support groups is very likely to end at a Vodafone support group. Such an incident is usually not redistributed to an EDS support group (further discussed in Section 4.8.1).
3. Not enough time to research every specific Vodafone support group.
4. The number of significant groups and specialists is unclear.
5. No detailed information on service and waiting times and availability of specialists in the available databases.

For the model, it will therefore be assumed that incidents sent to Vodafone support groups will leave the process without any further service. The incidents ending up at Vodafone can come from the 1st line or from redistribution from an EDS support group. This assumption is very useful for the reliability of the process model, since the incidents that visit the Vodafone support groups will have no (immediate) influence on incidents ending at a EDS support group. These incidents therefore will not be influenced with unreliable service and/or throughput times.

Many resources in the 2nd line mentioned the accessibility of callers. After a Vodafone employee has reported an incident, it often happens that the Vodafone employee cannot be reached by phone, voicemail or e-mail for assistance or service. This significantly increases the throughput time of incidents sent to the 2nd line.

4.8 Call (re)distribution to support groups

From process analysis and description (Chapter 3), it can be concluded that an incident sent to the 2nd line generally receives service by a specialist and is closed after a satisfying solution. It could happen that an incident is sent back to the generalist in the 1st line for further registration or distribution to another support group. Analysis showed that a large part of the incidents being registered in ITSM is solved at the first service treatment by a 1st line generalist or a 2nd line specialist. The rest of the incidents visits several support groups until the problem is solved. The sending to another support group is called redistribution. Analysis of the ITSM database showed a much higher number of redistribution of incidents to other support groups than expected.

4.8.1 Reasons for (re)distribution

Redistribution might be necessary because of:

- an incident is (re)distributed to the wrong support group.
- Problem turns out to have another cause. Another support group is needed.
- The incident is being sent to the distribution group BO-P&C and is further redistributed to BO.

Two different types of distribution with two different sets of analysis data have to be distinguished:

- First, the incident distribution probability from 1st line to the various 2nd line EDS support groups and Vodafone support groups is being forecasted from all incident data of INC's and RFI's. Including the incidents ending at Vodafone support groups.
- Second, for the redistribution probabilities amongst 2nd line EDS support groups, incident data for INC's and RFI's ending at EDS support groups are being used.

The distinction has been made due to findings presented in Appendix J. A significant part of the incidents that are being sent to the Vodafone support groups is also very likely to end at a Vodafone support group. Such an incident is usually not redistributed to an EDS support group. First distribution probabilities to support groups may therefore be forecasted from incidents that are sent to Vodafone support groups as well.

4.8.2 Characteristics of (re)distributions for INC and RFI incidents

Analysis of the available data sets, confirmed the fact that incidents can be distributed and redistributed to 2nd line support groups with a certain probability. This probability depends on the type of incident (INC or RFI), the priority of the incident (NONE, LOW, MEDIUM, HIGH, TOP) and the number of visited 2nd line support groups. Therefore the analysis of (re)distributed incidents has been performed for all possible combinations of type incident, priority and number of visited 2nd line support groups.

The number of redistributions to support groups of INC's is significantly higher than of RFI's. Priority of the incident is determinative as well for the maximum number of redistributions to other support groups. The higher the priority, the lower the maximum number of redistributions of incidents to support groups. In Appendix I.4 and I.7 an overview is provided of the maximum number of redistributions per ITSM type and priority.

Furthermore, the appendix contains the probability distribution of incidents being sent to a specific support group. As stated, for first distribution from 1st line to 2nd line (Appendix I.2 and I.5) and for redistribution of incidents (Appendix I.3 and I.6).

Demarcation at the previous Sections (4.7.2 and 4.7.3) has lead to leaving out some redistributions to support groups, because they are assumed not to be possible. Especially the sending of incidents to EDS-OD and several types of RFI incidents to about 6 EDS support groups have been left out of the process modeling.

4.8.3 Example of use of forecasted probabilities of (re)distributions

The probability that an incident with priority medium and a number of visited support groups of 4 has to be redistributed to a specific support group, is forecasted as follows:

- First, Table xiii in Appendix I is being checked for the probability that an incident (incident, medium) is solved after 4 visited support groups. This probability is 96.26%.
- If the incident is sent through for redistribution, Table viii in Appendix I has to be checked for the incident's probability to be sent to the support groups. With a probability of 13.73% the incident is being redistributed to support group EDS-SM.

4.9 Implications for modeling the process

In the sections of this chapter, a large number of characteristics, dimensions, constants and input parameters have been forecasted which will be of use, for the process model described in Chapter 5. Detailed results can mainly be found in the accompanying appendices. In many cases, the analyzed data are already elaborated or prepared for use in the CPN process model.

Scientific literature warns for different types of uncertainties, especially for model uncertainty which may have a negative effect on performance measures. A number of authors (see Stegeman and Jansen-Vullers, 2006) emphasizes the importance of verification and validation of estimates and forecasts found with statistical analysis.

5 IT Helpdesk process model in CPN Tools

A simulation model is a representation an existing process. It can be used to represent the existing process and gain insight in the dynamics of a process (Van der Aalst, 1995). Ability to deal with complexity and saving cost and time are advantages of using simulation models to analyze business processes. Constructing a simulation model of a process has to be performed in consecutive phases (Figure 7):

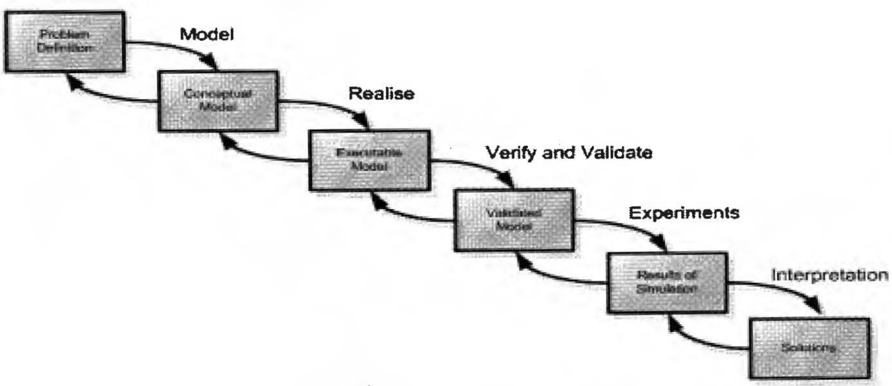

Figure 7: phases in a simulation study (Van der Aalst, 1995)

The identified phases are: problem definition, conceptual model, executable model, verified and validated model, results of simulation and the solution. This chapter covers phases 2 to 4: designing an executable model and validating the model. Section 2.2 (framework of the approach) already mentions the use of a modeling and simulation tool (CPN Tools) for designing a model of the IT Helpdesk process at EDS – Vodafone. The simulation model will be used for simulating different staffing designs and scenarios and measuring the process performance. Chapters 3 and 4 on respectively process description and data-analysis describe the preparation necessary for building the process model. All determined and forecasted characteristics, constants and input parameters and a number of demarcations and assumptions are described and are available as input for the process model. Chapter 6 deals with results of simulating different staffing or call center redesigns in search for a better solution.

This chapter first starts with the model assumptions and demarcation choices. Secondly, the process model that has been designed is discussed. Special functionality and features are explained as well. Thirdly, the verification of the process model is discussed. Fourthly, measuring process model performance with CPN Tools 2.0.0 is shortly dealt with. Fifthly, the validation phase is an important part of the design of a simulation model. Sixthly, a sensitivity analysis has been performed to judge on the robustness of the simulation model. Seventhly, this chapter ends with a short conclusion on the findings in the different sections.

5.1 Model assumptions and demarcation choices

The assumptions and demarcations are necessary to reduce the complexity of the process to be modeled. A model implies a more simple representation of reality. The process model is based on assumptions and demarcations that are described in the previous chapters. Furthermore, the simulation tool (CPN Tools) and its built-in functionality required to make some assumptions and demarcations as well. Assumptions and demarcations are summarized in Appendix N.8.

The model is a workload model that simulates the numbers of calls and incidents that have to be served by 1st and 2nd line resources in different support groups. Not all possible incident types and tasks are modeled. INC and RFI incidents are modeled because they account for more than 97% of the incidents. Other tasks that have to be performed by 2nd line resources have been left out, because they are not part of IM. The level of detail of incidents stops at ITSM type and priority, for the 2nd line support groups. The 1st line only deals with different ACD types and serves incidents in the HD and/or GWE support group. These characteristics of calls and incidents are assumed to be sufficient for forecasting and simulating the workload in the IM process.
The workload thus depends on number of calls per interval per ACD type, number of incidents solved (INC or RFI) at first attempt, priorities of incidents, support groups required and redistribution probabilities. The results of data analysis are:

- The forecasted numbers of types of calls and incidents offered to the 1st line and to every support group in the 2nd line of the IT Helpdesk.
- The probability distributions in service times for calls and incidents visiting 1st and 2nd line of the IT Helpdesk.

Together, these two represent the load or demand on the IT Helpdesk process caused by IM. The estimated availability pattern of resources in the 1st and 2nd line is available to model the resource occupation in the process model at all times of the week. Furthermore, the resources are not modeled in detail and are assumed to have the same service times for the same skills.

