Estimating the effectiveness of a mobile phone network's deferred revenue calculated through the use of a business automation and support system

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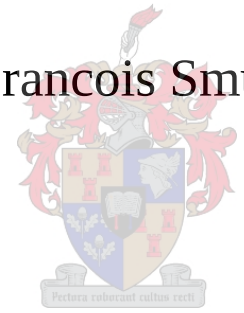

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

Mobile phone networks form an integral part of economic and social development globally. Mobile phones have become an everyday part of life and it is hard to imagine a competitive economy without the availability of mobile communications. Emerging markets benefit most from the implementation of mobile technology and growth trends are outperforming earlier predictions. The most popular and sustainable payment model used by mobile phone networks in emerging markets is the pre paid mechanism used for the distribution of airtime. This mechanism brings about unique challenges for networks in emerging markets.

In this thesis the importance of the mobile phone network pre paid value channel is introduced through an analysis of pre paid revenue. A brief introduction is given to the systems and products that contribute to the functioning of the pre paid value channel. The revenue generation process is described with regards to the pre paid sector of the market and an in-depth explanation of the importance of deferred revenue is given, how it is recorded and what role it fulfils in the generation of revenue.

The complexity of the network environment, both technical and operational makes the use of a business automation and support system (BSS) a necessary tool for effective execution of tasks and processes within the network environment. These systems record information from a wide spectrum of available technical network resources and use this information to automate the flow of network products. The use of such a system for the calculation of deferred revenue is suggested. Saaty's Analytical Hierarchy Process (AHP) algorithm and the Elimination and Choice Expressing Reality (ELECTRE) method are used to compare the newly proposed method for the calculation of deferred revenue using a BSS.

Using Saaty's algorithm to estimate the effectiveness of deferred revenue as reported through the use of a BSS yields favourable results for the proposed method. This helps to bridge the gap in the poorly researched mobile telecommunications industry. ELECTRE is used to substantiate the findings of the model using AHP and meaningful tests are done to motivate correctness and accuracy of the results obtained throughout. Most importantly, the findings

were shared with academic and industry experts, adding meaningful resemblance to the goals set out to achieve.

Opsomming

Mobiele foon netwerke is wêreldwyd ‘n onlosmaakbare deel van ekonomiese en sosiale ontwikkeling. Mobiele fone is deel van ons alledaagse lewe en dit is moeilik om ‘n kompeterende ekonomie te bedink sonder die beskikbaarheid van mobiele kommunikasie. Ontluikende markte trek die meeste voordeel uit die implementering van mobiele tegnologie en groeitendense vertoon beter as wat vroeër voorspel is. Die mees gewilde en volhoubare betaalmetode wat deur mobiele foon netwerke in ontluikende markte gebruik word, is die voorafbetalingsmeganisme wat vir die verspreiding van lugtyd gebruik word. Hierdie meganisme bring unieke uitdagings vorendag in ontluikende markte.

Die tesis beskryf die belangrikheid van die mobiele foon netwerk voorafbetalingswaardekanaal deur ‘n analise te maak van vooruitbetalingsinkomste. ‘n Kort oorsig oor die sisteme en produkte wat bydra tot die funksionering van die vooruitbetalingswaardekanaal word verskaf. ‘n Beskrywing van die inkomste-genereringsproses vir die vooruitbetaling-sektor van die mark word verskaf en ‘n in-diepte verduideliking van die belangrikheid van uitgestelde inkomste, hoe dit vasgelê word en watter rol dit speel in die generering van inkomste word verduidelik.

Die kompleksiteit van die netwerkomgewing, beide op ‘n tegniese en operasionele vlak, maak die gebruik van ‘n besigheidsoutomatisering en ondersteuningsisteem (BSS) ‘n noodsaaklike instrument vir die effektiewe uitvoer van take en prosesse binne die netwerkomgewing. Hierdie sisteme stoor informasie vanuit ‘n wye spektrum van beskikbare tegniese netwerkbronne en gebruik die inligting om die vloei van netwerkprodukte te outomatiseer. Die gebruik van sodanige sisteem word voorgestel vir die berekening van uitgestelde inkomste. Saaty se Analitiese Hierargie Proses-algoritme (AHP) en die Eliminasie en Realiteit-Deur-Keuse Uitdrukkingsmetode (ELECTRE) word gebruik vir die vergelyking van die voorgestelde metode vir die berekening van uitgestelde inkomste deur middel van ‘n BSS.

Die gebruik van Saaty se algoritme om die effektiwiteit te bereken van uitgestelde inkomste soos gemeld deur die gebruik van ‘n BSS, lewer gunstige resultate vir die voorgestelde

metode. Dit vul ‘n leemte in die swak nagevorsde mobiele telekommunikasie industrie. ELECTRE word gebruik om die bevindinge van die AHP-model te substansieer en betekenisvolle toetse word deurentyd gedoen om die korrektheid en akkuraatheid van die resultate te motiveer. Die belangrikste aspek van die navorsing is dat die bevindinge gedeel is met kenners binne die akademie sowel as die industrie, wat nou aansluit by die doelstellings wat aanvanklik beoog is.

Terms of reference

This thesis is a result of work which started early on in the author's working career as a software developer at In2one SA (Pty) Ltd (In2one) during 2003. The author was able to develop and deploy solutions for companies focusing on the supply of pre paid products to mobile phone networks.

In early 2007, while attending a billing and revenue assurance conference in Cape Town, South Africa, and while working for another company, namely Itemate Solutions (Pty) Ltd (Itemate), the author met Susan Burger, the MTN Group Limited (MTN Group) Revenue Assurance (RA) manager. Susan Burger then arranged a meeting with the key personnel members from one of MTN Group's operating networks that was based in Abidjan, the capitol of Cote d'Ivoire, to discuss the business automation and support system that In2one SA (Pty) Ltd had started to develop. At the time the MTN Group RA department was busy with the implementation of a project which they referred to as the MTN Group RA programme. This programme was initiated by the company's external auditors to identify specific shortcomings within the operating networks that were acquired by MTN Group through a buyout transaction of a Libyan based organisation called Investcom LLC (Investcom).

The outcome of the MTN Group revenue assurance programme was the identification of specific areas of concern, especially within the pre paid sector of the previously Investcom owned operating network based in Cote d'Ivoire. One of the main focus areas from a group audit perspective was the way in which deferred revenue was calculated and the inconsistencies that existed with regards to the accuracy of this variable. The author continued collaboration with the key personnel members of this company, as well as influential decision makers at MTN Group and before long a project for the identification of problem areas associated with the calculation of deferred revenue, was underway. The Itemate business automation and support system was implemented, hoping that this would introduce a new and more controlled method for the calculation of deferred revenue.

How effective this new method would eventually be, was anyone's guess. The project was commenced during mid 2007 and final installation and customization was completed during November 2007. From the 1st of December 2007 MTN Cote d'Ivoire (MTNCI) started using the new Itemate system for calculating deferred revenue on a regular basis. The aim of this study was to compare the new method with the previous one. Throughout this thesis input delivered from both MTN Group and the MTN operating network in Cote d'Ivoire, as well as consultation being delivered from industry experts and personnel members at Itemate, are considered.

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Glossary

aggregate value function A function determining value that can be used to calculate totals and to determine various statistics.

airtime The amount of time a person spends talking on their mobile handset.

airtime liability The liability the mobile phone network has towards its clients after airtime has been sold to them, but still remains to be loaded onto their accounts.

Arobase The Ivorian based Internet Service Provider (ISP) named Arobase Telecom SA.

Bharti Airtel The Indian based mobile phone network named Bharti Airtel Limited.

billable traffic Traffic that actually reaches the billing platform, where rating of the calls and other services on offer takes place.

bonus The amount of airtime that is given to the client for no additional cost and used as an incentive for the purchase of airtime bearing products.

base station Also referred to as a Base Transceiver Station (BTS), it is the equipment which facilitates the wireless communication between user equipment and the network.

cellular network A radio network made up of a number of radio cells each served by a fixed transmitter.

Citelcom The Ivorian based Internet ISP named Cote d'Ivoire Telecom SA.

churning The process of subscribers belonging to one mobile phone network migrating to a competitor mobile phone network in the same country.

credit applied The process of loading airtime onto a client's account.

debit applied The process of consuming airtime which is on a client's account.

deferred airtime Part of deferred revenue, constitutes the component thereof after the airtime has been loaded onto a client's account, but still remain to be used.

deferred revenue Income generated through the sale of pre paid recharge mechanisms (airtime), but the product (airtime) must still be consumed by the client to whom it was granted.

erlang A unit of traffic intensity in a telephone system.

Electronic Voucher Distribution (EVD) The distribution of airtime through means of an electronic Personal Identification Number (PIN) as opposed to a printed PIN.

expired credit Airtime bearing items, already sold into the market, surpassing their validity date and expiring before it could be loaded onto a client's account.

fair value The correct value paid for a service being received.

financial liability The same as deferred revenue.

incomparable Two alternatives having such substantially different profiles that they are not comparable to one another.

indifferent Indifferent alternatives are alternatives between which the differences are small, so that the preference for one over the other might easily be reversed if another criterion is introduced.

Investcom The group of mobile phone networks originally based in Libya, namely Investcom LLC.

In2one SA The software company named In2one SA (Pty) Ltd.

Itemate The software company named Itemate Solutions (Pty) Ltd.

kits Subscriber Identity Modules (SIM) cards containing airtime.

Koz The Ivorian mobile phone network named Comium Ivory Coast Inc.

Microsoft The software company named Microsoft Corporation.

mobile handset A mobile phone device used for communication on a Global Systems Mobile (GSM) network.

mobile phone network Also referred to as a mobile phone operating unit, it is a company that provides pre and post paid mobile telecommunication services to their clients in a resident country. A mobile phone network is most often part of a group company structure, but can also function as a company in isolation.

Moov The Ivorian mobile phone network named Moov Cote d'Ivoire.

MTN Group The holding company for all the Mobile Telecommunication Network (MTN) mobile phone networks worldwide, namely MTN Group Limited.

Oracle The software company named Oracle Corporation.

Orange The Ivorian mobile phone network named Orange Cote d'Ivoire.

outranking Alternative *a* outranks *b* if there is enough evidence to conclude that *a* is at least as good as *b* when all criteria was considered.

outranking relation A relation whereby elements are compared to each other in a comprehensive way for each pair of variables involved.

physical vouchers A tangible card or piece of paper containing a token for dispensing in exchange of airtime.

post paid A payment mechanism used in the case where a service is granted before payment for the service takes place.

pre paid A payment mechanism used in the case where payment is received for a service, before the service is granted.

pre paid distribution channel The distribution channel along which pre paid products are distributed.

pre paid value channel The sales and distribution channel along which products are sold on a pre paid basis.

pre paid opening clients The opening balance of the total amount of pre paid subscribers to a mobile phone network.

post paid value channel The sales and distribution channel along which products are sold on a post paid basis.

rating engine A programmable rule based algorithm that calculates the amount of airtime that is consumed when a client utilizes services offered by a mobile phone network.

revenue Income generated through the sale of pre paid recharge mechanisms (airtime).

revenue assurance A term used for the assurance of revenue as generated within an organization through its involvement with day to day business.

Sage The software company named SAGE Group plc.

sales credit The amount of airtime granted to a client on a sale.

SAP The software company named SAP AG.

Sync Lab The Italian based software company named Sync Lab S.r.l.

synthesis value Relative weights obtained for sub criteria, by multiplying a sub criterion weight with the main criterion weight it is grouped under.

TABS A post paid billing system.

Telecom Italia Mobile (TIM) The Italian based mobile phone network named Telecom Italia Mobile.

unused airtime The total airtime available in distribution after being sold by the network operator, but that has not been loaded onto client mobile handsets (Also referred to as airtime liability).

usage The consumption of airtime, also referred to as debit applied.

Vodacom The mobile phone network named Vodacom (Pty) Ltd.

Vodafone The holding company for all the Vodafone mobile phone networks worldwide, namely Vodafone Group Plc.

voucher table A database table which contains and manages the statuses of Personal Identification Numbers (PINs) used on vouchers for the redemption by clients.

Virtual Top Up (VTU) The allocation of airtime directly onto a subscriber's account without the involvement of a PIN.

wireless network Any type of computer network that is wireless, commonly associated with a telecommunications network whose interconnection between nodes is implemented without the use of wires.

List of acronyms

AHP Analytical Hierarchy Process

ARPU Average Revenue Per User

ASR Answer Seizure Ration

BSS Business Support System

BTS Base Transceiver Station

CAPEX Capital Expenses

CDR Call Data Record

CEO Chief Executive Officer

CHT Call Hold Time

CI Consistency Index

CIO Chief Information Office

COS Cost of Sale

CR Consistency Ratio

CRM Customer Relationship Manager

CSI Customer Satisfaction Index

CSR Customer Service Representative

CTIO Chief Technical and Information Officer

DSS Decision Support System

EBIDTA Earnings Before Interest, Depreciation, Tax and Amortization

ELECTRE Elimination and Choice Expressing Reality

ERM Enterprise Resource Management

ERP Enterprise Resource Planning

EU Expected Utility

EVD Electronic Voucher Distribution

FCFA Franc Communauté Financière d'Afrique

FTE Fixed Term Employee

GAAP Generally Accepted Accounting Practise

GCI Geometric Consistency Index

GPRS General Packet Radio Service

GSM Global Systems Mobile

HC Head Count

HLR Home Location Register

HR Human Resource

HT Hors Taxes (excluding VAT)

IFRS International Financial Reporting Standards

IN Intelligent Network

IP Internet Protocol

IS Information Systems

ISP Internet Service Provider

IT Information Technology

IVR Interactive Voice Response

KPI Key Performance Indicator

MAUT Multiple Attribute Utility Theory

MCDA Multi-Criteria Decision Analysis

MOU Mobile Operating Usage

MS Management Science

MTN Mobile Telecommunications Network

MTNCI MTN Cote d'Ivoire

MSC Mobile Switching Centre

NGN New Generation Network

OPEX Operational Expenditure

ODSS Organizational Decision Support Systems

OR Operations Research

OSS Operational Support System

ORSSA Operations Research Society of South Africa

PIN Personal Identification Number

POS Point of Sale

PROMETHEE Preference Ranking Organization Method for Enrichment Evaluations

QOS Quality of Service

RA Revenue Assurance

RGS Revenue Generating Subscriber

RI Random Index

SCP Service Control Point

SDP Service Data Point

SEU Subjective Expected Utility

SIM Subscriber Identity Module

SMS Short Message Service

TCH Transmission Channel

TCO Total Cost of Ownership

TIM Telecom Italia Mobile

TRXS GSM Transceivers

TTC Toutes Taxes Comprises (including VAT)

USSD Unstructured Supplementary Service Data

VAS Value Added Service

VAT Value Added Tax

VLR Visitor Location Register

VMS Voucher Management System

VTU Virtual Top Up

WASPA Wireless Application Service Providers' Association

WECA West and Central Africa

WiMAX Worldwide Interoperability for Microwave Access

List of reserved symbols

a	An alternative
A_u	Airtime usage (including expired and deactivated credit)
b	An alternative
$C(a,b)$	The concordance index of alternative a to alternative b
CI_l	The Consistency Index for comparison matrix L_l
CR_l	The Consistency Ration for comparison matrix L_l
C^*	The concordance threshold
$D(a,b)$	The discordance index of alternative a to alternative b
D^*	The discordance threshold
F	The set of all alternatives
GCI_l	The Geometric Consistency Index for comparison matrix L_l
i	The row of a matrix
j	The column of a matrix
k	An index value
L_A	The pairwise comparison matrix for the service delivery sub criteria, with element a_{ij} in row i and column j of L_A
$L_{A,norm}$	The normalized comparison matrix for the service delivery sub criteria
L_B	The pairwise comparison matrix for the profitability sub criteria, with element b_{ij} in row i and column j of L_B
$L_{B,norm}$	The normalized comparison matrix for the profitability sub criteria
L_C	The pairwise comparison matrix for the marketability sub criteria, with element c_{ij} in row i and column j of L_C
$L_{C,norm}$	The normalized comparison matrix for the marketability sub criteria
L_D	The pairwise comparison matrix for the network optimization sub criteria, with element d_{ij} in row i and column j of L_D
$L_{D,norm}$	The normalized comparison matrix for network optimization sub criteria

l_{ij}	A generic comparison matrix element
L_l	A generic comparison matrix
L_E	The pairwise comparison matrix for the four main criteria, with element e_{ij} in row i and column j of L_E
$L_{E,norm}$	The normalized comparison matrix for main criteria
m	An index value
n_l	The number of sub criteria in main criterion l
p	An index value
$Q(a,b)$	The set of criteria for which a is equal or preferred to b
$R(a,b)$	The set of criteria for which b is strictly preferred to a
R^b	Deferred revenue closing balance
RI_l	The Random Index for comparison matrix L_l
R^o	Deferred revenue opening balance
R^p	Deferred revenue for the period
S_c	Sales credit for the period (including bonuses allocated on the sales channel)
$\boldsymbol{w}_l$	The row vector of the sub criteria weights associated with matrix L_l
$w_{l,i}$	The weight assigned to criterion i
x	The variable used in the calculation of the historic method for the calculation of deferred revenue
y	The variable used in the calculation of the proposed method for the calculation of deferred revenue
$\boldsymbol{z}$	A vector of performance represented by an alternative with general elements z_i
$\boldsymbol{\omega}_l$	A vector of priorities
α_l	A value used in the calculation of CI_l

Chapter 1

Introduction

Emerging market mobile phone networks experience significant revenue losses due to a lack of effective management of the sales and distribution channel along which products are sold on a pre paid basis, also known as the pre paid value channel. Pre paid refers to a payment mechanism used in the case where payment is received for a service, before the service is granted [32]. A number of reasons contribute to the losses experienced on a day-to-day basis. These range from logical product delivery to business and operational process management. The complexity and diversity of the business, software and hardware systems that interact with the pre paid value channel further complicates the management of these losses. The reasons for this complexity may be summarized into the following categories:

Increased complexity of the network software and hardware systems

Mobile phone networks, as a part of the telecommunications industry, have been plagued by a multitude of different technologies. Cellular network technologies or more specifically Global Systems Mobile (GSM) technologies was originally managed by using existing fixed line technological infrastructure because it was the only telecommunications infrastructure available at the time. Since then, technology providing companies is catching on to the demand mobile phone networks have for more flexible and easier to deploy, low Total Cost of Ownership (TCO) software and hardware systems.

It created a never-ending spiral of supply and demand. Technology suppliers constantly entice the mobile phone networks with newer and better systems and the networks constantly look for more compatible systems able to manage new and conceptualized products that will give them a competitive edge in a challenging market environment. A lack of understanding, together with an increased complexity of management systems that interact with the pre paid

value channel, causes lost and misinterpreted information that skews pre paid reported revenues.

Proper controls and processes

The suppliers of technology are partly to blame for the lack of proper controls and processes with regards to logistics involved with pre paid product delivery [29]. Most often technology suppliers implement solutions that would maximize their profits, rather than to focus on the specific need of the mobile phone network. Typically the systems that maximize the supplier's profits are the most complex in nature. Suppliers therefore focus on the sales and implementation of these systems, rather than to focus on network product delivery. Management of mobile phone networks, find themselves allocating their most skilled employees to the management of the systems in which the largest capital investments are made, increasing the allocation of resources to these systems even further.

One of the most important channels within an emerging network environment is the pre paid distribution channel. This is the channel through which the pre paid product is delivered to the market. The pre paid product in emerging market mobile phone networks is the largest revenue generating product within the network environment, due to its wide market accessibility and the possibility for low income earners to load small amounts of credit onto their mobile phone accounts at a time [4]. Because the largest amount of investment capital is spent on the most complex problems, the pre paid delivery channel is most often neglected, as it is perceived to be quite a mundane and easily managed part of the business. However, this is not the case.

Inexperienced staff is normally allocated to pre paid product delivery and insufficient time and energy is spent on the processes responsible for getting the pre paid product into the market environment. It is due to the delivery of these products, not being securely managed by responsible and competent employees that the mobile phone networks experience a lot of fraud and product losses on this channel, contributing to lost revenues.

Lack of proper software systems that monitor, manage and control human-driven operation processes

The combination of complex systems involvement and incompetent management of pre paid product delivery is further aggravated by the lack of auditability with regards to the human driven processes within the pre paid value channel. The following are all direct results of lacking control features on the pre paid value channel, causing inaccurately reported revenues:

- Inaccurate and untimely reporting, due to the lack of trustworthy data sources and the complexity involved with data manipulation which causes data discrepancies,
- system failures and bad configurations,
- billed traffic discrepancies, and
- the lack of proper integration between existing and newly implemented software and hardware systems.

Rapid pace of emerging market mobile penetration

One of the root causes for mobile phone networks experiencing revenue losses is due to the fact that they are earning so much revenue. There is a significant focus of resources and capital on market penetration and the launch of new services to acquire the competitors' subscribers through improved and cheaper service delivery. Due to resources, time and energy being spent on realizing increased growth and market capitalization, the sustainability and security of the existing market and distribution processes of products to that market are most often neglected. Mobile phone networks are busy losing revenue at almost the same pace as what they are gaining new revenue [35].

1.1 Literature

The foundations of decision analysis can be traced back at least as far as Bernoulli and Bayes. According to Smith and Von Winterfeldt [41], Bernoulli was concerned with the fact that

people generally do not follow the expected value model when choosing among gambles, in particular when buying insurance. He proposed the expected utility model with a logarithmic utility function to explain these deviations from the expected value model. Bayes was interested in the revision of probability based on observations and proposed an updating procedure that is now known as Bayes theorem. The publication of the *Theory of Games and Economic Behaviour* by von Neumann and Morgenstern in 1944 was a major milestone in the history of decision analysis and economics [41]. The book established the foundation for decision analysis. In the second edition of the book von Neumann and Morgenstern provided an axiomatization of the expected utility (EU) model, showing that a cardinal utility function could be created from preferences among gambles. Their analysis took the probabilities in the decision problem as given and their axioms led to the conclusion that decision-makers should make decisions to maximize their expected utility. In *The Foundation of Statistics* published in 1964, Savage [41] extended von Neumann and Morgenstern's expected utility model. He considered cases in which the probabilities are not given. He proposed a set of axioms about preferences among gambles that enabled him to simultaneously derive the existence of subjective probabilities for events and utilities for outcomes, combining the ideas of utility theory from economics and subjective probability from statistics into what is now referred to as the subjective expected utility (SEU) model. Edwards and Phillips [33] followed this model, but by also studying Bayesian inference, they found that people tend to revise their opinion less strongly than prescribed by Bayes Theorem.

One of the foundations of decision analysis is the use of personal or subjective probabilities. This approach is Bayesian in that probabilities are interpreted as measures of an individual's beliefs rather than long-run frequencies to be estimated from data. One of the central challenges of decision analysis is reliably assessing probabilities from experts, taking into account the psychological heuristics that experts use in forming these judgments and the potential for biases. In many applications of decision analysis, the stakes are sufficiently large that a decision-maker will seek the opinions of several experts rather than rely solely on the judgment of a single expert or on his or her own expertise. This then raises the question of how to combine or aggregate these expert opinions to form a consensus distribution to be used in the decision model. While it is easy to say that the Bayesian modelling approach represents the solution to the expert combination problem in principle, in practice there remain many complex modelling challenges and questions about the effectiveness of different combination mechanisms. According to Edwards and Phillips [33], Clemen and

Winkler illustrated the importance of capturing dependence among the expert forecasts when combining forecasts.

Edwards and Phillips [33] also explains Weber *et al*. who studied how weights in multiattribute utility assessments change depending on the level of detail in a hierarchical mulitattribute utility function. For example, when a single attribute is treated as a single objective, but could just as easily be broken up into two component elements. They found that the level of detail used in the specification greatly impacted the weight assigned to the attribute. Attributes that are decomposed in more detail receive more weight than the same attribute with a less detailed decomposition. These results suggest that analysts need to take great care in defining a value hierarchy for utility functions. One of the more unfriendly debates in management sciences has concerned the Analytical Hierarchy Process (AHP), one of the methods used in this thesis. The AHP is a decision-making procedure originally developed by Thomas Saaty in the 1970s. Decision analysts that have been critical of the AHP argue that it lacks a strong normative foundation and that the questions the decision-maker must answer are ambiguous [33].

Decision analysis has clearly been recognized as an important tool for the evaluation of major decisions in the public sector. Decision analysis methods are not yet widespread in corporations. To have a greater impact on corporate decision-making, decision analysis researchers must build on and pay more attention to the principles of corporate finance and the theory of financial markets [33]. The idea of using the computer to help decision-makers was published as early as 1963 [7]. It was in the early 1970s that many suggested a wide range of terms to describe the system that help decision-makers in the process of making varying degrees of decision structures. Scott Morton is considered one of the first groups of researchers who coined the term *Decision Support System* (DSS). Since then, there has been a growing amount of research in the area of DSSs [40]. Eom and Kim [16] note that a focus on the customer is the cornerstone of modern management philosophy. Managing aggregate customer demand triggers the operations management process. DSSs have been implemented across various market sectors and to support the use of this technique a few successful implementations that have been done in the telecommunications and financial arena are listed here. Some minor applications include agent-enabled DSS design, information system project portfolio planning and business process optimization [21]. Many DSSs are developed to effectively design fibre-optic networks and to plan regional telecommunication networks

[13]. A survey by Kim [23] also shows that an increasing number of multi-functional DSSs have been implemented in various industries, with specific focus to telecommunications. The majority of DSS applications in the finance area are developed to support credit evaluation and management [14], selection of financial audit portfolios, credit risk management of home mortgage portfolios and to optimize investment policy strategy [30].

Eom and Kim [16] further notes that the dominant application area of DSSs is still production and operations, followed by marketing and logistics and management information systems field. The other corporate functional areas remain steady except accounting and international business. Those areas were not explored in the time period. It was further noted that Management Science (MS) and Operations Research (OR) models have been essential elements of DSS tools. Many commercial software packages now include visual interactive sensitivity analysis capabilities. Other emerging tools embedded in DSSs, in specific the Multi-Criteria Decision Analysis (MCDA) area, are the AHP or methods for outranking relations such as Elimination and Choice Expressing Reality (ELECTRE) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE). The ELECTRE method was first introduced in 1968 for outranking relations for modelling the decision-makers preferences in MCDA problems. Compared to this, the AHP is based on value measurement approaches that represent preferences by means of a utility function. PROMETHEE defines global ranking, which means that it provides the decision-maker with a ranking of all potential actions. ELECTRE methods incorporate some criteria as rejection points that block the outranking relationship between two potential actions. Owing to these differences, in Eom and Kim's [16] survey, PROMETHEE methods were more widely used in group decision-making or MCDA, although this has somewhat changed to date. Detailed comparison of the AHP, ELECTRE and PROMETHEE may be found in Zopounidis and Doumpos's [46] paper. They applied these techniques in the financial decision-making domain.

Besides using value measurement approaches to MCDA, such as the AHP and Multiple Attribute Utility Theory (MAUT), ELECTRE is introduced as an outranking method and used for estimating effectiveness as well. The outranking approaches differ from the value function approaches in that there is no underlying function determining value that can be used to calculate totals and other statistics (aggregative value function) [5]**.** The output of an analysis is not a value for each alternative, but a relation whereby elements are compared to

each other in a comprehensive way for each pair of the set of alternatives (outranking relation).

The way in which an outranking relation is exploited by a method depends on the particular problem. Roy [36] identified four different broad typologies or categories of problems, for which MCDA may be useful:

- **The choice *problematique*:** To make a simple choice from a set of alternatives.
- **The sorting *problematique*:** To sort actions into classes or categories, such as definitely acceptable, positively acceptable but needing more information and definitely unacceptable.
- **The ranking *problematique*:** To place actions in some form of preference ordering which might not necessarily be complete.
- **The description *problematique*:** To describe actions and their consequences in a formalized and systematic manner, so that decision-makers can evaluate these actions. A generalized understanding of this *problematique* is that it is essentially a learning *problematique*, in which the decision-maker seeks simply to gain greater understanding of what may or may not be achievable.

Much of the literature on outranking methods done in English is that of Roy and Vincke [5]. Roy, who must be credited for the initial and much subsequent work on outranking methods, was critical of the utility function and value function methods on the grounds that they require all options to be comparable. He developed the ELECTRE methods which he describes as providing weaker, poorer models than a value function, built with less effort and fewer hypotheses, but not always allowing a conclusion to be drawn [5].

1.2 Decision making in the telecommunications industry

Strategic decision support encompasses a wide range of different strategies such as functional strategy, business strategy and global corporate strategy. Rapid advancement in telecommunications technologies triggered a revolution in the structure and operations of many firms in the internet-driven global economy. The advantage of web-based DSS is that

optimization results are easy to communicate among multiple users in an organization such as functional managers, management scientists, top managers, etc. During the 1990s, the focus of DSS research shifted from the optimization of functional decisions in an organizational unit to the optimization of an organizational decision that affects several organizational units. The best examples of Organizational Decision Support Systems (ODSSs) are Enterprise Resource Management (ERM) systems and Enterprise Resource Planning (ERP) systems. ERP systems integrate and optimize the entire organization's multiple functional units (marketing, human resource, production, etc.) [40].