A short introduction to CPN Tools has already been provided in Section 2.1.7 and Appendix M on Petri Nets. Furthermore, it has to be said that at the start of the project, CPN Tools has been chosen as the simulation tool. It has been assumed that CPN Tools is suitable to model and simulate a process like the one at the IT Helpdesk of EDS – Vodafone. Actually, it is the first attempt to model such a process with CPN Tools and the possibilities of the tool will be explored. The tool offers functionalities that are required for simulation (according to the handbook by Van Der Aalst, 1995). Scenarios, simulations with replications, simulating alternatives (what-if analysis) and logging of detailed information are some of the functionalities of CPN Tools.

5.2 Process model description

The appendices (N, O and P) on the CPN process model provide a detailed description of the model that has been constructed. Explanation of all functionalities, declarations, modeling choices and representations of the different process parts are gathered in these appendices. The token that is sent through the process model is referred to as call, even when the call has become an incident (after registration in ITSM).

5.2.1 Description of the main process

As can be seen in Figure 8 (and Figure i of Appendix O), the main process model contains 5 transitions or activities and 10 places. The "arrivals" transition generates calls. The calls arrive with a Poisson inter-arrival intensity and are assigned with a number of attributes or characteristics, necessary to lead the calls through the process model. The call has type CALL. More detail on the "arrivals" transition can be found in Appendix N.2. The generated calls are sent through to the place "to ACD menu", without delay.

At the transition "ACD menu" the call is assigned with an ACD choice the caller has made. This ACD choice determines the service time required to serve the caller. The ACD choice is used in the IT Helpdesk transition that will be described later on. More detail on the "ACD menu" transition can be found in Appendix N.3. The calls are then sent to the next place "to queue", again without any delay in time.

At the transition "queueing process", the call is added to the end of the waiting queue. The first call that comes in is served first (FIFO). If an agent at the IT Helpdesk is available, and the caller has not abandoned the process model via place "aband", the call will be sent through for service to the place "to 1st line". More detail on the "queueing process" transition can be found in Appendix N.4. The assignment of a resource to the call is discussed in Appendix N.7.

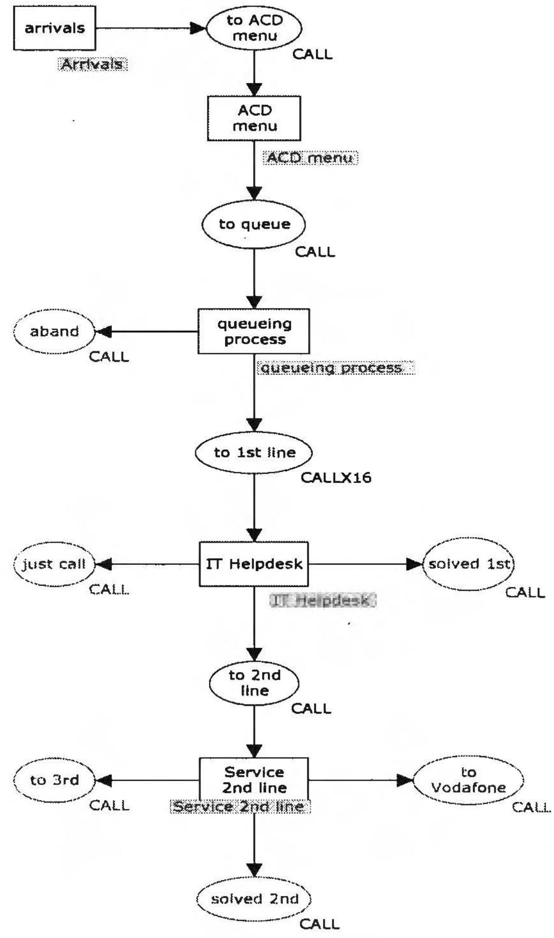

Figure 8: overview main process model IT Helpdesk

After possible delay in the queueing part of the model, the call is sent through to the next transition, which is called "IT Helpdesk". Afterwards, the call may leave this transition through three different places:

- "just call": the call did not need any particular service and was not registered in ITSM, the registration tool of EDS – Vodafone.
- "solved 1st": the call has been solved by the IT Helpdesk at 1st attempt. The call is registered partly, handled and closed.
- "to 2nd line": the call needs further service, gets a registration in ITSM and is sent through to the 2nd line support groups.

When a call is being sent to the place "to 2nd line" the call is assigned with a number of attributes. Type of call (INC or RFI), priority (NONE, LOW, MEDIUM, HIGH, TOP) and support group needed are assigned to the call. More detail on the "IT Helpdesk" transition and all of its sub processes can be found in Appendix N.5.

The final main transition in the process model is called "Service 2nd line". The call has been assigned with a support group name, which determines the service needed to possibly solve the call, according to the judgment of the 1st line agents. The call will be guided to the assigned support group for service and is assigned with a suitable resource for service. The call can then either leave the process model or is redistributed to another support group for further service. From the transition "Service 2nd line" the call can leave the process model through three different places:

- "to Vodafone": calls that need service from a Vodafone support group are not sent back to any EDS support group. That is why these calls leave the process (model). Calls with another ITSM type (not INC or RFI) also will end up at this support group.
- "to 3rd": if a call is being sent to the support group "REPAIR", the call will end up at a 3rd line service supplier with a probability of 80%.
- "solved 2nd": If a call is solved in the 2nd line, it will end up at this place.

More detail on the "2nd line service" transition and all of its sub processes can be found in Appendix N.6.

5.2.2 Call characteristics

A call is unique by means of its attributes. Each call is assigned with a unique ID number at the generator of the process model. Furthermore, the call will be assigned with a number of other characteristics or values to send and guide the call through the process. The call is a product of:

- ID, a unique integer number
- ACDtype, an integer number which identifies the assigned ACD type in the ACD menu.
- ITSMtype, a string with two possible values: INC and RFI.
- SGs is a list of strings. The strings are the names of the support groups that are (to be) visited.
- PRIO, an integer number implying the priority of the call. 1 Stands for priority NONE, 5 stands for priority TOP and 99 stands for one of the other ITSM types.
- STATUS is a list of strings. The strings are the states that a call has gone through. For example, one of the states can be "toSG" and means that a call has to be redistributed to another support group.
- TimeT is a list of timestamps that are assigned to the call when moving through the process model. The target time that depends on the priority of the call is also assigned to this list.

Through the whole process, the call carries the values of its attributes and makes it possible to determine a route through the process model.

5.2.3 Stochastic behavior and use of probability distributions

One of the main characteristics of a call center process is its stochastic behavior. The route of the call through the process model is determined by its attributes and the decision points in the process model. The introduction of a number of probability distributions for inter-arrival rates, service and waiting times and for different routings of calls enables the stochastic behavior of the process model. For example, the inter-arrival time of the call is determined by a Poisson distribution that uses a list of forecasted constants as its input value: a stepwise rate function $\lambda(t)$. Each half an hour of the week uses another input value for the Poisson distribution.

Attributes and delays are assigned to calls based on the forecasted probability distributions of the attributes and delays. A uniform discrete probability distribution is used every time to pick a value from a collection of historical data that has been used at data analysis. This procedure is performed with assigning:

- the ACD type to the call;
- the maximum waiting time to the call, based on ACD type;

- the front office service time to the call; based on ACD type;
- the outbound extension call service time to the call; based on ACD type;
- the type of ITSM to the call and whether or not the call is solved at first attempt (initial resolution rate);
- the priority of the call; based on the ITSM type;
- the support group to the call; based on ITSM type and priority and the number of visited support groups.

All uniform discrete probability distributions and the forecasted data distributions are inputs to the decision making for routing of calls through the IT Helpdesk process and representing the workload in the process.

Take for example the ACD menu in the process model (Figure iii in Appendix O). Appendix P.2.2 explains the whole procedure in this sub process. The call is assigned with an extra integer value, x1, by means of a discrete uniform distribution: discrete (1,10000). Depending on the value for x1, the system will determine which ACD type has to be assigned to the call, by means of function add_acdtype(x1). If x1 is assigned with 8100, the data distribution for ACD types will tell the process model to assign ACD type 281 to the call.

5.2.4 Resources in the process model

The resources and their availability or unavailability times are modeled with a weekly pattern. Every week, the resources are delayed (unavailable) or available in the same periods of time of the week. This accounts for the 1st and the 2nd line resources. As mentioned in Section 5.1, the resources are assumed to be equal and interchangeable when they have the same skills (ACD type or support group type).

The 1st line resources and their delay times are modeled with more detail due to the more detailed historical data of the 1st line. Per 30 minute time interval, the delay time has been forecasted. If a resource is finished with a call, he or she first visits a transition in the model that calculates the amount of delay time for the resource. When the resource is waiting to serve new incoming calls, he or she is sent to this delay calculator every 60 seconds to guarantee the right number of available resources at every time of the day and week. The delay time depends on the time of the week. This transition and its accompanying function (Appendix P.3.2.1) guarantee the availability of the resources as forecasted (Section 4.6) at every second of the week. The right number of resources has to start every day at 08.00 hours and the right number of resources has to be available in the last time intervals of the day.