Over the past decade, many firms invested in their core information technology infrastructures including the business intelligence system. The infrastructure includes data warehousing, business intelligence software tools, pre-packaged analytical applications and telecommunications and internet technologies. Thanks to the information technology infrastructure, many organizations are undergoing a fundamental shift in making their decisions [40]. When it comes to advanced data systems in use within the mobile phone network environment, most organizations choose to develop, implement and manage these themselves in order to retain control, guarantee the security of data and reduce their costs [9]. This is not a new trend. In technology companies servicing different aspects of the market, whether that is first world or emerging markets, such as the Internet Service Provider (ISP) environment, one finds the same behaviour. When adopting new technologies, such as Worldwide Interoperability for Microwave Access (WiMAX), organizations implement this with great cause, in order not to upset existing revenue streams [6]. The adoption of this approach is not necessarily wrong. Resources are scarce to get hold off, understanding of the exact nature of the business is rare and when developed outside of the mobile phone network, a supplier relationship needs to be maintained and this normally means expensive license fees and support retainers.

According to Rob Bamforth, practice leader for wireless and mobile networks at Bloor Research, companies should overcome the risks, such as security and management concerns, involved with outsourcing specific technological business functions by the use of appropriate policies and procedures. This can be accomplished in a cost effective manner if the right tools, products and services directly support the implementation of those policies and procedures [3]. A number of articles highlighted risks associated with the implementation of new systems within an organization, even more so when it comes to mobile phone networks.

But, as is shown in this thesis, it is not necessarily a bad approach to implement specific modular functions that control specific aspects of the mobile phone network's operations if it is a controlled implementation. By using the correct tools, the most effective implementation will be a likely result.

Another trend in the telecommunications market is that of acquisitions and mergers. Larger and more established telecommunication groups either acquire other organizations in their entirety or invest large amounts of capital for acquisition of shares in that company. This is due to large profits and even more optimistic future growth potential being shown in the companies being acquired. Bharti Airtel Limited (Bharti Airtel), one of the world's largest mobile phone networks, having profits tripling year on year lead to Vodafone Group Plc (Vodafone) purchasing a 10% share in the company for US$1.5 billion [42]. One important aspect is that the investing group companies effectively acquire management skills, obtained within the market sector that the acquired technology company operates within. This is not a new trend, especially not in the mobile telecommunications arena. Mobile Telecommunications Network Group Limited (MTN Group) has been known to offer services to numerous companies offering value added services to MTN Group's subsidiary companies and when the service is launched successfully, MTN Group either executes an acquisition of that company, or if not able to do this, simply terminates the service offering in order to internalize the value added service offering for personal gain [27]. Another example of this trend can be seen in the Bharti Airtel scenario, where current profits being shown are large, but profitability has only been realized since 2003 and this after their launch in 1995 [42]. The two trends that exist when outsourcing a function until it is managed correctly, in which case it becomes more attractive to internalize the function, are firstly through acquisition as was done by Vodafone investing in Bharti Airtel or secondly by internalizing the value added service offering as was done by MTN Group.

A large mobile phone network like Bharti Airtel has been able to effectively capitalize on opportunities within the Indian market by outsourcing services. This enables a reduction in capital expenditure requirements, providing more time for Bharti Airtel's management to focus on other key issues, such as strategy, marketing and customer orientation. According to the chairman and managing director Sanil Bharti Mittal, it allows them to place a lot more emphasis on building a company with world class processes [42]. Large organizations should not only look locally to outsource services as it has become ever more important to look at

your organization from a global perspective. Globalization has extended the geographic scope of business. The ability to source globally, for example, provides a much wider choice. More and more often local suppliers compete in national and international markets for local business. It is vital for organizations to adopt strategies that will help them manage globally. Globalization and outsourcing help raise awareness of conditions in other parts of the world, and thus it can help raise standards. For an organization to have a global mindset, managers must think internationally even if they are operating a local department in a local company [22].

In recent years, growing attention is being paid in the industry to developing efficient techniques and tools for monitoring business processes accurately and in a timely fashion on a local and international scale. Dependable monitoring is a key aspect of business process management, since it provides information that is crucial for determining the actual Quality of Service (QOS) delivered to individual parties and for promptly handling off-plan deviations. Vendors do not provide details about internal mechanisms, implementation choices and field performance with most commercial products. Two examples where matters were handled differently are provided. The first is that of MTN Group which has been working closely with the University of Pretoria in South Africa for a number of years. The university developed, at MTN Group's request, an algorithm for the generation of uniquely identifiable sequences of numbers for use when recharging a mobile subscriber's account with a preconfigured amount of airtime. The second was a research activity conducted cooperatively by an academic and an industrial party. The Dipartimento per le Technologie of the University of Naples Parthenope and Sync Lab S.r.l. (Sync Lab) redesigned a general purpose business process monitor to meet the performance requirements imposed by Telecom Italia Mobile (TIM) mobile phone recharging system [10].

The recharging system monitor was redesigned architecturally to collect and filter a sustained rate of 4000 recharge events per second. In order to demonstrate the effectiveness of the newly designed proposed approach an experimental campaign was carried out for comparing the original (buffered) architecture to the new (streamed) architecture. The experimental campaign was fundamentally aimed at evaluating the impact of the architectural choices made in the streamed solution and all underlying components were left unchanged in the two systems. The execution times of the original and the stream-based solutions were compared through defining a set of points of observation that was used as reference for timing

measurements. The two systems were then tested at their maximum capability by means of a flow generator that fed them with a continuous event flow. Results showed that the parsing performance of the stream-based architecture is more than 33 times higher than the one of the buffered architecture. Again it is concluded that monitoring is a crucial aspect of business process management, since it provides information that is key for determining the actual QOS delivered to individual parties, and for promptly handling off-plan deviations [10].

1.3 Objectives of this study

This thesis sets out to introduce a novel approach to the calculation of deferred revenue. The main objective of the study is to use known measurement techniques to measure how effective the novel approach is in comparison to the legacy approach previously used by MTN Group's subsidiary mobile phone network to calculate their deferred revenues.

The underlying notion of using appropriate techniques, mentioned in literature, to estimate efficiency in the telecommunications industry is not new. The specific field of implementation as described in this thesis, that of measuring the effectiveness of calculated deferred revenue, has not yet been done and by doing so a basis for the future study of efficiency measurement with regards to this aspect of a mobile phone network's environment is set. By establishing a footprint, it is hoped that more research will be conducted and bettered methods for Operational Support Systems (OSSs) and Business Support Systems (BSSs) will be presented.

1.4 Thesis layout

In Chapter 2 some industry background is provided to form a solid understanding of the mobile phone network environment. The reasons why the pre paid value channel contribute such a large portion to the generation of revenue in emerging markets is explored. Identification of the causes for revenue losses is presented. The concept central to this study,

namely deferred revenue, is introduced and its role in the pre paid revenue generating stream, and the different methods for calculating deferred revenue is discussed in detail. Historical methods for the calculation of deferred revenue and accompanying indicators are described. In Chapter 3 a new method for determining deferred revenue and accompanying indicators are derived through the implementation of a BSS. Chapter 4 introduces the AHP algorithm for determining the effectiveness of the deferred revenue calculated through the introduced method. ELECTRE is also presented as an outranking method to address the same problem.

Chapter 5 concludes this thesis, summarising the main findings and recommendations. This thesis is concluded with a section on possible future work with regards to the subject at hand.

Chapter 2

Industry background

In order to understand how mobile phone networks generate revenue and what significant impact the concept of deferred revenue plays in the generation of revenue, it is necessary to understand (1) the network products and (2) the software and hardware architecture of a typical mobile phone network.

By understanding the network products, it can be determined how the sales channel generates revenue. By understanding the systems architecture, one is able to isolate deficiencies that are addressed by implementing a BSS. Through addressing these deficiencies, revenue reporting mechanisms can be derived that have previously not been possible.

Understanding the network products and the network environment are not the only factors that influence the revenue reporting process. Other factors include logical constraints, such as restricted access to complex information sources, the bulk of data to be processed and the distributed nature of the data at these sources. Finding short cuts or resolving logical constraints, don't necessarily better the revenue reporting results. It rather speeds up the problem resolution time while using the same calculation methods. Therefore the only real scope to improve revenue reporting is to use better formulae. Pockets of retained intellectual property exist within the network environment, but they seldom overlap to form a larger networked diagram of the systems architecture in use, effectively providing the in-depth understanding of the macro image required to better revenue reporting results.

2.1 Network products

A mobile phone network, like most companies in the service industry, is reliant on selling their services to maintain an existence. A mobile phone network maintains a great amount of cellular network infrastructure used in the realization of its service. The cellular network infrastructure collectively forms a wireless network that spans the network coverage area. The wireless network uses electromagnetic waves to transmit data between mobile handsets. Data that can be wirelessly transmitted between handsets is the product that mobile phone networks sell to their clients.

Although the data product can be used in many different ways (such as voice and packet data) and can be transmitted using many available protocols (such as General Packet Radio Service (GPRS), Short Message Service (SMS) and Unstructured Supplementary Service Data (USSD), attention is given to the methods identified to date which are used to distribute data to clients in the form of a marketable product. The data product (also called airtime) offered by the mobile phone networks is referred to as the amount of time a person consumes while working on a mobile handset. The following airtime bearing products exist in a typical mobile phone network.

Physical vouchers

Physical vouchers are tangible cards or pieces of paper containing a Personal Identification Number (PIN). The PIN can be dispensed in exchange for a representative amount of airtime.

Electronic Voucher Distribution (EVD)

EVD is an electronic representation of a physical voucher. The electronic PIN can be dispensed in exchange for a representative amount of airtime.

Virtual Top Up (VTU)

VTU is a term used for airtime that is purchased for a nominal value in any specified denomination. The denomination is exchanged for a corresponding amount of airtime that is loaded directly onto a client's account.

Subscriber Identity Module (SIM) cards

A SIM card is an identity module that is inserted into a mobile handset. The SIM card identifies a client on the network. SIM cards normally have airtime loaded on them and the airtime becomes active on the client's account when the card is activated by the client (normally when the card is inserted into a mobile handset and the handset containing the SIM card is switched on for the first time).

2.2 Network systems

This section shows the software and hardware systems and human-driven operation processes that interact with the flow of revenue within a mobile phone network's pre paid value channel. A brief description of the functionality provided by each system which impacts on revenue within the pre paid value channel is given according to the illustration of these systems in Figures 2.1, 2.2 and 2.3.

In Figure 2.1 the high level architecture of the systems that interact with a mobile phone network's pre paid value channel during an airtime purchase transaction is outlined. The following steps summarize the airtime purchase process.

Step 1: The client interacts with a Point of Sale (POS) operator to purchase airtime.

Step 2: The POS interacts with an accounting system, generally referred to as an ERP system to record the sales transaction.

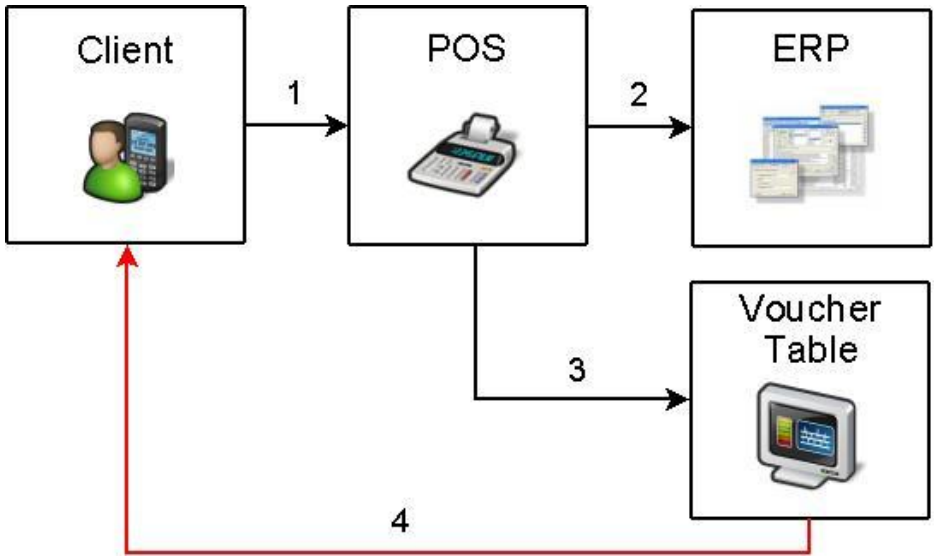

Figure 2.1: *The high level architecture of the systems interacting with a mobile phone network's pre paid value channel during an airtime purchase transaction.*

Step 3: The POS also interacts with a database table, called a voucher table, which contains and manages the statuses of PIN numbers used on vouchers for the redemption by clients. The voucher table is also used to retrieve the necessary airtime bearing product (either a physical voucher or EVD) for delivery to the client. If the airtime bearing product is not a physical voucher or EVD (therefore either VTU or SIM card), the POS would interact with a different system, but ultimately the airtime would be delivered to the client for usage at a later stage.

Step 4: The airtime bearing product is delivered to the client through the use of any available carrier medium.

In Figure 2.2 the high level architecture of the systems that interact with a mobile phone network's pre paid value channel during a transaction whereby the client loads airtime onto his account (credit applied) is outlined. Credit applied is the action of recharging a client's account with an airtime bearing product. The client therefore exchanges an airtime bearing product for airtime on his account. The following steps summarize the credit applied process.

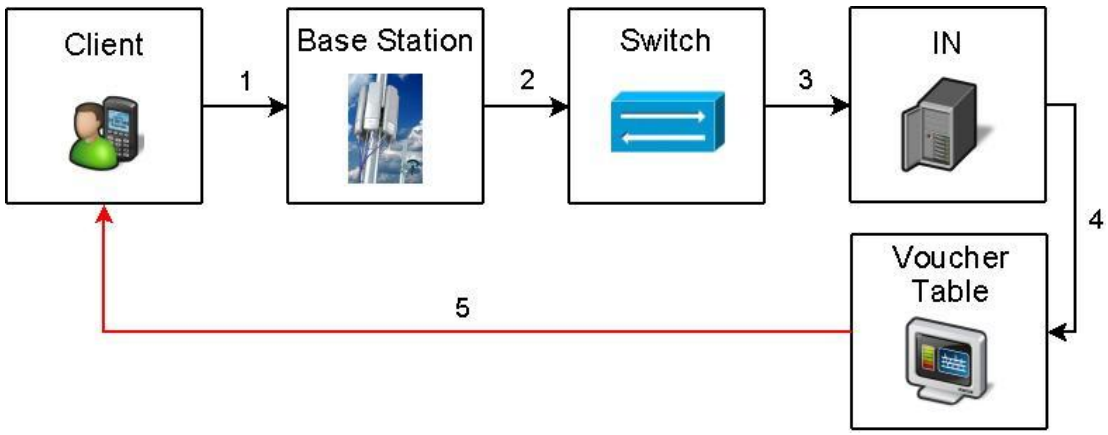

Figure 2.2: *The high level architecture of the systems interacting with a mobile phone network's credit applied transaction.*

Step 1: The client sends a request via the existing mobile phone infrastructure to recharge his account with a specified amount of airtime. The client interacts through any available protocol for communication with a mobile phone network's Base Transceiver Station (BTS).

Step 2: The BTS passes the request through to the switch. The switch handles all network traffic and decides what to do with any specific network request.

Step 3: The switch passes the request on to the mobile phone network's Intelligent Network (IN). The IN handles all data related to a network's pre paid clients.

Step 4: The IN verifies the necessary airtime bearing product (a physical voucher or EVD) in the voucher table. If the airtime bearing product is not a physical voucher or EVD (therefore a VTU or SIM card), the IN would still verify the transaction for validity using a different system, however, similar to the voucher table in nature.

Step 5: If the verification step is successful the client would now have the airtime available for usage on his account. The IN is updated with this information and the client is notified accordingly.

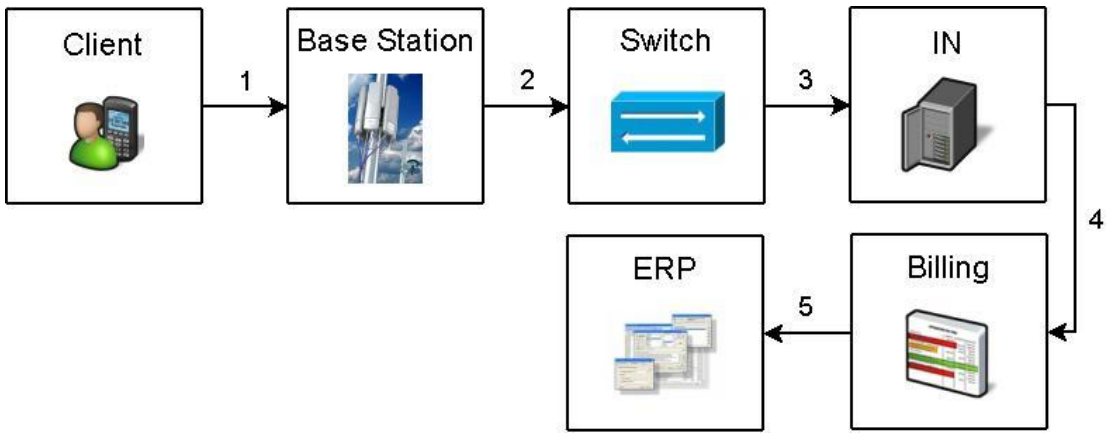

Figure 2.3: *The high level architecture of the systems interacting with a mobile phone network's debit applied transaction.*

In Figure 2.3 the high level architecture of the systems that interact with a mobile phone network's pre paid value channel while the network's client is busy with the consumption of airtime through the utilization of services, such as voice calls, SMS or data access is outlined. This is referred to as a debit applied transaction. Debit applied is the action performed by a client by using the airtime that is on his account. The following steps summarize the debit applied process.

Step 1: The client interacts through any available protocol for communication with a mobile phone network's base station while using his airtime on the network.

Step 2: The base station passes the request through to the switch. The switch handles all network traffic and decides what to do with any specific network request.

Step 3: The switch passes the request on to the mobile phone network's IN.

Step 4: The IN verifies whether the client has airtime remaining on his account and notifies the switch of how long the client can interact on the network. The switch will only allow the client to interact while there is airtime remaining on the client's account. While the client is interacting, the duration of his interaction is sent through to a billing system. The billing

system contains rules that are applied to the specific transaction taking place. The rules determine how the transaction will be rated.

Step 5: The rated transaction information is sent through to the mobile phone network's accounting system or ERP system to update specific information of interest to the mobile phone network.

For purposes of this thesis, only the systems that interact with the data responsible for revenue generation are dealt with in detail. Therefore, how revenue is realized through the interaction of data as described in this section will be described next.

2.3 Revenue

All mobile phone network operators have at least two channels through which revenue is generated. The first is the value channel where the service is granted, before payment is expected for the service, namely the post paid value channel. Traffic is generated on the mobile phone network and bills are typically settled afterwards at month end or whenever the contractual agreement entered into with the client stipulates that he is obliged to do so.

The second, and according to reports by far the most popular, is the pre paid value channel [24]. Emerging markets, especially in Africa, lack proper financial control mechanisms [12]. A sales channel through which the client purchases a product, before it is consumed is therefore beneficial in monetary terms, but also in the value associated with the limited liability (or diminished credit risk) on the part of the mobile phone network. Typically, a client purchases a fixed amount of airtime and then would eventually load that airtime onto his handset for use at some future point in time. This use of airtime is referred to as consumption or usage of airtime.

The concept of the pre paid airtime mechanism came about through the lack of proper financial control mechanisms in emerging telecommunication markets [18]. This forced the mobile phone networks to look for alternative technologies that could manage a risk free

product that would eventually put a mobile handset in the hands of even the poorest households in Africa. There are many reasons why the mobile phone networks grow at the increased rates they do in emerging markets. The main attributing factor being the lack of physical infrastructure, but the only reason for increases in pre paid products as opposed to post paid products are because of the low risk from a network perspective and the low cost to entry from a client perspective [31]. The pre paid market share in emerging markets is between 99 and 100 percent and the revenue they contribute as a percentage of total revenue is well above 95 percent in most cases [39].

Having shown that at least 95 percent of the revenue generated in emerging market mobile phone networks is attributed to the use of the pre paid product, it should be noted that from here onwards the focus is placed on this value channel.

2.4 Revenue reporting

Historically, revenue has been reported on using standard accounting software, such as enterprise software provided by solutions companies SAGE Group plc (Sage) and SAP AG (SAP) and customised versions of systems databases provided by companies such as Oracle Corporation (Oracle) and Microsoft Corporation (Microsoft). These accounting systems or ERP tools, record sales and use Generally Accepted Accounting Practise (GAAP) techniques adhering to International Financial Reporting Standards (IFRS) to prepare financial statements, calculate statutory financial obligations and generate reports used for auditing purposes.

Since the inception of mobile phone networks, little has been required to change regarding revenue reporting standards imposed by auditing firms. The first big change in revenue reporting came about with the introduction of the pre paid product to the network environment and consumer market. The pre paid product, launched with the invent of the first mobile phone network in Africa, (Vodacom (Pty) Ltd (Vodacom) was launched in South Africa during 1994) posed very specific challenges to the network’s existing systems and architecture which up to that point had focussed on post paid payment mechanisms for

remuneration of network services [19]. A further challenge to managing revenues and the pre paid product was imposed by the reporting requirements needing to be adhered to as indicated by IFRS.

IFRS stipulates that revenue must be measured at a value equalling the correct price paid, or fair value, of the consideration received and represents the amounts receivable for goods and services provided in the normal course of business, net of discounts and sales taxes [4]. Deferred revenue cannot be reported as straight revenue, as there is a risk associated with the realization thereof. Although the money has been received, the service has not been delivered yet and there is always a risk factor to consider when delivering any service, as delivery of the service may fail. Furthermore, IFRS stipulates that deferred revenue must be recognized over a period of one to three years [4]. So if revenue is recognized over a period of one to three years after deferred revenue has been recorded, the difference will be seen as a defect the mobile phone operator experienced in delivery of its service, as discrepancy exists between money collected and the monetary value of the service offered.

It is very important that deferred revenue is calculated accurately. Not only does it create expectations with the mobile phone network's shareholders, but it is also used for budget planning and other executive decision-making processes. Mobile phone networks report on deferred revenue by using a formula that can deliver a snapshot view of deferred revenue at any given point in time. This formula is referred to as the IN method of deferred revenue calculation. The IN method relies solely on real time calculations performed by the IN on a 24 hour basis. By querying the IN for relevant information at a specific point in time, it is possible to determine the deferred revenue for a network at that point in time.

2.4.1 Credit applied

When a mobile phone network sells airtime and the client loads the airtime onto his handset, referred to as a credit applied action, the amount of credit that is applied during this action is equal to the airtime value associated with the sale of the airtime that is being loaded onto the client's handset. Just as credit applied for a specific client or handset can be defined, the collective amount of credit applied for the mobile phone network pre paid subscriber base

over any given period of time can also be collected. This information can be retrieved from the IN. The IN records airtime on a client's account when it receives an instruction to do so, it does not save what gave it that instruction, nor does it attempt to retain information related to the monetary cause of the value in airtime.

2.4.2 Debit applied

There are certain rules that determine the value of credit that is applied for a corresponding monetary value exchanging hands. Similarly there is a corresponding predetermined set of rules that determine the amount of airtime that is consumed when a client utilizes services offered by a mobile phone network. These rules may also change from time to time. The part of the IN that performs this task is referred to as a rating engine, but as with credit applied the rating engine only uses the rules that apply at any given moment. It is not designed to maintain a historic record of which rules were applied at the time the airtime was generated on a client's account. Rather the IN stores time series data of what the total amount of debit applied was over a specific period of time for the entire mobile phone network pre paid subscriber base.

2.5 Deferred revenue

Consider an example of how deferred revenue is calculated using the formula based on the IN method. Typically, the IN will be queried for the necessary information at midnight on the last day of every month. The deferred revenue is calculated from the information retrieved and this is used in determining the mobile phone network's revenue at month end. The IN method consists of the following variables all queried from the IN at any specific time interval:

- Unused airtime,
- physical voucher airtime,
- EVD airtime,

- VTU airtime,
- unused SIM card airtime, and
- airtime remaining on the IN.

2.5.1 Unused airtime

Unused airtime is the total airtime available in distribution after being sold by the network operator, but that has not been loaded onto client mobile handsets yet. This value is determined by performing multiple queries on the IN, one for each type of airtime bearing item as was previously discussed. After each query, some data manipulation is necessary to estimate the exact value of airtime in circulation for the specific product type. The data manipulation typically involves subtracting the airtime still in distribution, because this airtime still has to be sold before it can be in circulation. The question that might arise is why the airtime is available on the IN if it has not been sold yet, implicating a security threat? The answer lies in a specific constraint imposed by the IN leaving the mobile phone network with no alternative but to continue with this process of premature loading of airtime. Tests performed by In2one SA (Pty) Ltd (In2one SA) have shown that any IN in use during peak times (typically between 8AM and 8PM) is too busy to perform effective loading of airtime as and when it is sold at the network outlets [43]. A workaround solution for poor loading performance of the IN, is to load airtime during low peak hours, typically at night when most people are asleep and not making use of their mobile handsets which places the IN under heavy load. The result of any query executed on the IN for airtime associated with products of any nature, therefore has to be decreased with the airtime still in distribution to be acceptable for use in the calculation of deferred revenue.

In Table 2.1 columns 5 and 6 the activation (loading of airtime into the voucher table) and deactivation (unloading of airtime from the voucher table) rates typically obtained when interacting with the IN during peak performance times are shown. It can be observed from the rows where the batch number ranges go from 2.1 to 2.10 and 3.1 to 3.16 that when loading airtime concurrently, performance can be optimized. This is apparent from the activation rates obtained for these ranges in column 5 and deactivation rates obtained from these ranges in column 6. For example, when 10 batches of 10 000 PIN numbers were

activated (batch number range 2.1 to 2.10) on the IN by running 10 concurrent programs, the worse case scenario for all 100 000 (10 x 10 000) PIN numbers to be activated was batch number 2.6 which took 364 seconds to complete activation while running concurrently with 9 other batches. The normal rate for 100 000 PIN numbers to activate when running in isolation would have been 1 637 seconds (batch number 1.4). Thus by splitting batches into smaller subsets and running concurrently the activation time was brought down from 1 637 seconds to 364 seconds; i.e. with 77.76%.

The same optimization parameters apply when deactivating PINs in the voucher table. This can be seen from the deactivation rates obtained in column 6 for the same ranges as specified above. The results in Table 2.1 cannot be guaranteed however, as the IN may or may not perform worse during any given day.

2.5.2 Physical voucher airtime

Physical voucher airtime is the total amount of airtime associated with all vouchers that have been loaded onto the IN. However, the total amount of airtime that is still in the mobile phone network's distribution chain needs to be subtracted. To determine the total amount of airtime in the network's distribution chain, a stock count of all physical vouchers needs to be performed and it has to be done at all network outlets country wide and at the same time that the IN is queried, or at least before the network outlets open their doors for trade the following day.

2.5.3 EVD airtime

Similar to physical vouchers, the EVD airtime that is in circulation, but still not loaded onto client mobile handsets, needs to be determined. This is done by performing a query on the IN that returns the total amount of EVD airtime currently loaded onto the IN and which has not yet been loaded onto client mobile handsets. Again, in this case, the information regarding

EVD airtime still in distribution has to be collected from all network outlets and subtracted from the total reported through the query on the IN.

Batch number	PIN quantity	PIN activation (sec)	PIN deactivation (sec)	Activation rate (PINs/sec)	Deactivation rate (PINs/sec)
Single sequences					
1.1	*1 000*	18	14	56	72
1.2	*10 000*	178	133	56	75
1.3	*50 000*	783	943	64	53
1.4	*100 000*	1 637	1 302	61	77
1.5	*200 000*	3 412	2 584	59	77
1.6	*1 000 000*	13 664	19 122	73	52
10 Concurrent batches of 10 000 each = 100 000					
2.1	*10 000*	342	271	29	37
2.2	*10 000*	353	267	28	37
2.3	*10 000*	349	271	29	37
2.4	*10 000*	361	269	28	37
2.5	*10 000*	358	274	28	36
2.6	*10 000*	364	275	27	36
2.7	*10 000*	361	274	28	36
2.8	*10 000*	363	277	28	36
2.9	*10 000*	360	277	28	36
2.10	*10 000*	351	276	28	36
16 Concurrent batches of 100 000 each = 1 600 000					
3.1	*100 000*	7 438	Data unavailable	13	Data unavailable
3.2	*100 000*	7 460	Data unavailable	13	Data unavailable
3.3	*100 000*	7 470	Data unavailable	13	Data unavailable
3.4	*100 000*	7 471	Data unavailable	13	Data unavailable
3.5	*100 000*	7 479	Data unavailable	13	Data unavailable
3.6	*100 000*	7 479	Data unavailable	13	Data unavailable
3.7	*100 000*	7 480	Data unavailable	13	Data unavailable
3.8	*100 000*	7 482	Data unavailable	13	Data unavailable
3.9	*100 000*	7 488	Data unavailable	13	Data unavailable
3.10	*100 000*	7 496	Data unavailable	13	Data unavailable
3.11	*100 000*	7 501	Data unavailable	13	Data unavailable
3.12	*100 000*	7 506	Data unavailable	13	Data unavailable
3.13	*100 000*	7 590	Data unavailable	13	Data unavailable
3.14	*100 000*	7 591	Data unavailable	13	Data unavailable
3.15	*100 000*	7 544	Data unavailable	13	Data unavailable
3.16	*100 000*	7 593	Data unavailable	13	Data unavailable

Table 2.1: *IN performance evaluation of loading and unloading airtime (in seconds) into the voucher table during peak times (typically between 8AM and 8PM).*

2.5.4 VTU airtime

VTU airtime is queried from the IN as airtime on specialized SIM cards obtained from the mobile phone network by dealers responsible for the resale of the VTU airtime. The value consists of airtime purchased directly from the network and airtime allocated to dealer VTU accounts, earned as commissions due to the resale of VTU airtime. Unlike physical voucher and EVD airtime, no adjustments need to be made and the exact value as reported by the IN can be used as is.