The resources in the 2nd line (Appendix P.3.2.2) and their availability are modeled with less detail. They are assumed to be available during their shift (of 8.5 hours) with exception of a 30 minute break in the afternoon. Historical data was unavailable for forecasting the available number of 2nd line resources for every time of the day (Section 4.7.1). Some resources in the SM support group are not 100% available to handle calls. This has been modeled with a delay per time interval, which should equal the percentage of time that the resource has other activities to perform.

Appendix P.3.1 provides the skills matrix (Table v) which is an overview of the skills per resource. The matrix is divided into 1st and 2nd line resources and into ACD skills and support group skills. 1st Line resources have skills to serve calls that are sent to the HD or GWE support group in the 2nd line. Resources in the 2nd line support groups may have more than 1 skill, as mentioned before in 5.1. The method adopted for the skills matrix has also been found in scientific literature. Mazzuchi and Wallace (2004) do not make the distinction between generalists and specialists, but set up a skill matrix for every individual agent. The matrix contains the skills agents have or have not.

In the process model, a call will be served by a resource. The call and the resource are traveling together through the model during service. The type of the combination is CALLEMP and carries all of the calls' and resources' attributes.

5.3 Verification of the process model

CPN Tools automatically checks the syntax of a net or process model during creation. Furthermore, CPN Tools can check the correctness of the process model. This functionality is called the State Space Analysis (also called occurrence graphs, reachability graphs or reachability trees). The model is checked for wrong or double names, wrong modeling, deadlocks and infinite occurrences. In other words: what goes into the model should come out as well. No tokens, resources or calls may be lost or "cloned" in the process model. The findings from the verification phase have been obtained from Appendix S. State space analysis reports have been described and form the basis of the conclusions. The model is considered to be verified.

5.4 Performance measurements with CPN Tools with monitors

Performance of the process model can be measured with CPN Tools 2.0.0. The monitors in CPN Tools can be designed to obtain all kinds of information and measurements from the process model. In theory, every detail of the simulated process can be logged. The monitors will be primarily used to measure waiting, service and throughput times, numbers of calls, numbers of (re)distributed incidents and numbers of available resources. Simulation performance reports provide an overview of the statistics that are calculated during one simulation for the data collector monitors in the process model. These statistical results include the 95%-CI of the measured statistic.

The way simulations are performed by CPN Tools has been described in Appendix Q.1 and Appendix M.5. The simulation method of CPN Tools guarantees the independency and identically distribution of the measured values, because each replication uses another seed to generate random numbers. Furthermore, a number of simulation settings needed determination:

- The number of replications per simulation has been determined at 30 (Appendix Q.2). This number has been obtained from literature (Van Der Aalst, 1995) and is a good balance between reliability and time needed for the simulation runs.
- Initialization period. The process model is empty at the start of the simulation and replications. No calls are in the process at time = 0. Therefore, the initialization period needed to be determined. The initialization period is the time after which a process (model) reaches steady-state. This period needs to be run before the measurements in a replication may be started. The initialization or warm-up period has been determined at 8 weeks for the process model of the IT Helpdesk process. A detailed description of the determination can be found in Appendix Q.4.
- The replication length has been set at 4 weeks of process run time. The SLA reports of EDS to Vodafone are based as well on monthly results. 4 Weeks of process run time imply that each replication is stopped after 12 weeks of warm-up and simulation time. Possible negative effects of the process running empty or

of a cooling down period are removed from the simulation due to the stop criterion.

The validation of the process model has been performed by means of simulations with the monitor version of CPN Tools

5.5 Validation of the IT Helpdesk process model

The model needs to be validated for determining whether or not the process model is reasonable and correct for the intended application. Is the model a good representation of reality and performing according to the forecasted behavior?

Scientific literature provides some guidelines for validating a simulation model. Van Der Aalst (1995) states that the results of a simulation run have to be compared to observations of the real process. Usually this means a comparison with available historical data. According to Zapf (2004) the suitability of the simulation model can be checked in the following validation and verification steps:

1. Conceptual model validation: determine that the conceptual model is reasonable and correct for the intended application. This has been partly performed by presenting a concept of the model to the service delivery manager (SDM) of EDS who is responsible for the daily operations of the IT Helpdesk. The concept model was approved by the SDM. The other part of the validation is described in the next paragraph.
2. Computerized model verification: ensure that the computer programming and implementation of the model is correct. This has been covered by the State Space Analysis described in Section 5.3. Within the computerized model verification, sensitivity analysis was used to ensure that small changes of process parameters are not critical for the performance measurement. The sensitivity analysis will be provided in Section 5.6.
3. Data validity: ensure that data is appropriate, accurate and sufficient. This has been covered in Chapter 4. Amply historical data was available for statistical testing and forecasting.
4. Operational validity: determine that the results are sufficiently accurate for the intended purpose over the application domain. Regarding the operational validity 95% confidence intervals have to be calculated for every performance measurement. In order to reflect the nature of a communication center, the single experiments have to be performed in the form of multiple (terminating) simulation runs. For every experiment 30 independent replications have to be made according to a general rule. CPN Tools calculates the 95%-CI automatically and the number of replications has already been determined at 30.

Data-analysis results are compared with the measurements from various simulations. Monitors have been designed to obtain the necessary results and numbers. Appendix T provides a detailed description of the validation of the model. Appendix T.13 discusses the validation results. Either the forecasted means had to be within the simulated 95%-CI's or the deviation of simulated results from forecasted means had to be acceptable. The final outcome is that the developed process model is valid.

5.6 Sensitivity analysis of the IT Helpdesk process model

The settings of the process model are based on the data analysis that has been performed in Chapter 4. The data analysis resulted in a number of forecasts and process model characteristics that account for a specific situation. Therefore, a sensitivity

analysis has to be performed. The variable input parameters have to be adjusted by a fraction to measure the sensitivity of the performance of the process model. The small variations in the parameter settings should cause small variation in the performances of the simulations. The size of the variations in performance reflect the sensitivity and thus the robustness of the process model that has been designed (Van der Aalst 1995).
Appendix U describes the details of the sensitivity analysis and the changes to the other main input parameters of the process model. The analysis shows that the process model is very robust and that small variations in different settings of model cause small variations in the results of the simulations: a linear reaction of results on the variation of input parameters.

5.7 Findings and implications for redesigns and simulations

This chapter has described the design and functionality of the process model of the IT Helpdesk. A general description of the process flow has been provided in this chapter. Appendices N, O and P provide a much more detailed description of the process model by explaining every activity and sub process, presenting the process by figures and providing all declarations and functions in the process model.
The stochastic behavior of the process is guaranteed by using a lot of probability distributions like Poisson for the inter-arrival rates and data distributions from real historical data for other parameters and decision variables in the process model.

Furthermore, the model has been verified as far as possible by means of the on-board tool of CPN Tools: the state space analysis. The validation of the process model was successful as well. All parts of the model have been validated. This required some slight adjustments to the settings of the parameters of the model in order to make the process model as realistic (based on forecasts) as possible. The sensitivity analysis resulted in a process model that is very robust. Small variations in input parameters of the model cause very linear and small variations in the performance of the process model.

The chapter started with summing up the assumptions and demarcations that have been made in the previous chapters. Furthermore, some extra assumptions were made to build the process model for the IT Helpdesk process. One of the main conclusions of these extra assumptions was that the process model to be designed is actually a workload model. The process model generates the workload in terms of different types of calls and incidents with accompanying target dates and service times. Multiplying the number of incoming calls by the average service times and probabilities of redistribution would results in the workload for the resources in the 1st and 2nd line.

The ideal solution would be to adapt the availability of resources to the workload model that has been created. For every time of the day an estimate or forecast exists of the number of calls and average service time required. Simply matching the demand pattern with the number of available resources would be the easiest way to obtain good performance of the process. Though, this is rather unrealistic because there are many restrictions: employee contracts, legal issues and process characteristics. Resources are not flexible or part-time. Therefore, the resources simply have to work 40 hours a week, during the working days of 08.00 hours till 18.00 hours. Furthermore, the required level of skills of resources is too high to work with flexible and less educated and skilled personnel. The costs of flexible and skilled resources would be too high.

6 Improving the performance of the IT Helpdesk process

This chapter will discuss the search for a better (re)design of the call center process at the IT Helpdesk of EDS – Vodafone. The process model of the actual situation has been described, verified and validated in the previous chapter. This process model will be used as a basis for the redesigns of the IT Helpdesk process and the accompanying staffing levels of resources at various levels in the process. Providing results for answering RQ3 is the objective in this chapter and this inherently means an answer for RQ2 and RQ4.

The results from the validation phase and from the sensitivity analysis already point at the good performance of the process model of the existing situation. This substantiates the earlier remarks (Sections 3.4 and 3.5) on the performance of the IT Helpdesk. The good performance, based on the SLA agreements, is substantiated furthermore in Section 6.1 with a number of simulation results. In addition, a few simulated scenarios of the existing process show the possible effects of staffing resources a little bit differently. The process model of the existing process at the IT Helpdesk requires some adjustments and extra functionalities to make it suitable for redesign purposes. This procedure is described in Section 6.2. Section 6.3 discusses possible redesigns of the IT Helpdesk process and substantiates the redesigns with scientific literature on call centers and BPR. The simulations of redesigns and scenarios are summed up in Section 6.4. The redesigns and their simulation results are compared by SLA performance measurements and costs of resources and possible changes to the IT Helpdesk process.