2.5.5 Unused SIM card airtime

Unused SIM card airtime is the total amount of airtime associated with all SIM cards that have been loaded onto the IN. However, again the total amount of airtime that is still in the mobile phone network's distribution chain needs to be subtracted from this total. To determine the total amount of airtime in the network's distribution chain, a stock count of all SIM cards needs to be performed and it has to be done at all network outlets country wide and at the same time that the IN is queried, or at least before the network outlets open their doors for trade the following day. Besides unused airtime, consideration also has to be given to airtime which has already been sold and loaded onto the clients' mobile handsets, but which has yet to be consumed.

2.5.6 Airtime remaining on the IN

Airtime remaining on the IN is simply the total amount of airtime remaining on all clients' accounts as represented by the IN. It may be queried from the IN at any given point in time, but for the value to be effective in its use for calculating deferred revenue it has to be queried from the IN at the same point in time as unused airtime. If queried later or earlier, there would be duplication of airtime accounted for twice and recorded on both ends of the scale.

2.5.7 Calculations

In Table 2.2, based on data sampled from MTN Cote d'Ivoire (MTNCI), there are 4 variables depicted in a currency belonging to MTNCI and the rest of the French speaking West and Central Africa (WECA) countries, namely *Franc Communauté Financière d'Afrique* (FCFA). These variables include: *Vouchers Available* (columns 2 and 3), so called *Kits Available* (columns 4 and 5), *Credit Available* (columns 6 and 7) and *EVD Available* (columns 8 and 9). The four variables are used for the determination of deferred revenue using the IN method of calculation. Each variable column is divided into 2 separate columns. One depicting the variable value before Value Added Tax (VAT) has been taken into account, namely *Toutes Taxes Comprises* (TTC), and the other for after the VAT has been subtracted, namely *Hors Taxes* (HT).

In Table 2.2, the heading *Vouchers Available* represents *physical voucher airtime*. It is calculated by querying the total amount of airtime represented by vouchers that have been loaded in the IN and subtracting the total amount of airtime represented by voucher stock that is retained in MTNCI warehouses. Therefore rendering the resulting answer, namely the total amount of airtime that has already been sold by MTNCI and is currently in a dealer distribution channel, but those vouchers still has not been loaded onto a client's account. The *HT* value for this variable, namely *Vouchers Available*, is calculated as

$$HT = TTC - TTC \times 18\%,$$

where 18% is the effective VAT rate in Cote d'Ivoire at the time of writing this thesis.

Similarly the heading *Kits Available* in Table 2.2 represents *unused SIM card airtime*. It is calculated by querying the total amount of airtime represented by SIM cards on the IN and subtracting the total amount of airtime represented by SIM card stock that is retained in MTNCI warehouses. Therefore rendering the resulting answer, namely the total amount of airtime that has been loaded onto SIM cards and been sold by MTNCI, but the SIM card is currently in a dealer distribution channel and still not activated or loaded onto a client's account. The *HT* value for this variable, namely *Kits Available*, is determined in the same way as above.

The heading *Credit Available* in Table 2.2 or *airtime remaining on the IN* is, however, a relatively easy value to get hold of and this is simply all of the airtime that is currently loaded onto clients' accounts, but that has still not been consumed by the total subscriber market belonging to MTNCI.

The heading *EVD Available* in Table 2.2 represents the total amount of *EVD airtime* and *VTU airtime* that has been sold to clients, therefore includes whatever is currently in dealer distribution channels, but not loaded onto any client's account as yet. Again the EVD airtime that is still in MTNCI possession has to be subtracted, as this has not yet been sold. The *HT* value for this variable is also calculated as above.

The *Deferred Revenue* values in the last column of Table 2.2 reflects deferred revenue per day and is the summed result of the four variables during each period mentioned above. The deferred revenue is representative of the *TTC* value and VAT still has to be taken into account, before this value can be compared with the value obtained from any other method for the calculation of deferred revenue.

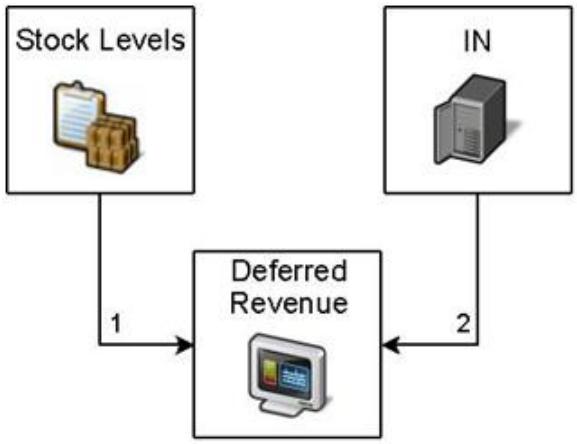

Figure 2.4: *Graphical depiction of the calculation of deferred revenue using the formula based on the IN method.*

Figure 2.4 illustrates where the IN method for the calculation of deferred revenue gets its information from. Stock levels maintained by the mobile phone network (1) are reconciled

Reporting

Reconcilliation Report per day

01-03-2008 - 23-05-2008

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Period	Vouchers Available		Kits Available		Credit Available		EVD Available		Deferred Revenue
	TTC	HT	TTC	HT	TTC	HT	TTC	HT	
01-03-2008	3,868,228,400	3,278,159,661	603,548,462	511,481,747	2,413,502,440	2,045,341,051	0	0	6,885,279,302
02-03-2008	3,592,694,200	3,044,656,102	594,173,341	503,536,730	2,385,461,967	2,021,577,938	0	0	6,572,329,508
03-03-2008	3,433,502,300	2,909,747,712	585,393,341	496,096,052	2,408,483,870	2,041,088,025	0	0	6,427,379,511
04-03-2008	4,437,160,200	3,760,305,254	462,591,328	392,026,549	2,427,287,206	2,057,023,056	0	0	7,327,038,734
05-03-2008	3,660,879,700	3,102,440,424	436,973,663	370,316,664	2,412,178,986	2,044,219,488	0	0	6,510,032,359
06-03-2008	3,717,555,500	3,150,470,763	450,813,613	382,045,435	2,409,831,027	2,042,229,684	0	0	6,578,200,140
07-03-2008	-18,256,316,100	-15,471,454,322	443,765,613	376,072,553	2,407,598,925	2,040,338,072	171,427,963	145,277,935	-15,233,523,599
08-03-2008	-15,118,175,500	-12,812,013,136	440,712,204	373,484,919	2,389,324,850	2,024,851,568	0	0	-12,288,138,446
09-03-2008	4,238,322,400	3,591,798,644	431,813,176	365,943,369	2,318,408,632	1,964,753,078	0	0	6,988,544,208
10-03-2008	4,876,237,900	4,132,405,000	842,893,676	714,316,675	2,335,386,535	1,979,141,131	173,955,312	147,419,756	8,228,473,423
11-03-2008	4,874,705,400	4,131,106,271	840,064,176	711,918,793	2,327,835,764	1,972,742,173	168,734,421	142,995,272	8,211,339,761
12-03-2008	5,239,994,500	4,440,673,305	839,986,230	711,852,737	2,326,161,445	1,971,323,258	165,512,016	140,264,420	8,571,654,191
13-03-2008	3,498,897,700	2,965,167,542	830,785,491	704,055,501	2,309,541,599	1,957,238,643	162,998,791	138,134,569	6,802,223,581
14-03-2008	3,686,494,000	3,124,147,458	826,917,432	700,777,485	2,310,491,604	1,958,043,732	160,616,345	136,115,547	6,984,519,381
15-03-2008	3,334,295,200	2,825,673,898	826,624,432	700,529,180	2,298,002,170	1,947,459,466	211,904,054	179,579,707	6,670,825,856

Table 2.2: *Table showing the variables in use for determining deferred revenue using the IN method of calculation.*

with airtime received from the IN for each of the airtime bearing products mentioned above (2) and are used to calculate deferred revenue.

In this chapter background was given to the mobile phone network environment and industry components relevant to the topic of this thesis were discussed. An explanation of the network's airtime bearing product types followed and exploration of the network's operational environment, relevant to the pre paid value channel, was done. An overview of revenue and revenue reporting was given and why deferred revenue contributes to revenue generated on a mobile phone network's pre paid value channel was explained. For clarification purposes it was concluded with an example of how deferred revenue is currently being calculated through the use of an IN.

Chapter 3

A new BSS

Before introducing the proposed method for the calculation of deferred revenue, an explanation of the BSS used for the calculation of this new method is justified. It is only possible to derive at the proposed method through the implementation of the BSS. The system is particularly modularized and it automates most of the processes involved in the calculation of deferred revenue. Specific focus is placed on the automated delivery of key variables used in the novel formula and manual process interventions are minimised, to keep the report generation process as clean and simple as possible.

Once each of the modules contained within the BSS have been explained in Section 3.1, a breakdown of the components for deferred revenue is revisited in Section 3.2, but with specific reference to the proposed method for the calculation thereof.

3.1 BSS functionality

BSSs have been known for their capabilities to outperform all human driven operational processes where the following functional requirements are present [17]:

- high volume data processing,
- high speed transactions,
- accuracy of information, and
- repetitive transactions similar in nature.

The following features make a BSS an attractive alternative to human driven operational processes [17]:

- **Increased availability:** Data is available on any hardware and readily so.

- **Reduced cost:** The cost of providing data per user is greatly lowered.
- **Reduced danger:** A BSS can be used in environments that are potentially hazardous for a human.
- **Permanence:** The information is permanent. Unlike human information and expertise, BSS information as stored digitally will last indefinitely.
- **Multiple expertise:** The knowledge and data of multiple human experts can be made available to work simultaneously and continuously at any time of day or night.
- **Increased reliability:** The BSS increases confidence that the correct calculation was made by providing a second opinion to a human calculation.
- **Explanation:** The BSS can explicitly explain in detail the reason that led to a conclusion. A human may be too tired, unwilling, or unable to do this all the time. This increases the confidence that the correct decision is made.
- **Fast response:** Depending on the software and hardware used, a BSS may respond faster and be more available than a human.
- **Steady, unemotional, and completely responsive at all times:** This may be very important in real-time and emergency situations, when a human expert may not operate at peak efficiency because of stress or fatigue.
- **Intelligent database:** A BSS can be used to access databases in an intelligent manner.

The two specific modules contained in the BSS that are of interest, is a POS module and a warehouse management and order processing module or Voucher Management System (VMS). These modules are strategically placed within the mobile phone network's pre paid environment to perform specific, previously human-driven, functions. Here they collect information from the software and hardware systems controlling the flow of data throughout. Raw data is collected directly from the source and data manipulation is done by a set of software algorithms specifically designed and tested for their accurate computational abilities.

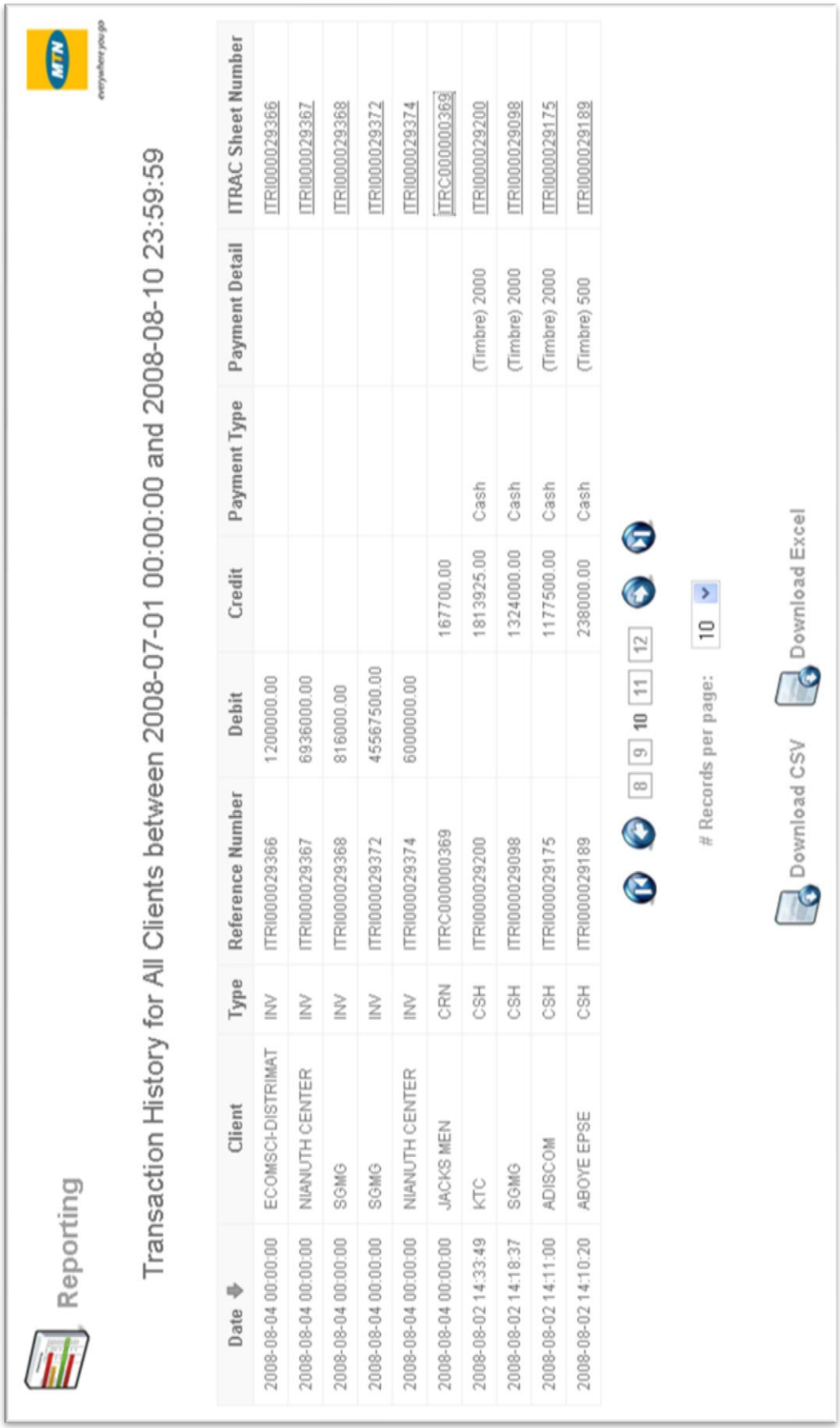
3.1.1 POS module

Through implementation of a POS module, an accurate measure for the sale of airtime bearing products may be established. For physical products such as airtime vouchers and EVD, this is done through the unique identification tag (serial number represented by a bar code) that is attached to the product. For virtual products, such as VTU, the airtime associated with the sale is derived from the financial value stipulated on the invoice or credit note, depending on whether airtime is granted to a client or returned by the client. A POS also records the airtime being returned to the mobile phone network due to product failure. Other than the normal sale and credit note functions provided by the POS, it signals the BSS for every transaction that takes place. The BSS, on receipt of a signal from the POS module, records the airtime value associated with the specific transaction being signalled. It then adjusts the total amount of airtime allocated to the market accordingly.