6.1 Performance of the actual process model and some scenarios

During the validation phase and the sensitivity analysis, the simulation results already showed good performance of the process model of the actual situation at the IT Helpdesk. This will be substantiated by simulation results (Table 7) of different scenarios:

1. scenario of the actual situation
2. scenario with one resource less
3. scenario with overload
4. scenario with overload and shifting of one resource from 2nd to 1st line
5. scenario with overload, rescheduling compensation hours of a 1st line resource.

Since the ASA of the process model is so unrealistic (Sections 5.5 and Appendix T.4), this SLA criterion will be replaced by the number of abandoned calls which is very closely related to the ASA. A high ASA will cause high numbers of abandoned calls, because the patience of callers is put to the proof. Instead of the SLA of 90% of the calls to be answered within 45 seconds, the SLA of abandoned calls will be set to a maximum of 5% of the total of incoming calls. This new criterion is much stricter than the one of ASA, because the total percentage of callers that is willing to wait more than 45 seconds is slightly above 10% (Appendix D.4). In other words: about 90% of the callers has a maximum waiting time and patience of up to 45 seconds.
Furthermore, the incidents that are over target will remain of interest in the simulation results.

6.1.1 Scenarios 1 (actual situation) and 2 (resource less)

The process model has been simulated in the state that it has been modeled as described in Chapter 5 (scenario 1). The relevant results as defined for the SLA are presented in Table 7, second row. The percentage of calls that abandons the waiting queue before service is 1.69% for the actual process (model). There are no incidents over target, which means that all incidents are served within the allowed time scope. The simulation results show incidents that are over target, but these incidents have visited one of the three support groups that deal with long delay times due to third party service suppliers. These incidents are not of interest since they are handled outside the SLA.
Row 3 in Table 7 shows a situation where 1 resource (Peter) is left out of the 1st line (scenario 2). The abandonment (4.06%) is still within the acceptable maximum percentage of 5%. This only accounts for the weeks in which the number of incoming calls is as forecasted (average, general load). In busier periods, leaving out a resource in the 1st line is bad for the performance of the IT Helpdesk process. The percentage of abandoned calls will be more than the allowed 5% of total of incoming calls.

Table 7: Results of simulated scenarios for the actual process model

Scenario	AnsCalls	AbandCalls	Aband%	OverTarget
1	5625.47	96.97	1.69	0.00
2	7339.83	303.93	3.98	0.10
3	5487.07	232.47	4.06	0.00
4	7357.23	284.50	3.72	0.13
5	7384.93	257.47	3.37	0.13

6.1.2 Scenario 3 (overload situation)

The load on the call center has been increased by manipulating the inter-arrival rate. Scenario 3 has been designed to prove that the process model can very easily handle higher numbers of calls in more busy weeks. The inter-arrival time constant that is input to the Poisson inter-arrival function is multiplied by 0.75, which implies a raise of the number of generated calls of approximately 33%. The number of generated calls per week increases from 1430 to 1907. The results of scenario 3 are presented in the fourth row of Table 7. The abandonment percentage has increased to almost 4%, which is still within the defined maximum of 5%. In this scenario it occasionally happens that an incident is over target, but the number (0.10) remains extremely low and within the defined SLA of a maximum of 10% of the registered calls.

6.1.3 Scenarios 4 and 5 (rescheduling resources)

Analysis of the abandonment data in the actual process model simulation results show that half of the number of abandoning calls in one week leaves the waiting queue on Monday morning between 09.00 and 11.30. In more busy periods (overload situation assumed in scenarios 4 and 5), these are the intervals where large increases of performance (according to SLA) can be reached.

- Shifting a resource from 2nd to 1st line is an option (scenario 4). The fifth row of Table 7 shows the results of scenario 4 where resource Leo from support group BO has been assigned with ACD type 62 which makes him capable of serving this type of incoming calls for the specified time intervals. The number of abandoned calls has been significantly decreased by more than 7%.
- Rescheduling compensation hours or days is also very effective to decrease the number of abandoning calls (scenario 5). In reality, one or more resources have

to work in the weekends as well, which is compensated by a day off throughout the week. If the compensation day is Monday, it will affect the performance of the IT Helpdesk process more than any other day, since Mondays are the busiest. Row 6 of Table 7 shows the results of scenario 5 where the number of available 1st line resources at Monday (morning) is increased by 1. A significant decrease in number of abandoned calls of more than 15% can be achieved. That is twice as much as with scenario 4. Of course, these hours have to be compensated by less available resources at other, more quite hours of the week. The total number of working hours for the 6 resources in the 1st line should remain the same. Check the simulation results for these scenarios.

The shifting of capacity can be performed as well for other days or intervals of the week which deal with higher than average numbers of incoming calls. Thursday morning for example could also profit from this rescheduling of resources in the 1st line.

Another interesting scenario would be to change the ACD types (distribution) and manipulate the abandonment behavior of callers and the workload for the process model. These characteristics are namely different for every ACD type. The actual process model though is performing very well and changes in distribution of ACD types are not expected to have any effects on the performance of the process model in a way that the performance would be outside the SLA. In the upcoming sections, versions of this scenario will be used to compare a customized design of the actual model with redesigns of the process model of the IT Helpdesk.

6.2 A suitable process model for redesign of the IT Helpdesk process

Answering RQ2 requires the model to be used for simulating different staffing designs and/or scenarios of the call center process model and measuring the performance of the process. Performance can be measured with CPN Tools, as described in Section 5.4. The design of the actual process model is capable of simulating different scenarios in terms of load (numbers, inter-arrival rates), changing the distributions of case types (ACD or ITSM, priorities) and the numbers of resources in 1st and 2nd line. These are all rather simple changes to the model and not really strategic redesigns of the process. A redesign is considered to be a structural, long term change of (some) process characteristics or settings. Some adjustments to the model and extra functionalities in the model are necessary to facilitate implementation of other call center or staffing designs. These adjustments and extra functionalities are considered not to influence the objective our research aims at. The process model maintains a workload character (Section 5.1) and the amount of total workload for the 1st line is decreased by 2.7%. The division of workload over 1st (front office) and 2nd (back office) line changes, but is necessary to study the sensitivity of changes in different call center characteristics.

6.2.1 Adjustments

The adjustments in the process model are:

- The calls that were classified as "just call" (Section 5.2.1), do not leave the process model without registration, but are all sent through to the classification route. The model is very well capable of dealing with these numbers of calls and it makes comparing redesign simulation results easier.
- Calls with ACD type 300 (mail) are assumed to be synchronous as well and are now assigned with a maximum waiting time. They are assumed to have abandonment probabilities as well. The abandonment behavior of calls with ACD type 283 is used for calls with ACD type 300. All calls are synchronous.

- Up to now, no relationship has been assumed between ACD types of calls and incident types that are sent to the 2nd line (ITSM type). The ACD types will be either standard or special and the ITSM types RFI and INC are assumed to be respectively a standard and a special type of incident. Since the initial resolution rate is a given fact in the model, the referral rates for the standard and special types incidents are assumed to be respectively 0% and 100% (used to be 52% for all incidents, Section 4.2.3). The new division of percentages per ACD type results in a small decrease in average service time (and thus workload) for the total number of incoming calls, because the average service time per ACD type is different. This total average decreases from 149 to 145 seconds (-2.7%). The division of types of calls is now 50/50 for standard and special calls:
  - The ACD types that are classified as standard are 207, 282 and 283, because the problem is defined by the specific ACD type that is chosen in the ACD menu. 50% Of the calls is standard. The percentages of calls that have ACD types 207, 282 and 283 are respectively 20, 15 and 15.
  - The ACD types that are classified as special are 62, 281 and 300, because these ACD types do not specify a specific problem. This has to be determined by a 1st line agent by means of registration and classification. 50% Of the calls is special. The percentages of calls that have ACD types 62, 281 and 300 are respectively 40, 5 and 5%.
- All resources in the 1st line have the same set of skills to all ACD types.
- All resources in the 2nd line only have one support group skill to serve incidents in a particular support group.
- Two resources in the 2nd line (Patrick from the SM support group and Richard from the BO support group) have been left out for the ease of designing different resource groups.

Figure 6 (Section 3.2.2.3) is the representation of the customized, actual process model of the IT Helpdesk process. This design will be referred to as design A. The calls are divided into the standard and special types (based on ACD type). Generalist resources register, classify and handle the standard calls and incidents and register and classify the special calls and incidents. The handling of the special incidents will always be done by the specialists in the 2nd line who all have only 1 skill.

6.2.2 Extra functionalities

The extra functionalities that are introduced here are based on best practices in Business Process Reengineering (Reijers and Limam Mansar, 2005), described in the upcoming Section 6.3. The assumptions that have been made in the previous section on standard and special call and incident types based on ACD and ITSM type facilitate the introduction of automated classification by an ACD menu or by an extra classification menu. The classification of calls is based on the data analysis of historical data, described in Sections 4.1 and 4.2. The automated classification offers the possibility to route calls directly to the right resource (specialist or generalist) in front or back office. In the process model the ACD menu and classification process can be used anywhere at any moment in the process. An argument against such an automated classification is that it is very difficult to design an ACD menu or intranet site for the callers or users that want to report the problem. It is not inconceivable that a caller does not have a clue of the cause of the problem and is not capable of giving correct input. An automated ACD or classification menu becomes useless in such a case and calls are sent to the wrong resource, which is not assumed to be very efficient.

Furthermore, division (automated or not) into call and incident types offers opportunities for implementing triage and using one level designs (no back or front office) instead of the modeled two level design. If an incident is too difficult to be handled and solved by the gatekeeper, he or she refers the incident to a specialist. This is called a triaging system, because customers first interact with a generalist who determines if the customer requires the attention of a specialist or not.

The assignment of resources to calls and incidents has been changed in the 1st and 2nd line. The resource with the least number of skills is assumed to be the most specialized and is assigned to the call or incident. When call or incident type and skill type of the resource match of course. This is called the flexible assignment. The more generic resources are preserved and the possibilities for having a suitable resource for the next work item are maximal. There is a smaller chance that a case has to wait for a specific resource and it is expected that the overall queueing time in the process will be reduced. Probably, other assignment rules can be designed that are even more efficient, but in this research the goal is to explore the possibilities of simulating other designs/functionalities. Implementing other assignment rules is considered to be interesting for future research. The extended functionality of flexible assignment for the process model is described in Appendix V.
The queueing process in the 1st line of the actual process model (Section 5.2.1) is also available for calls that are sent directly (by automated classification) to the 2nd line, in case this is used in a redesign.

6.2.3 Performance measurements

The comparison of the (re)designs needs to be done on some important call center characteristics and known performance criteria:

- As mentioned in Section 6.1, the measured ASA of the original process model is considered to be unrealistic. Therefore, the percentage of calls that abandon the process is used as an alternative measurement and is not allowed to be more than 5% of the incoming calls. The lower the abandonment rate the better of course.
- To compare the different (re)designs, the throughput time of different types (standard and special) of incidents will be measured as well.
- Furthermore, the incidents that are over target will remain of interest. The original SLA on over target incidents is a maximum of 90% of the served incidents (that do not abandon before service).
- The utilization rates of different types of agents will be measured as well for means of comparing the (re)designs. This rate can be used as well to determine the influence of the design changes on the costs of resources.

6.3 Redesigns for the IT Helpdesk process, inspired by BPR literature

The process model is based on average loads of calls which can generally be observed. Even with a significantly higher number of incoming calls, the minimum SLA criteria are made. The 2nd line resources cannot be changed that easily due to their other activities for system management and dealing with changes and work orders. Therefore, the choice has been made to look at the relative performances of redesigns (strategic, long term) and (what-if) scenarios and explore the possibilities that would provide an answer to RQ2. While doing that, RQ3 can probably be answered by evaluating and assessing the redesigns for feasibility for the EDS – Vodafone case.

Matching characteristics and settings of this specific call center process with scientific literature on BPR and best practices (Reijers and Limam Mansar, 2005) leads to a set of various interesting redesign options (Jansen-Vullers et al., 2006). The best practices identified are:

- Task composition, which would facilitate a one level design instead of a two level design. Registration, classification and handling (service) are the three identified distinctive tasks in the IT Helpdesk process. These can be combined or separated according to the redesign.
- Case types: the IT Helpdesk process consists of different ACD and ITSM types of cases. Furthermore, there are mails with service requests as well. These call types facilitate the use of standard and special call types and synchronous and asynchronous call types (Section 3.2.2.2).
- Triage (Section 3.2.2.3) which is based on the two case types that have been mentioned just before. It facilitates different routings of calls through the process (model). Standard calls are not referred to the 2nd line, special calls will be referred to the 2nd line 100%.
- Generalist/specialist, which would lead to different skill sets for specialists (cross-trained). The skill sets are based on the different call types (ACD type and support group needed). Initially, the specialists are assumed to be heterogeneous. Specialists with the same set of skills are assumed to be homogeneous.
- Task automation. Division into call types facilitates the use of an ACD menu or extra classification menu to automatically route calls to the right person or group.

The changes to the original process model of the IT Helpdesk process necessary for implementing these redesign options have already been performed and are described in Section 6.2. The actual implementation into the redesigns will be described here after, together with the changes to the customized design of Section 6.2.

6.3.1 Cross-trained workers in the 2nd line

The first redesign (design B) is presented in Figure 9 and is almost exactly the same as in Figure 6 which represents the customized current model. In the 2nd line, some specialists are assigned with more than 1 skill, which allows them to serve different types of calls that are sent through to the 2nd line. Specialists become cross-trained workers. Resources are assigned to calls with flexible assignment. This is introduced in Section 6.2.2 and selects the resource with the least number of skills.

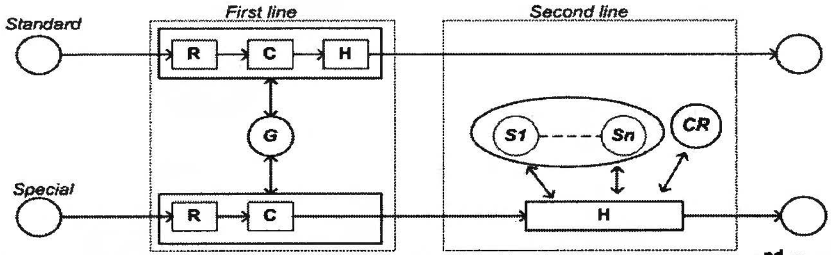

Figure 9: design B - redesign with cross-trained workers in the 2nd line

The assignment of skills to resources in the 2nd line is based on load of incidents on the different support groups which can be extracted from Appendix I. Each skill set should bring about a balanced load on every resource (group). Geographic location and type of tasks are ignored while assigning the skills to the resources. This redesign is just meant to be illustrative for the result of using cross-trained resources. The division of skills over the 16 available resources is as follows:

- 8 resources with one skill for every support group (except REPAIR)
- 4 resources with skill set ["REPAIR","BO-P&C","HQ","AM"]
- 4 resources with skill set ["BO","SM","ILFIO","MEGA","SWITCH+DB"]

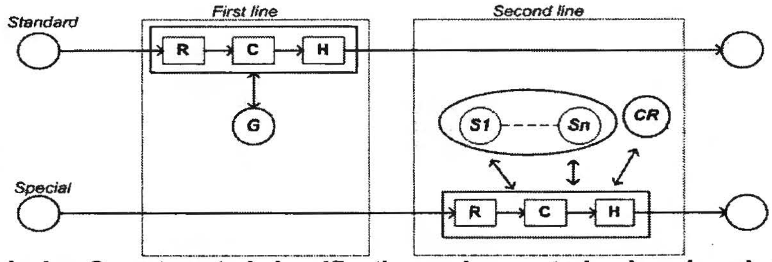

Figure 10: design C - automated classification and cross-trained workers in the 2nd line

The next redesign (design C) is a design which assumes automated classification of special calls in order to guide them straight to the right resource or support group in the 2nd line (Figure 10). A waiting queue has therefore been introduced in the 2nd line. Calls may abandon here as well (as described in Section 5.2.1). Furthermore, the cross-trained resources are modeled the same as in the previous redesign.

6.3.2 One level designs of the IT Helpdesk process model

The next three redesigns are one level designs of the IT Helpdesk process model. The distinction between front and back office has been removed.

Figure 11 shows a one level design (design D) with only generalist resources which can serve all types of calls and incidents, implies the registering, classifying and handling of calls and incidents by one particular resource that is assigned to the resource from start to end. Triaging still determines the different routings of standard and special calls and incidents. The classification and redistribution functionalities of the original process model determine the routings and service times.

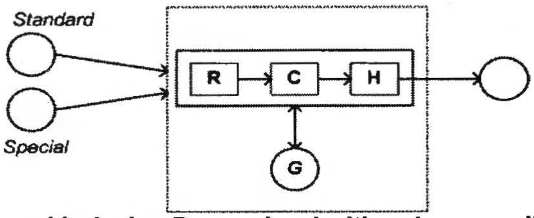

Figure 11: design D - one level with only generalists

Figure 12 shows a one level design (design E) with only specialist resources (one skill per resource) is the result. Extreme triaging creates two separate routes for standard and special calls and incidents. The calls with ACD type 62, 281 and 300 are directly sent to the specialists in the support groups for service. Automated classification for these calls has been modeled in the redesign. The skills for the standard calls and incidents are equally divided over the former 1st line resources. The skills for the special calls and incidents are divided over the former 2nd line resources. The calls with ACD type 62, 281 and 300 are directly sent to the specialists in the support groups for service.

Automated classification for these calls has been modeled in the redesign. The skills for the standard calls and incidents are equally divided over the former 1st line resources. The skills for the special calls and incidents are divided over the former 2nd line resources.