In Table 3.1 some transactions as recorded by a POS are presented. The sale associated with invoice *ITRI000029374* which constituted a sale to a client by the name of *Nianuth Centre* on 04-08-2008 would have increased the airtime allocated for this day with 6 000 000 FCFA for MTNCI. Similarly, the stock returned in association with credit note *ITRC000000369* would have decreased the airtime allocated for this day by 167 700 FCFA for MTNCI.

Rows 1 through to 4, starting with *Reference Number* ITRI000029366, would also have increased the airtime allocated by MTNCI and so would rows 7 through to 10, starting with *Reference Number* ITRI000029200. The difference between rows 1 to 5 and rows 7 to 10, is just that rows 1 to 5 was paid on account and therefore the dealer's account purchasing the airtime stock would have been debited. Whereas rows 7 to 10 was paid using cash and credited on the dealer account as can be seen in Table 3.1.

The POS therefore provides us with an accurate measure of the exact amount of airtime that has entered the market over a period of time. For the information recorded at the POS to be relevant for use in the calculation of deferred revenue using the proposed method a number of factors need to be present:



Date	Client	Type	Reference Number	Debit	Credit	Payment Type	Payment Detail	ITRAC Sheet Number
2008-08-04 00:00:00	ECOMSCI-DISTRIMAT	INV	ITRI0000029366	1200000.00				ITRI0000029366
2008-08-04 00:00:00	NIANUTH CENTER	INV	ITRI0000029367	6936000.00				ITRI0000029367
2008-08-04 00:00:00	SGMG	INV	ITRI0000029368	816000.00				ITRI0000029368
2008-08-04 00:00:00	SGMG	INV	ITRI0000029372	45567500.00				ITRI0000029372
2008-08-04 00:00:00	NIANUTH CENTER	INV	ITRI0000029374	60000000.00				ITRI0000029374
2008-08-04 00:00:00	JACKS MEN	CRN	ITRC0000000369		167700.00			ITRC0000000369
2008-08-02 14:33:49	KTC	CSH	ITRI0000029200		1813925.00	Cash	(Timbre) 2000	ITRI0000029200
2008-08-02 14:18:37	SGMG	CSH	ITRI0000029098		1324000.00	Cash	(Timbre) 2000	ITRI0000029098
2008-08-02 14:11:00	ADISCOM	CSH	ITRI0000029175		1177500.00	Cash	(Timbre) 2000	ITRI0000029175
2008-08-02 14:10:20	ABOYE EPSE	CSH	ITRI0000029189		238000.00	Cash	(Timbre) 500	ITRI0000029189

Table 3.1: *Client history as reported on a POS over a selected period of time.*

- The POS needs to report on the airtime value associated with a sale and/or stock returned (credit note), taking into account bonus airtime associated with a product, but excluding commissions associated with the transaction.
- For accuracy of the transaction, it is advised to make use of a serialized sales model, whereby every item contains a bar code, linking it to a product record containing the necessary airtime and bonus information.
- The airtime value and bonus airtime associated with a specific product needs to be kept up to date with the selling price of that product.

Besides the factors mentioned above, it would be helpful if the POS module (but this would also be the case with the VMS, or any other module) is in direct communication with the BSS processing kernel so that the flow of information is automated. This speeds up the delivery of final reports and prevents manual intervention with the potential of causing data discrepancies.

3.1.2 VMS module

Similar to the serialized tracking of vouchers at the POS, the VMS has specific functions to retrieve information for the automated reporting of deferred revenue using the proposed method for the calculation thereof. The POS handles transactions at the sales point, but these actions are then relayed to the VMS for interaction with the IN and the ERP. The functions of most relevance are mainly focussed on the interaction the VMS has with the IN. Two functional areas of the VMS that is necessary for the calculation of deferred revenue using the method proposed here are addressed in the following paragraphs.

IN updates performed by the VMS

The VMS controls the manipulation of airtime bearing products on the IN. If those products are physical (i.e. have serial numbers) the VMS would simply perform the activation or deactivation of the products on the IN, based on whether stock is being invoiced or credit

noted. It also allocates the correct bonus airtime to the IN based on a product sale, or minimises the IN airtime value if a product is being returned to the mobile phone network.

If the product being transacted on is not physical by nature (i.e. VTU), the VMS updates the client's account directly when a sale occurs, or decreases the client's account when a credit note occurs, always to the exact airtime value associated with the transaction taking place at the POS. The reason for expressing such keen interest in the quantification of airtime on the IN is relevant for one reason only. In the next step, reliance is placed on the VMS to calculate the airtime usage on its own account and it would not do this approach good if airtime allocation takes place on the IN and is not accounted for by the VMS, otherwise unallocated usage information would be collected from the IN. Similarly, if more airtime is provisioned on the IN than what is actually being transacted at the POS, there would be less usage recorded than anticipated, skewing the calculations related to the eventual calculation of deferred revenue.

IN data processed by the VMS

In the second instance, interest is placed in the VMS's capabilities to parse IN Call Data Record (CDR) files. The IN produces CDR files at a fixed rate determined by the initial configuration thereof. The CDR files contain information related to every single transaction that took place on the IN. Every single time a call is made, or a SMS is sent, or a voucher is recharged onto a client's account, or any other transactions that influences the IN in any manner takes place a new entry is recorded in the CDR files generated by the IN. It can be seen as a continuous output log that records the details of every transaction that takes place on the IN.

The VMS uses the generated CDR files to calculate the airtime usage that has taken place for a specific period in time. It reads the CDR file content into a rating engine and performs rating of specifically identified CDR tags to calculate the total amount of airtime used by clients for a complete CDR file. In Figure 3.1 a typical CDR tag contained in a CDR file is shown. Amongst the information displayed, the sample tag shown is for a call that was 113 seconds long (*chargeableDuration*), it originated from the number 4127642931 (*callingPartyNumber*) and has to be rated at the rating rule represented by 0002 (*tariffClass*).

Collectively the information obtained from the POS and VMS is processed by the BSS to report on deferred revenue using the proposed method.

```
861024

-- message 1 --
CallDataRecord {
   uMTSGSMPLMNCallDataRecord {
      callModule {
         mSOriginating {
            callPosition = b_AnswerHasBeenReceived
            chargeableDuration = 000113
            dateForStartOfCharge = 07070D
            exchangeIdentity = OBW*MSC1/R11 A0
            interruptionTime = 000000
            recordSequenceNumber = CA86D1
            tariffClass = 0002
            tariffSwitchInd = noTariffSwitch
            timeForStartOfCharge = 092F03
            timeForStopOfCharge = 093017
            outputType = tTOutputOnly
            switchIdentity = FFFF
            mSCIdentification = 116277020000F0
            callingSubscriberIMEI = 53521000625533F0
            callingSubscriberIMEISV = 5352100062553312
            callingSubscriberIMSI = 56020201601664F6
            teleServiceCode = 11
            iNMarkingOfMS = originatingINCategoryKeyService
            firstCallingLocationInformation = 56F2200001014C
            calledPartyNumber = 217771528793F1
            frequencyBandSupported = 06
            originatingLocationNumber = 116277020000F1
            timeForTCSeizureCalling = 092E34
            firstRadioChannelUsed = fullRateChannel
            firstAssignedSpeechCoderVersion = fullRateVersion2
            speechCoderPreferenceList = 010003
            callingPartyNumber = 4127642931
            incomingRoute = BSC3I
            originatedCode = callOriginatingFromOwnSubscriberInGSN
            callIdentificationNumber = ADDB47
            networkCallReference = 8DD770FFFF
            typeOfCallingSubscriber = 01
            radioChannelProperty = dualRateFullRatePreferred
            tAC = 0B020D
            subscriptionType = 00
            originForCharging = 00
            chargingCase = 0002
            chargedParty = chargingOfCallingSubscriber
            timeFromRegisterSeizureToStartOfCharging = 00000B
            internalCauseAndLoc = 0003
            lastCallingLocationInformation = 56F2200001014C
            incomingAssignedRoute = BSC3I
            translatedNumber = 4127753819
            outgoingRoute = IVR2O
            eosInfo = 05
            disconnectingParty = callingPartyRelease
         }
      }
   }
}
```

Figure 3.1: *Sample CDR output data after decryption.*

3.2 Proposed method for the calculation of deferred revenue

Through the implementation of the BSS modules (POS and VMS) sufficient information to introduce a novel formula for the calculation of deferred revenue is available. The POS and

VMS modules record information from specific sources along the pre paid value channel. The proposed method uses the following variables to calculate deferred revenue.

3.2.1 Sales credit (including bonuses allocated on the sales channel)

Sales credit, as described in Section 3.1.1, is collected by the BSS through the use of a POS. Movement of airtime associated with physical vouchers, EVD, VTU, SIM cards and bonuses, affect the sales credit variable.

A sale will increase the sales credit variable equal to the amount of airtime being granted on the sale. A return of products, such as when a credit note is issued, will decrease the sales credit variable with an amount equal to the airtime associated with the products being returned. Positive sales credit will increase the deferred revenue total using this method of calculation. Airtime usage has the opposite effect and decreases so-called deferred airtime once applied to the proposed method. Deferred airtime is the second portion of deferred revenue. If the life cycle of deferred revenue is considered, the first phase is when airtime has been sold, but still not loaded (loading of airtime is also referred to as credit applied) on a client's account and this is called airtime liability. The second phase starts when airtime is loaded onto a client's account, but still remains to be used (usage of airtime is also referred to as debit applied), this is called deferred airtime. Deferred airtime and therefore the lifecycle of deferred revenue ends when the client uses his airtime by, for instance, making a call.

3.2.2 Airtime usage (including expired and deactivated credit)

Airtime usage, as described in Section 3.1.2 is collected by the BSS through the use of a VMS. Expired and deactivated credit are both also collected from the IN's CDR files through the use of a VMS, but the information is collected once a month as and when the checks and balances are performed. Once a month a script will execute on the IN determining the statuses of clients' accounts. If there has been no activity (incoming or outgoing traffic to or from a client's mobile handset) for some period of time (normally determined by the

telecommunications regulatory body) the account is identified as inactive. The airtime remaining on that account is then included in the usage variable so that it can decrease the deferred revenue accordingly, as the airtime is not in circulation any more.

Sometimes airtime bearing items, already sold into the market, surpass their validity date and the products end up expiring before it could be used (loaded onto an account) by a client. Airtime associated with such occurrence is referred to as expired credit. Expired credit is also included in the airtime usage variable, as it decreases the deferred revenue (current airtime in circulation). Figure 3.2 graphically depicts the high level methodology used for calculation of deferred revenue using the proposed method just explained. Figure 3.3 shows a higher level process flow, but for both methods used for calculating deferred revenue. The POS delivers sales data and the VMS collects IN data for calculation on a continual basis.

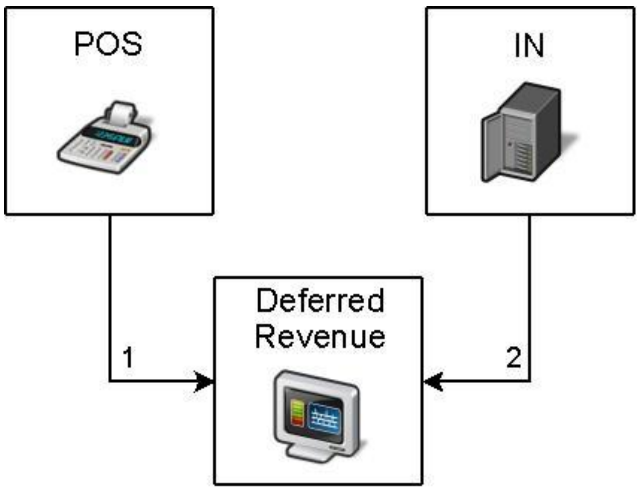


Figure 3.2: *Deferred revenue calculated for a typical mobile phone network using the proposed method.*

The formula used for calculation of deferred revenue using the proposed method is

$$R^p = S_c - A_u,$$

where R^p is the deferred revenue for the period, S_c is the sales credit for the period (including bonuses allocated on the sales channel) and A_u is the airtime usage including expired and deactivated credit). To determine the deferred revenue closing balance at a specific point in time the formula needs to be expanded to include a deferred revenue opening balance.

Typically at the start of a mobile phone network's life cycle the opening balance is zero. However, when implementing the formula for the first time within an existing mobile phone network, an acceptable opening balance needs to be determined. This balance is typically obtained at the end of a fiscal year as determined by the company external auditors. The balance is calculated as

$$R^b = R^o - R^p,$$

where R^b is the deferred revenue closing balance, R^o is the deferred revenue opening balance and R^p is the deferred revenue for the period.