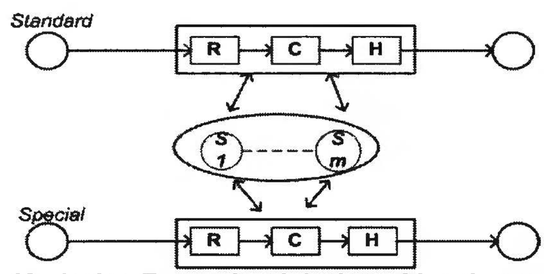

Figure 12: design E - one level design with only specialists

For more flexibility in the one level redesign with only specialists, some cross-trained workers are introduced in the process model. This resulted in design F (Figure 13). The groups of resources are:

- 6 Resources (former 1st line resources) have skillsets [207, 282, 283], ["BO", "SM", "ILFIO", "MEGA", "SWITCH+DB"] for respectively ACD and support group skills.
- 4 Resources have skillsets [207, 282, 283] and ["REPAIR", "BO-P&C", "HQ", "AM"] for respectively ACD and support group skills.
- 11 resources are specialists with only 1 skill to serve special incidents.

The same remarks on resources and their skills as mentioned in Section 6.3.1 account here.

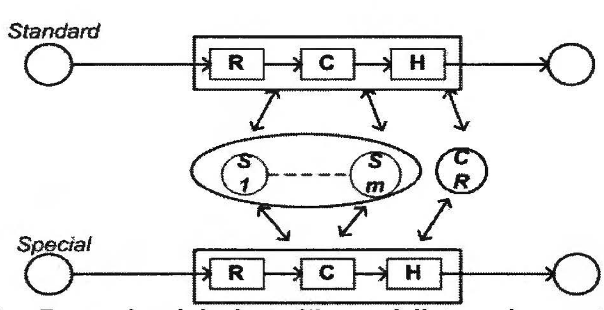

Figure 13: design F - one level design with specialists and cross-trained workers

Section 4.7.4 mentions the sometimes lacking accessibility of Vodafone employees that have reported a problem. The one level design with only generalists would be interesting since it aims at reducing the number of contacts between callers and resources.

6.3.3 Registration of special calls in the 1st line

Figure 14 shows a redesign where the registration will be done by 1st line generalist and where all calls will be classified (automatically) and handled in the 2nd line. The longer service times in the 2nd line will not have any effect on the abandonment of special calls. For registering the special calls, a registration time of 60 to 120 seconds is assumed (uniformly distributed over that interval). The average of this distribution of registration times is lower than the ACD service times for the 1st line that have been forecasted in Section 4.4.

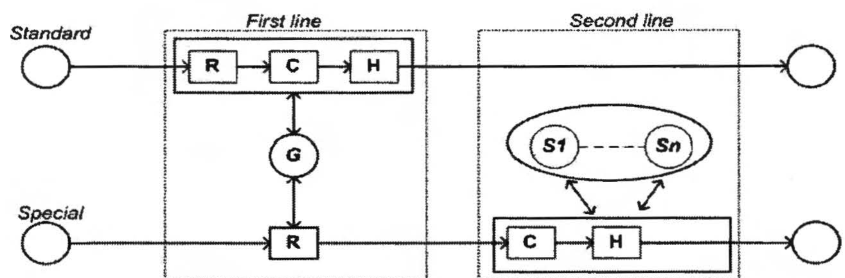

Figure 14: design G - registration in the 1st line of special calls

6.4 Simulating different (re)designs and scenarios

The minimal performance criteria of the SLA are not a problem for the IT Helpdesk in the more general weeks with average (and higher) loads of calls. This conclusion can be substantiated by the findings of Sections 6.1.1 and 6.1.2. The actual staffing levels are assumed to be the necessary minimum for the higher loads of calls that can occur at any (unpredictable) time and for the other tasks that have to be performed by resources in the 2nd line. The need for a redesign to improve performance of the IT Helpdesk process seems to be low, with the assumed settings and circumstances (actual situation). Therefore, a number of what-if scenarios is added to observe the impact of redesigns in changed circumstances:

1. current situation (50/50% standard and special calls)
2. change in arrival pattern: number of calls increases with 33%
3. number of standard calls increases to 75%. ACD types 62, 281, 300, 207, 282 and 283 respectively have the percentages 15, 5, 5, 25, 25 and 25.
4. number of special calls increases to 75%. ACD types 62, 281, 300, 207, 282 and 283 respectively have the percentages 50, 10, 15, 15, 5 and 5.
5. number of generalists has been reduced from 6 to 5.
6. number of specialists has been reduced from 16 to 15.

The results of simulations of all redesigns and scenarios can be found in Appendix W.

First, the best design per scenario will be described, in terms of performance, costs and considering both aspects for a possible redesign. The difference in performance is considered to be significant when the 95%-CI's of both measurements are not overlapping. When necessary, the (absolute) difference between the performance measures are discussed. Furthermore, the options/reflections towards the EDS – Vodafone case are provided in terms of feasibility and costs.

6.4.1 Best design per scenario

The columns in Tables 8 to 11 respectively show the number of the redesign, the number of the scenario, the percentage of calls that abandoned, the utilization rate of resources in the 1st and 2nd line, the throughput times of standard and special incidents and the number of incidents that is over target. Some tables only show one rate for utilization of resources in case there is only one resource pool.

6.4.1.1 Scenarios 1 and 2

Scenarios 1 (Table 8) and 2 (Table 9) for all redesigns (except redesign E) show a satisfying abandonment percentage, within the SLA. For scenarios 1 and 2, redesign D is performing the best for throughput times of special incidents. The costs for the redesign though are expected and considered to be too high, since all resources should be able to handle all calls and incidents. This requires training and higher salaries for all resources. The least costs will be made for redesigns G and B, but the gain in throughput times for special incidents is considered to be too small compared to (the original) design A.

Table 8: redesign results for scenario 1

Design	Abandoned Calls [%]	Resource utilization 1	Resource utilization 2	Throughput standard [s]	Throughput special [s]	Incidents over target
A	1.39	0.572	0.277	145.46	3743.27	0.10
B	1.43	0.571	0.302	144.56	3351.44	0.03
C	1.37	0.426	0.297	145.05	2390.05	0.00
D	0.00	0.342	N/A	143.46	1488.98	0.00
E	11.07	0.286	N/A	147.14	2532.94	0.00
F	0.82	0.327	N/A	144.56	2424.84	0.10
G	0.69	0.522	0.280	144.51	3680.71	0.03

Table 9: redesign results for scenario 2

Design	Abandoned Calls [%]	Resource utilization 1	Resource utilization 2	Throughput standard [s]	Throughput special [s]	Incidents over target
A	3.36	0.646	0.358	146.43	4042.20	0.00
B	3.36	0.646	0.387	146.47	3463.13	0.16
C	2.96	0.481	0.376	144.88	2436.39	0.07
D	0.02	0.431	N/A	144.58	1481.93	0.00
E	14.76	0.339	N/A	148.68	2637.37	0.10
F	1.82	0.398	N/A	144.50	2482.69	0.10
G	1.68	0.583	0.364	145.56	3951.68	0.20

The improvements of throughput times of special incidents by redesigns F and C are also very good and the costs are expected to be much lower than redesign D. Redesigns F and C are considered to be the best combination of improvement of performance and costs. Only half of the resources (cross-trained workers) needs to be trained extra and receives higher salary for their extra skills. The costs for resources in the 1st line will be lower due to the lower utilization rate. An automated ACD or classification menu to be designed for these two redesigns, which is considered to be a one-time investment.

6.4.1.2 Scenario 3

For scenario 3 (Table 10), roughly the same conclusions can be drawn as for scenarios 1 and 2. The difference lays within the utilization rates of 1st and 2nd line resources. In case the standard calls account for 75% of the workload, redesigns F and C are considered to be the best combination of performance improvement and costs. The load on the 2nd line and the resource costs for specialists and cross-trained workers will be significantly lower.

Table 10: redesign results for scenario 3

Design	Abandoned Calls [%]	Resource utilization 1	Resource utilization 2	Throughput standard [s]	Throughput special [s]	Incidents over target
A	1.03	0.559	0.145	148.87	3538.43	0.03
B	1.09	0.559	0.152	149.07	3206.98	0.00
C	0.55	0.492	0.154	148.89	2392.16	0.07
D	0.00	0.282	N/A	147.89	1513.21	0.00
E	10.73	0.228	N/A	153.31	2465.25	0.03
F	0.13	0.259	N/A	148.06	2467.63	0.00
G	0.76	0.534	0.146	148.85	3397.07	0.03

6.4.1.3 Scenario 4

For scenario 4, the abandonment percentages of redesigns C and E are outside the SLA (Table 11). At first sight, only redesign B is considered to be a serious candidate when looking for a good combination of improvement of performance and costs. Redesign B requires training costs and higher salaries for the cross-trained workers against a significant gain in throughput time for special incidents. For redesign F, the abandonment percentage is relatively high and is expected to be outside the SLA when the load on the call center increases (more special calls). This could simply be solved by assigning fewer resources with skills to serve standard calls and incidents and more resources with skills to serve special calls and incidents. The redesign should then be capable to handle higher numbers of calls with a significant improvement in throughput times for special incidents. This requires more training and salary costs for the resources and an investment in the automated classification menu for special calls. Redesign F is the best redesign for scenario 4, since the significantly lower (extreme) throughput times of special incidents are considered to be worth the investment.

Table 11: redesign results for scenario 4

Design	Abandoned Calls [%]	Resource utilization 1	Resource utilization 2	Throughput standard [s]	Throughput special [s]	Incidents over target
A	1.85	0.587	0.405	134.19	4432.48	0.10
B	1.81	0.586	0.437	133.49	3556.98	0.16
C	5.20	0.331	0.410	132.43	2429.02	0.14
D	0.00	0.403	N/A	133.79	1488.24	0.00
E	17.01	0.313	N/A	134.02	2645.40	0.10
F	3.13	0.382	N/A	132.89	2488.51	0.17
G	0.50	0.511	0.409	133.26	4355.20	0.10

6.4.1.5 Scenarios 5 and 6

The best redesigns for scenarios 5 and 6 are considered to be F and C which is based on the same arguments as mentioned for scenarios 1 and 2. The results for these redesigns and scenarios can be found in Appendix W.

6.4.2 Best redesign for the IT Helpdesk of EDS – Vodafone

Redesign F, the one level design with specialists and cross-trained workers, and redesign C, the two level design with specialists and cross-trained workers in the 2nd line, turn out to be the best redesigns for almost all (except scenario 4) scenarios. The previous section looked at a good combination of process performance and costs and did not reflect the possibilities of such a redesign on the situation at the IT Helpdesk of EDS – Vodafone. This will now be done for changes with small and for changes with large impact on performance, structure and costs. A few remarks have to be made that restrict the number of feasible redesigns:

- The other tasks and duties of the specialists in the 2nd line may amount to more than half of the specialists' workload. Taking out specialists out of the IT Helpdesk process is not easy as it influences other processes.
- The forecasted workload on the IT Helpdesk is based on historical data of the more generally occurring weeks. Extremely busy weeks have been removed from data-analysis. These peaks though have to be coped with which makes scenario 2 a very realistic one.
- Scenario 3 and 4 are not expected to occur in the near future. Sometimes an extra temporary ACD type or a temporary extra support group in the 2nd line is introduced to cope with special types of calls and incidents, but this is never on a structurally basis.

6.4.2.1 Relatively easy, low cost redesigns

Redesign B contains the cross-trained resources to increase the flexibility and utilization rate of specialists in the 2nd line and the throughput times of special incidents. The activities at the support groups BO, BO-P&C, MEGA, ILFIO and HQ are showing large similarities which would hardly require extra training of cross-trained resources. The costs of training and higher salaries thus can be neglected. The only problem is the geographical spread of the support groups due to the different locations of offices and buildings. Therefore it would be realistic to have 3 or 4 cross-trained workers in the back office, in the aforementioned support groups. The flexibility of the resources in the 2nd line will be increased and this may lead to an improvement of throughput time of special incidents by a few percents. This is based on simulation results of the more extreme design B where 8 cross-trained workers are introduced that would cover all support groups in the 2nd line. The redesign showed a significant improvement in throughput time of 10%. It has to be said that some specialist already operate as cross-trained resources when their workload allows them to. With a minimum of costs and a small but significant improvement in throughput times of special incidents and utilization rate of specialists, redesign B is a very interesting redesign option.

Another relatively simple and low cost redesign option would be redesign G, where all special calls are shortly registered by 1st line generalist and referred to the 2nd line. The generalists should not try to solve the special incidents which would save a significant amount of service time. This requires a more user friendly ACD menu for callers and generalists. The callers should have more clear options to report their specific problem and the generalists should use the reported ACD type in their consideration for referral

or not. Furthermore, the registration would only require the determination of the priority of the special incident, since support group or specialist needed is already determined by the ACD type. The costs of this option are estimated to be 160 man hours, for example by the team leader of the front office of the IT Helpdesk: the (special) types of incidents that always should be referred to the 2nd line need analysis and determination. The functionality of the ACD menu is already available and can easily be redesigned for the specified (new) requirements. The significant savings in service time might lead to decreasing the number of resources needed in the 1st line by one or two. The required level of skills of generalists is also expected to be lower. The increase in workload for the 2nd line is estimated to be 5 to 10 % maximum, caused by the incidents that are not allowed to be solved (as used to be) by the 1st line generalists, because of the higher service times needed.
A disadvantage of this redesign option could be the simplification of tasks in the 1st line and thus the decrease in satisfaction experienced by generalists.

Redesign G and B could very well be combined into one new redesign. On top of this, the registration and classification of asynchronous service requests could be automated by means of a website for reporting these service requests which would lead the calls straight to the required support group or specialist. The 1st line would be completely skipped from the asynchronous special service requests process. Costs for the analysis, modeling and implementation of such a website are estimated at 120 man hours of work.

Furthermore, Section 6.1.3 showed that simply scheduling one extra resource at the peak hours (Monday and Thursday mornings) of regular weeks of call load can decrease the number of abandoned calls significantly (up to 50%).

6.4.2.2 Redesigns with more impact

If management is willing to invest more into the IT Helpdesk for significantly better performance, redesigns F and C will lead to best combinations of improvement of process performance and costs of the redesign. The throughput times can be decreased by a maximum of 35% and the problem of inaccessible Vodafone employees can be solved to a large extent (contact reduction). The customers perception of quality of service will be significantly higher.
The costs that have to be made are for designing an automated ACD or classification menu and for training and higher salaries of cross-trained workers. All 1st line resources have to be transformed into either specialists or cross-trained. As stated in the previous section, a number of support groups has similar tasks and activities which does not make the cross-trained workers for these skills more expensive than the actual situation. The costs that have to be made to integrate the skills of the other specialists and support groups ("SM", "AM", "REPAIR", "GWE") into a pool of cross-trained workers are expected to be much higher and will lead to higher training costs and salaries. The division of skills and workload over the resources requires analysis and could be based on the forecasts of Appendix I.
The feasibility of executing and implementing redesign F and C will strongly depend on the possibilities of the automated classification that has to be designed. This will be more difficult then in redesign G. The number of possible ACD types or options in this menu will increase significantly because it should lead the call straight to the right resource or support group. Thus, it should allow the Vodafone caller to determine the problem as quick as possible, in a user friendly way. This can be difficult since it is quite common that the caller has no clue at all of possible causes of the problem or does not have the

slightest IT knowledge that is needed to go through the ACD or classification menu. The menu becomes useless and causes inefficient use of expensive specialists or cross-trained workers. Research for determining the feasibility of the automated classification is estimated to take 160 to 240 man hours, performed by the manager of the IT Helpdesk, assisted by team leaders of front and back office. From here on, it needs to be decided whether or not to research the possibilities to divide the resources over the pools of generalists, specialists and cross-trained workers.

Furthermore, the queue that is built after the automated ACD or classification menu has to be based on priority and waiting time of the call.

A disadvantage of this redesign could be the higher abandonment rate. If the situation (high load) requires so, this could be simply solved by having the specialists or cross-trained workers decide whether or not to handle a special (time-consuming) incident right away or postpone the handling of the incident to a more quite point of time. A good agreement has to be made with the caller who reported the service request. Another option is the handling of standard calls and incidents by a couple of generalists as in redesign C. Analysis of abandonment data namely shows significant differences in patience of callers that want to report standard or special calls. The special calls show higher maximum waiting times.

Again, on top of redesigns F and C, the registration and classification of asynchronous service requests could be automated by means of a website for reporting these service requests which would lead the calls straight to the required support group or specialist. The website should have the same functionalities as the aforementioned automated ACD or classification menu.

7 Conclusions and Recommendations

The framework for the approach towards answering the research questions, that has been identified in Chapter 2 and extended at the start of Chapter 5, is elaborated in Chapters 2 to 6. In this final chapter, each research question is mentioned again and followed up by a conclusion. Furthermore, the recommendations and directions for future research are provided.

7.1 Conclusion for the posed research questions

> *RQ1: What is the definition of process performance at the IT Helpdesk process of EDS – Vodafone?*

The requirements for the minimum process performance are defined in the SLA between EDS and Vodafone. The identified SLA performance criteria account for specific periods of time and for specific activities that have to do with IM. The criteria are mainly quantitative and related to ASA, initial resolution rate of front office and target times for solving different types of priorities of incidents. Furthermore, a bi-annual satisfaction survey among Vodafone employees is used as qualitative measurement. For modeling and simulation reasons, the initial resolution rate is assumed to be given and measuring ASA was replaced by measuring the percentage of incoming calls that was lost.

> *RQ2: Is it possible to measure process performance of different staffing level designs and scenarios for a process model of the EDS – Vodafone IT Helpdesk?*

The elaboration of the designed framework and the results of Chapters 5 and 6 prove that it is possible to build and simulate a process model and measure performance of redesigns and scenarios with the objective of researching different staffing levels in a process. The process model of the existing situation is valid and verified and has been extended with extra functionalities. This enabled the simulation and comparison of process performance of redesigns and scenarios. The redesigns are different in terms of numbers and types of resources: generalists, specialists and cross-trained workers.

Furthermore, the sensitivity analysis in Chapter 5 has been used to substantiate the value of the process model. The reactions on changes of several important helpdesk or call center characteristics in the process model are close to linear. Small changes in inter-arrival rates, service times, abandonment behavior, resource availability and distributions of call types do not cause any extremely sensitive reactions in performance of the process.
Next to the sensitivity analysis, the simulation results of redesigns and scenarios in Chapter 6 have been used to explore the possibilities of the process model and its redesigns. The use of call center redesigns may cause extreme sensitivity of the process performance. A one level redesign (no back office anymore) of the IT Helpdesk process for example, may cause the throughput time of special incidents to decrease by a maximum of 35%. Using other types of resources in the 2nd line (cross-trained workers instead of specialists) also shows the high sensitivity of the process model and its performance to this kind of changes.