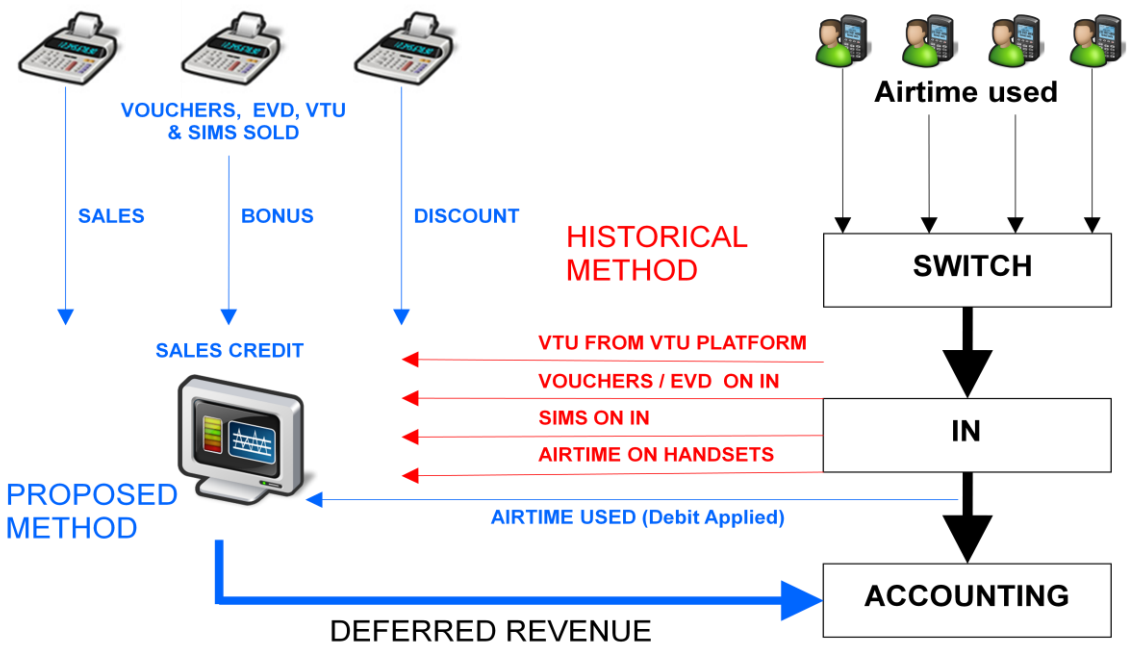


Figure 3.3: *Graphical depiction of the IN method and proposed method for the calculation of deferred revenue.*

The main difference between the historical and proposed methods for deferred revenue calculation lies in the origin of the variables used in the calculation process. The historical method is completely IN dependent and relies purely on what the IN reports as available in terms of airtime bearing products. The sum of the balances of all airtime bearing products as reported by the IN represents deferred revenue when following the historical method for calculation purposes. A few alterations are made to the final value, to take bonus airtime, discounts applied and expired and deactivated credit into account. The proposed method, as explained, uses information obtained from the IN (through the use of a VMS) and sales information (through the use of a POS). The sales channel delivers *sales credit* and the IN provides *airtime used / debit applied*. The difference between the two variables is then added to the deferred revenue opening balance of the previous period to calculate the closing balance for the current period under review.

For purposes of calculating deferred revenue using the proposed method, only selected variables are explained by means of the values in Table 3.3. The first variable of interest as depicted by Table 3.3 is *Sales Credit*. *Sales Credit*, particular the *TTC* value, depicts the total amount of airtime associated with sales that was recorded at the POS for the period under review, in this case on a daily basis.

The next variable used in the calculation of this method, is *Bonus*. *Bonus* is the total amount of airtime allocated based on the number of sales that took place during the period under review. *Bonus* also has a *TTC* and *HT* value, calculated on the same principle as all other variables mentioned and using an effective VAT rate of 18%.

The only variable that is subtracted in the use of the proposed method for calculation is *Usage* as depicted in Table 3.3. *Usage*, also containing a *TTC* and *HT* value, is the total amount of airtime that was consumed by clients during the period under review. To bring the proposed method into context, it will be formulated differently, so that it can be compared with the IN method discussed in Section 2.4.

Table 3.2 shows the different variables interacting with both formulas and where they overlap to form a synergistic approach. *Financial liability* (another name for deferred revenue) shows the calculations used in the proposed method. It may be noted that the top half of Table 3.2 is a presentation of the proposed method for the calculation of deferred

revenue. In this method deferred revenue increases when *sales credit* (including bonuses allocated on the sales channel) applies and it decreases when *usage (credit applied*) takes place.

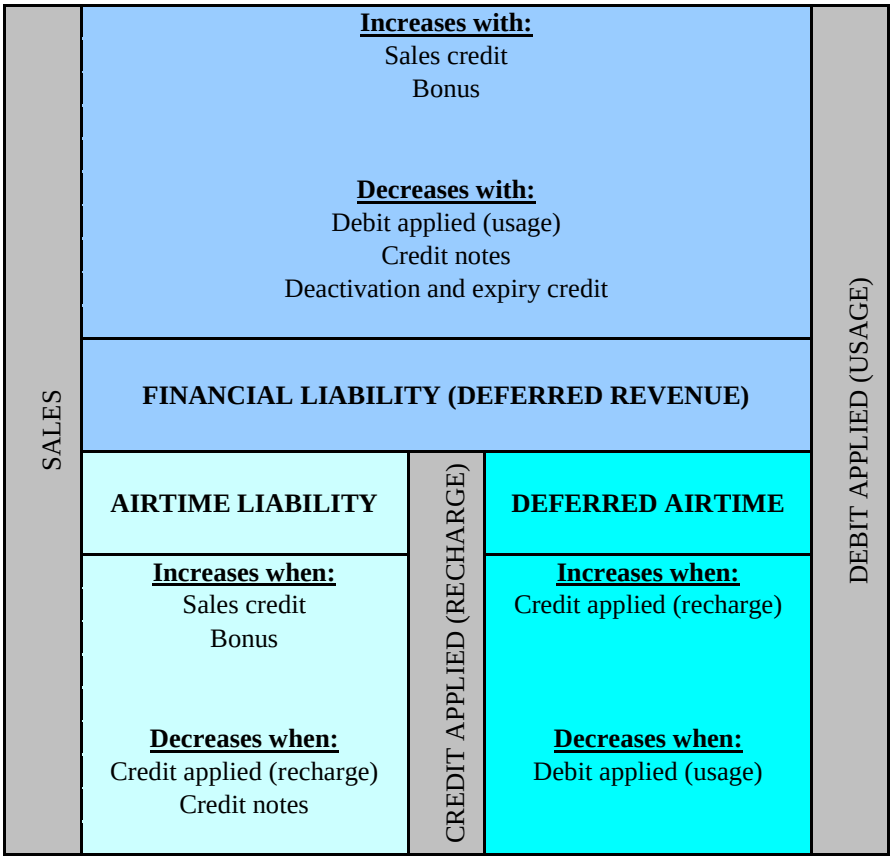
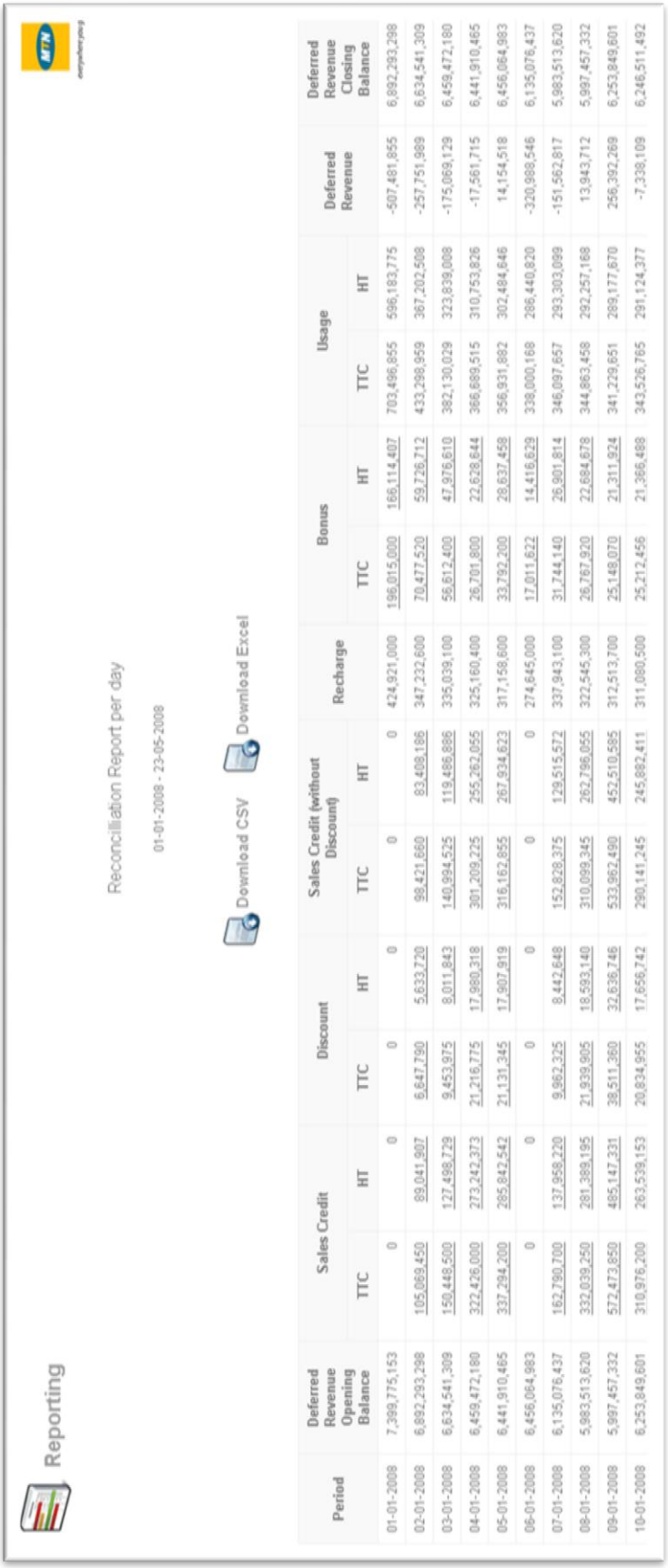


Table 3.2: *The relationship between financial liability (deferred revenue), airtime liability and deferred airtime.*

Similarly the bottom half of the table is representative of the IN method for the calculation of deferred revenue. It shows that *airtime liability* is a depiction of *sales* that have been realized (including bonuses allocated on the sales channel), typically this would be *unused airtime*, described in Section 2.4 as the sum of physical voucher airtime, EVD airtime, VTU airtime and unused SIM card airtime. Whereas *deferred airtime* as shown on the bottom right of Table 3.2 is the later part of the IN method, being airtime remaining on the IN. *Airtime liability* thus becomes *deferred airtime* when airtime is loaded onto a client's mobile phone.



Reporting

Reconcilliation Report per day

01-01-2008 - 23-05-2008

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Period	Deferred Revenue Opening Balance	Sales Credit		Discount		Sales Credit (without Discount)		Recharge	Bonus		Usage		Deferred Revenue	Deferred Revenue Closing Balance
		TTC	HT	TTC	HT	TTC	HT		TTC	HT	TTC	HT		
01-01-2008	7,399,775,153	0	0	0	0	0	0	424,921,000	196,015,000	166,114,407	703,496,855	596,183,775	-507,481,855	6,892,293,298
02-01-2008	6,892,293,298	105,069,450	89,041,907	6,647,790	5,633,720	98,421,660	83,408,186	347,232,600	70,477,520	59,726,712	433,298,959	367,202,508	-257,751,989	6,634,541,309
03-01-2008	6,634,541,309	150,448,500	127,498,729	9,453,975	8,011,843	140,994,525	119,486,886	335,039,100	56,612,400	47,976,610	382,130,029	323,839,008	-175,069,129	6,459,472,180
04-01-2008	6,459,472,180	322,426,000	273,242,373	21,216,775	17,980,318	301,209,225	255,262,055	325,160,400	26,701,800	22,628,644	366,689,515	310,753,826	-17,561,715	6,441,910,465
05-01-2008	6,441,910,465	337,294,200	285,842,542	21,131,345	17,907,919	316,162,855	267,934,623	317,158,600	33,792,200	28,637,458	356,931,882	302,484,846	14,154,518	6,456,064,983
06-01-2008	6,456,064,983	0	0	0	0	0	0	274,645,000	17,011,622	14,416,629	338,000,168	286,440,820	-320,988,546	6,135,076,437
07-01-2008	6,135,076,437	162,790,700	137,958,220	9,962,325	8,442,648	152,828,375	129,515,572	337,943,100	31,744,140	26,901,814	346,097,657	293,303,099	-151,562,817	5,983,513,620
08-01-2008	5,983,513,620	332,039,250	281,389,195	21,939,905	18,593,140	310,099,345	262,796,055	322,545,300	26,767,920	22,684,678	344,863,458	292,257,168	13,943,712	5,997,457,332
09-01-2008	5,997,457,332	572,473,650	485,147,331	38,511,360	32,636,746	533,962,490	452,510,585	312,513,700	25,148,070	21,311,924	341,229,651	289,177,670	256,392,269	6,253,849,601
10-01-2008	6,253,849,601	310,976,200	263,539,153	20,834,955	17,656,742	290,141,245	245,882,411	311,080,500	25,212,456	21,366,488	343,526,765	291,124,377	-7,338,109	6,246,511,492

Table 3.3: *The variables used for the calculation of deferred revenue by means of the proposed method.*

When a client consumes airtime, it stops being accounted for as deferred revenue and *deferred airtime* simultaneously and is accounted for revenue immediately thereafter.

Other factors that have a direct result on the variables depicted in Table 3.3 are *credit notes*. These affect deferred revenue as explained, but also *airtime liability*, as the airtime would only have been sold and not yet loaded onto a client's account at the time the credit note is issued.

In this chapter a new method for the calculation of deferred revenue was proposed. The method is cumulative and utilizes an opening and closing balance to estimate deferred revenue in soft real time, as opposed to hard real time, where hard real time is an instantaneous occurrence and in our example, calculations take up processing time rendering only soft real time a possibility. The IN method, although slower in obtaining results due to its complexity and reliance on the IN, does not require an opening balance to determine the closing balance for a selected period as it is not cumulative. Rather it is a snapshot approach, whereby results that are delivered by the IN are processed for a measurement of deferred revenue at a given point in time. If the data is not queried, the results at that point in time can never be known. Both methods have specific benefits and pitfalls and it is in the next chapter that we use the AHP and ELECTRE for measuring the effectiveness of both methods for the calculation of deferred revenue.

Chapter 4

The model

The AHP is a method for decision formulation and analysis [37]. It has been extensively studied and refined since Thomas L. Saaty developed it in the 1970s [44]. Being an MCDA approach the AHP is designed to handle the decision atmosphere in which subjective judgments are inherent to the decision-making process. Furthermore, the AHP provides a systematic method for evaluating the importance of each criterion in relation to the other criteria in a hierarchical manner [38]. The model presented here consists of using the AHP to evaluate the two methods for the calculation of deferred revenue. The IN method being the historical method that has been used by mobile phone networks for the calculation of deferred revenue to date and the proposed method being the one made possible by the use of a BSS.