RQ3: Could the EDS – Vodafone IT Helpdesk process perform at the same or a higher level with different staffing levels at equal or lower costs?

The need for a redesign to improve performance of the IT Helpdesk process seems to be low, with the assumed settings and circumstances (actual situation). The minimal performance criteria of the SLA are not a problem for the IT Helpdesk in the more general weeks with average (and higher) loads of calls. The actual staffing levels are assumed to be the necessary minimum for the higher loads of calls that can occur at any (unpredictable) time and for the other tasks that have to be performed by resources in the 2nd line. The redesigns though resulted in some interesting findings for different what-if scenarios.

With a simple and almost costless change in the staffing or scheduling of resources, a significant improvement can be reached in terms of ASA and percentage of calls that is lost in particular intervals of the week. Data-analysis of inter-arrival rates and simulation results show that the more busy moments of the week (Monday and Thursday morning) account for almost half of the number of abandoned calls. Rescheduling compensation periods or temporarily using a specialist from the 2nd line for answering specific types of calls, will increase the process performance significantly. The specialist from the 2nd line is especially useful at unexpected peaks since he is already available in the back office.

Another easy and low cost change would be the introduction of 3 or 4 cross-trained workers for some of the support groups in the 2nd line: BO, BO-P&C, MEGA, HQ and ILFIO. The flexibility of the resources in the 2nd line will be increased and this may lead to an improvement of throughput time of special incidents by a few percents.

In case the distribution of standard and special calls remains the same and the number of calls increases to more than 2000 calls, a combination of both the aforementioned redesigns will be capable to handle incoming calls in front and back office and is attractive for implementation.
An extra feature could be the simplification of the 1st line activities by just registering and classifying the special calls and immediately referring them to the 2nd line. The costs of such a redesign are estimated at a month work for the front office team leader and the number of 1st line resources could be decreased by at least one. The increase of workload for the 2nd line is estimated at 5 to 10%. This negative effect is assumed to be overcome by the effects of the other redesigns that should be part of the implementation. On top of this, the registration and classification of asynchronous calls (=mails) could be automated by means of a website for reporting these calls which would lead the calls directly to the required support group or specialist. The 1st line would be completely skipped from the asynchronous special calls process. It would only remain responsible for handling the standard asynchronous calls.

More radical redesigns were simulated, like one level designs with only generalists or specialists or a mix of specialists and cross-trained workers. Significant improvements have been observed (up to 35%) in throughput time, but the necessary investments in training and higher salaries and in an automated classification menu for calls are considered to be too high for this IT Helpdesk case. The process model and its simulation results show that the process can easily perform above the minimum performance criteria. If contact reduction becomes an important issue, the one level redesigns will be attractive for implementation. Contact reduction could become an issue because of the bad accessibility of Vodafone employees who reported a service request.

Another important consideration for the feasibility of the redesigns is the presence of other essential tasks to be performed by resources in the 2nd line. These tasks cannot possibly be ignored when deciding which redesign is better or worse. The presence of these tasks is not facilitating the decision making process.

RQ4: Is it possible to develop a generic model that would make staffing levels, process performance and costs manageable?

Whether or not a generic model or framework can be developed, should depend on results and conclusions from similar cases to be researched. From that point of view this RQ cannot be answered positively. Our conclusion from this specific case though, is that such a generic model is not inconceivable. The results of Chapter 6, with feasible and realistic redesigns and scenarios, show that a number of important call center characteristics may have a significant impact on the performance of the process (model) in this particular case. Based on a valid and verified process model that offers the flexibility of exploring different redesigns and best practices in BPR, it is possible to directly relate changes in call center characteristics to typical call center performance criteria. Criteria such as ASA, percentages of lost calls, throughput times of different types of incidents can be compared to resource utilization, which is an indication of the (differences in) costs for different types and numbers of resources. The model or framework though is not yet manageable, since it is lacking possibilities and functionality to obtain optimal results for redesigns.

7.2 Recommendations and future research

From the conclusions in the previous section one can extract the recommendations for possible redesigns of the IT Helpdesk process. At first sight, no radical changes are necessary to improve the process performance. Some what-if scenarios have therefore been simulated for different redesigns.

In case the IT Helpdesk is faced with higher workloads and still wants to meet the minimal criteria from the SLA, they can choose from several redesigns options. The actual staffing levels are assumed to be the necessary minimum for the higher loads of calls that can occur at any (unpredictable) time and for the other tasks that have to be performed by resources in the 2nd line. The specific redesigns are attractive for either sporadically (short term) or structurally (long term) higher loads of calls.

- Sporadically busier periods call for simple rescheduling or shifting of resources, depending on the predictability of the peak(s). As described in Section 6.1.3.
- With structurally busier periods the simple rescheduling of resources should be accompanied by cross-trained workers in the 2nd line (for a specific number of resources and support groups) and may be extended with a simplified process in the 1st line. Special calls should all be registered, classified and referred to the 2nd line. Even with less resources in the 1st line, one could obtain better ASA performances.

Illness of resources and (predictable) peaks in loads of calls can be anticipated with a flexible workforce as well. When necessary, a pool of resources from a specialized agency should be called upon. A flexible workforce with generalists is assumed to be more interesting than a flexible workforce with specialists, since generalists have a lower level of skills and are therefore cheaper. For the IT Helpdesk case this means that fewer (1 or 2) full time resources are needed throughout the week and 1 or 2 generalists from the flexible workforce are scheduled at Mondays and Thursdays, to anticipate the higher loads of calls. For generic purpose of the framework this means that flexible workforce should be introduced as BPR best practice and redesigns with flexible workforce should be developed and simulated as well.

A rather realistic scenario is the one where the number of special (difficult) calls increases even more or one where the issue of reducing the number of contacts between IT Helpdesk and user (contact reduction) becomes more important. A one level redesign (F) then becomes interestingly enough to calculate the costs for the automated classification menu (and determine its feasibility) for special calls and the costs for resource training and higher salaries.
Contact reduction could also be achieved by making better agreements with Vodafone and its users on their accessibility and the related level of service to be provided by EDS. For example, one could agree that the Vodafone employee leaves his computer powered on for remote service.

The question whether or not an even better (re)design can be found for the IT Helpdesk than the redesigns that are presented in Chapter 6 can be answered by a simple "yes". The objective of this graduation project was not to search for the optimal design and staffing levels for the IT Helpdesk, but to research the possibilities to build a framework and a model to simulate different staffing level scenarios and measure process performance.
The search for an optimal result may take a lot of time when simulating a large number of versions of the redesign and/or scenarios. By presenting the measured performances of the different simulations graphically, one could optically determine the optimal redesign or redesign version per scenario.

The answer for RQ2 is for the specific case of the IT Helpdesk process at EDS - Vodafone. The relationships among staffing levels, process performance and costs that have to be managed, are identified. As described above, the framework is lacking possibilities and functionality to obtain optimal results for redesigns. The development of a framework for generic purpose, requires the use of the same approach and framework adopted in this research for other IT helpdesks and call centers. With a few more similar cases it will become clear whether or not the approach, framework and generic model are interesting for future research, possibly in other types of call centers and industries. Furthermore, the framework has to be extended with an analytical tool or algorithm to calibrate redesigns and determine an optimal solution. This will improve the manageable part of the framework.

Lack of reliable historical data of service times and availability of resources in the 2nd line has a negative influence on the strength of the conclusions of the redesigns in Chapter 6. The forecasts are less reliable than for the 1st line process characteristics. For the actual situation it is assumed that the handling of calls always has priority over other tasks. The ignorance of these tasks in the process model is not realistic, since the process model that has been developed is a workload model and requires the other tasks to simulate the total workload. Future research should use processes that have

recorded historical data of all activities, in front and back office. All activities that influence the service times and availability of resources (utilization rate).
For the EDS – Vodafone case, it is recommended (for future research) to either extend the model with the other tasks of the 2nd line resources or design more detailed functions that determine the (un)availability and utilization rate of 2nd line resources. The latter option means that the other tasks are represented by unavailability of (specific) 2nd line resources. The best option in terms of reliability and for ease of use in redesigns and simulations is considered to be the first proposition. Therefore, the workload of other tasks (changes, work orders, system management) on 2nd line resources should be studied and forecasted in more detail for integration of these activities into the process model. The results of simulations of redesigns will then be more realistic and valuable for redesign decisions.

In the designs and redesigns, the initial resolution rate of 1st line resources is assumed to be given and is forecasted (from historical data) at about 50%. According to the SLA the rate is preferred to be at least 80%. To provide some direction for a solution or improvement, two options are proposed to increase the initial resolution.

- The 1st line agents should be trained extra to increase their level of skills. This increases the training costs and the salary for each agent.
- The 1st line agents should be allowed and encouraged to spend more time on solving an incident. This requires more agents in the 1st line.

The higher resolution rate of the 1st line agents will decrease the workload from IM on the 2nd line resources. Extra costs (investment) for the 1st line are expected to be lower than the savings that can be made for the 2nd line, which would make the two options mentioned interesting for future research.

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