Some assumptions are made in Section 4.1 regarding the use of the AHP for evaluation of the two methods. The variables and parameters used for evaluation of the main criteria of our model are identified in Section 4.2. These criteria are weighted using a pairwise comparison matrix in Section 4.3. In Section 4.4 consistency checking of criteria comparisons used in each network department is performed before determination of the scores of the alternative criteria is done in Section 4.5. Section 4.6 outlines the findings for determining departmental dependency and consistency with regards to choosing the criteria. The final scores when using the AHP are analyzed and the findings, with regards to using this approach, are documented in Section 4.7. Finally, ELECTRE is introduced as an outranking alternative to AHP in Section 4.8. Then sensitivity and robustness analysis on both methods used for the measurement of effectiveness is performed in the final section of this chapter.

4.1 Assumptions

Before the models for evaluation are discussed a few assumptions have to be made. These general assumptions enable firstly, the calculation of deferred revenue using both the IN method and proposed method and secondly, the construction of two models, the one which utilizes the AHP for evaluating the two methods and the other which utilizes ELECTRE for evaluation.

Pre paid value channel

It is assumed that the mobile phone network has a pre paid value channel through which the sales of pre paid products are sold into a market for use by the end client. It is also assumed that the pre paid value channel constitutes a large enough portion of the mobile phone network subscriber population so that it contribute significantly to the generation of revenue. This is the case in all emerging market economies [35] as was explained in Chapter 1. If the pre paid value channel does not contribute significantly to the generation of revenue, it would not be viable to perform this study.

The existence of an IN

It is assumed that an IN exists within the mobile phone network's system architecture which would enable the network to determine deferred revenue using the IN method as discussed in Section 2.4.

POS accuracy

It is assumed that a POS delivers accurate sales figures based on actual transactions at the POS for use in the calculation of deferred revenue using the proposed method.

The existence of a VMS

It is assumed that there exists a VMS that performs IN airtime updates and IN data processing and that delivers the data that is transacted on to a BSS from where it can be used for the determination of deferred revenue using the proposed method of calculation.

4.2 Criteria

To select appropriate criteria for evaluation of the two methods used for the calculation of deferred revenue, MTN Group based in Johannesburg, South Africa was approached to share their Key Performance Indicators (KPIs). These KPIs are used for the evaluation of the subsidiary mobile phone networks in which MTN Group has a significant stake. Each of these networks is in a different country, but all are within emerging markets [26]. Of the 361 KPIs in use by MTN Group, all are grouped according to network business units or departments, which make them more manageable when reported on by networks, as key personnel from each department within a single MTN network only has to report on the KPIs assigned to their business unit. Also, of the 361, only a few are affected by the results posted after the calculation of deferred revenue. Specifically identified KPIs are used as criteria in our two models. Department heads / senior managers were interviewed to select the specific KPIs that would act as sub criteria within his/her own business unit.

One of MTN Group's subsidiary companies, namely MTNCI was selected as a target network for extracting specific quantitative and qualitative variables used in the evaluation of the model criteria. MTNCI as a subsidiary company of MTN Group was selected for being the most influential (other than MTN Group's Nigerian based operation) network in the WECA region [34]. Furthermore, according to MTN Group Chief Technical and Information Officer (CTIO) [34], the WECA region is an important business hub for the rest of Africa. This is due to the fact that the region is culturally quite diverse and has relatively large populations per representative country. Within the WECA region countries that MTN Group has operational mobile phone networks, these networks experience good growth. Positive growth effectively contributes to a significant portion of the profits retained through dividend payouts to MTN Group every year.

MTNCI's departments are evaluated on a monthly basis and appraised by MTN Group according to their overall performance based on the KPIs submitted by MTN Group [25]. Within MTNCI, a key personnel member from each department was invited to identify KPIs that are affected by deferred revenue. Typically sessions were held with the business unit owners or department heads, but in certain instances rather with the senior manager of a specific department, who has more insight into the operational environment when it comes to system interactions and reported results. As mentioned, the identified KPIs are then used as criteria. Summarized in Table 4.1 are the selected criteria used to determine the eventual weights assigned to each criterion used in the evaluation method.

Table 4.1 shows the main and sub criteria used in the model. Each department that has been assigned KPIs within MTNCI is seen as a main criterion. There exists within each of the main criteria, sub criteria represented by the variable KPIs identified by the key personnel member in that business unit. Each criterion, whether a main criterion or a sub criterion to a main criterion has to be carefully considered for its use in the model to determine (1) whether it has an impact on deferred revenue, (2) if that impact is relevant to the method used for calculation purposes and (3) to avoid duplication with other criteria in the same set, which can lead to double counting and skewing of the results.

Since mobile phone networks structure their organizations around the four core departments, namely that of commercial, finance, marketing and information systems (IS), these departments are used as representative of the four main criteria. However, below it is explained how the specific sub criteria represented in the final selection for each main criterion was selected for its absolute involvement by the department heads / senior managers representing each of the main criteria. This was done with the help of an expert, so that each of the sub criteria is representative of a consistent decision-making process within that department and contributes to the consistency of the main criteria without failure.

In Appendix B the complete list of sub criteria available for each department is given. In applying the three rules that apply for selection of the sub criteria to each main criterion, a key personnel member from each department filtered through the complete list of available sub criteria for his/her department, to determine if a direct or indirect effect on deferred revenue is realized.

Secondly, the key personnel members from their respective departments reviewed if the impact of change in the relevant sub criteria is relevant to the method used for the calculation of deferred revenue. This was done by analysing changes in deferred revenue, using each method independently of the other, with changes in each of the specific and remaining sub criteria. Thus, if an impactful positive change in deferred revenue, always corresponds with a change in the measured sub criteria and this applies for both methods used for the calculation of deferred revenue, then it is assumed the sub criteria is significant enough to select. The results of this exercise are exactly the same as the previous step of refinement. The reason for this is that both methods provide a mechanism for measuring a single variable, namely deferred revenue. Therefore, all remaining sub criteria, after removing the sub criteria that do not have a direct or indirect effect on deferred revenue, automatically applies to both methods for calculation, as both methods calculate the same thing. The objective is to determine which one is more effective. The results of these 2 steps are represented in Appendix C.

Finally, the identified personnel members from the respective departments analyzed each of the remaining sub criteria shown in Appendix C to determine if duplication is present. If duplication exists with other remaining sub criteria, it is removed from the list. In this exercise it is particularly interesting to look at the impact of sub criteria that has an indirect effect on deferred revenue. An indirect effect often affects another sub criterion that has a direct effect on the calculation of deferred revenue. The results of this third step are shown in Appendix D, but this is also the final list obtained and shown in Table 4.1. It is worth placing some focus on the selection process explained above, by motivating why the specific sub criteria were chosen to represent the main criteria in each instance. Only criteria that are affected by the two methods used in the evaluation process were used. There could either be a direct effect on a criterion as opposed to using one method for the calculation of deferred revenue to the other, or the influence could be indirect. In the second instance, typically the method used for the calculation of deferred revenue impacts on the criterion under review through another KPI. However, in all cases the sub criterion under review will have some sort of change in its reported value, being caused by the method used for calculation of deferred revenue.

Table 4.1: *Main and sub criteria, network business units, key personnel name and designation at MTNCI who performed identification and eventual weighting of criteria and criteria comparisons.*

Main criteria	Sub criteria	Business definition	Unit of measurement	Captured	Business unit	Business unit head	Designation
Service delivery	Days to deliver invoice	Average number of days to deliver invoices	Number	Monthly	Commercial	Nada Coulibaly	Customer Care Manager
Service delivery	Cost per productive hour	Average staff cost per productive hour	Currency	Monthly	Commercial	Nada Coulibaly	Customer Care Manager
Profitability	Pre paid total revenue	Total pre paid revenue before discounts	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Earnings before interest, tax, depreciation and amortization (EBITDA)	Earnings before interest, tax, depreciation and amortization	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Mobile handset and accessory sales	Revenue from selling handsets and accessories	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	License and management fees	Licence fee cost that have been capitalized during the period	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Operational Expenditure (OPEX)	OPEX related to all operations	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Bad debt provisioning	Movements in the provision for doubtful debt	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Taxes	Tax due for payment to the government	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Dealer commissions	Currency value of commissions paid out to MTNCI dealers during the period	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Profitability	Creditors and accounts payable	Currency value owed to creditors and other accounts	Currency	Monthly	Finance	Kadidjatou Keita	Senior Financial Manager
Marketability	Pre paid opening clients	Total number of clients connected to the network	Number	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Pre paid Average Revenue per User (ARPU)	Total airtime revenue divided by total MTNCI clients	Currency	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Total on network	Total number of outgoing seconds of billable usage on the network (MTNCI to MTNCI) per average subscriber	Number	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Total off network	Total number of outgoing seconds of billable usage off the network (MTNCI to other networks) per average subscriber	Number	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Operating income per pre paid client	Average operating income per pre paid client	Currency	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	OPEX per pre paid client	Average network OPEX per pre paid client	Currency	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Total pre paid clients	Active MTNCI clients	Number	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Pre paid market share	Total MTNCI pre paid clients as a percentage of all pre paid clients	%	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Marketability	Pre paid penetration rate	Total MTNCI pre paid clients as a percentage of total population	%	Monthly	Marketing	Dougbey Jovite	Senior Marketing Manager
Network optimization	Total pre paid outgoing billable traffic	Total number of pre paid outgoing seconds of billable usage on the network	Number	Monthly	IS	Eloge Beonao	Senior Network Operations Manager
Network optimization	Total pre paid incoming traffic	Total number of pre paid incoming seconds of usage on the network per average client	Number	Monthly	IS	Eloge Beonao	Senior Network Operations Manager
Network optimization	Pre paid billing system availability	Pre paid billing system availability	%	Monthly	IS	Eloge Beonao	Senior Network Operations Manager

4.2.1 Service delivery

The service delivery main criterion is representative of the commercial department within MTNCI. Networks find themselves in the service industry and servicing their clients' needs should come first. Lack of proper client services will see clients turn to competitors offering better service delivery. This is not only in the way that networks handle their clients' concerns, but also through the delivery of network coverage, call quality, availability of Value Added Services (VASs) and all other factors related to the delivery of the network product. The following sub criteria were selected to represent this main criterion and the reasons for their selection are given.

Days to deliver invoice

There exists a direct relationship between the paper trail, representing the efficiency of the sales process, and sales dealer payments made. This has a direct effect on deferred revenue, as sales made to sales dealers put large amounts of airtime in the field and the money for that airtime needs to be received, before it can be effectively included in the calculation process. Sometimes, money is still not received and the airtime sold is already being used. This skews deferred revenue tremendously. In reality it is not deferred revenue until the money for the service has been received. Furthermore, the method used for the calculation of deferred revenue has a direct impact on the speed and efficiency of the paper trail in place, which is most often presented in the form of a KPI as the number of days to deliver an invoice.

Cost per productive hour

The network cost for each productive man hour delivered is representative of all the factors contributing to service delivery. By including this single sub criterion all other financial KPIs, handled as sub criteria, has to be excluded from the service delivery main criterion as it will lead to double counting. The cost per productive hour is directly influenced by the method used for the calculation of deferred revenue.

4.2.2 Profitability

The profitability criterion is representative of the finance department within MTNCI. Without profit there would be no company. It is understandable that all new companies take some time before delivering a return on initial investment, but with a well established network, shareholders will only invest if profit and in turn healthy dividends are realized. The sub criteria selected to represent this main criterion are motivated below.

Pre paid total revenue

Pre paid total revenue is representative of the sales made of airtime within the pre paid market sector and where the airtime has already been used (if not yet used it is referred to as deferred revenue). Sales have a direct impact on deferred revenue, but only sales made within the pre paid environment. As explained earlier, revenues from post paid products do not have an effect on deferred revenue at all. Pre paid total revenue is affected by the systems in place to realize the revenue, so it is an important sub criterion for evaluation of the method used for calculation of deferred revenue.

Earnings Before Interest, Depreciation, Tax and Amortization (EBIDTA)

Good EBIDTA, rather than being a determinant to positive deferred revenue, is the result of well managed deferred revenue. EBIDTA is realized from deferred revenue. Deferred revenue becomes revenue and EBIDTA after the airtime contained in deferred revenue has been consumed. Careful consideration was given to double counting when considering EBIDTA and pre paid total revenue, but both have been included, as it is possible to have low EBIDTA, but still high pre paid total revenue, the two are not directly correlated. This typically occurs in countries where the pre paid subscriber market is quite small and revenue is greatly generated from a post paid subscriber population.

Mobile handset and accessory sales

The sale of handsets and accessories has a double impact on deferred revenue. Handset sales normally contain a small portion of airtime, but the pre paid total revenue sub criterion takes care of this direct contributing factor. Rather mobile handset and accessory sales are included under the profitability list for its indirect impact on deferred revenue. It is representative of how well the network is performing within the pre paid environment, as post paid packages normally include mobile handsets and accessories. Good mobile handset and accessory sales will have a positive effect on deferred revenue.

License and management fees

These fees are a reflection of the amount of effort, in monetary terms, spent on the promotion of systems and processes that better overall performance within the network. Improved performance contributes positively to deferred revenue and the calculation thereof. Furthermore, different methods used also contribute different amounts of license and management fees to the grand total.

Operational Expenditure (OPEX)

Other than license and management fees, OPEX represents expenditure on products used in the generation of income/revenue. Positive OPEX is a good sign that it is going well with the network and that more positive deferred revenue is to be realized.

Bad debt provisioning

Bad debt provisioning has a very negative impact on deferred revenue and if more bad debt is being provisioned, it means sales dealers have problems paying and that it is not going well with the control of processes impacting on deferred revenue. An effective system for the calculation of deferred revenue should also control bad debts and minimise bad debt write-offs.

Taxes

Deferred revenue and the calculation thereof have a critical impact on taxes. Taxes is therefore a good measurement tool to determine if the system calculating deferred revenue is performing well. Income tax for example is only charged on the realization of revenue. While money for services has been received, but that service has not yet been rendered, the income is seen as deferred revenue and non taxable. It becomes taxable once the service has been rendered and deferred revenue becomes revenue. Taxes are also representative of deferred tax and it is realized more or less in the same way that deferred revenue is realized.

Dealer commissions

Low dealer commissions and increased sales is a determinant of how good the product is. An improved product is the result of an improved organization and the efficiency of the processes within that organization, such as the systems that impact on the calculation of deferred revenue.

Creditors and accounts payable

Large creditors' accounts are money that still needs to be received. This is a direct result of payment processes not being managed efficiently. More efficient management of the internal payment processes will result in acceptable creditor balances. As mentioned before, money needs to accrue in the mobile phone network's account before it can be factored into the deferred revenue calculation.

4.2.3 Marketability

The marketing department is fundamental to the success of any network. Without products being properly marketed, a mobile phone network will not succeed in the highly competitive telecommunications industry. A network has to be marketable to attain market share.

Therefore to retain clientele as well as gain new clients through continuous growth, effective marketing strategies need to be implemented. Marketing is one of the most difficult criteria to benchmark, as it is difficult to quantify marketing expenditure. Marketability refers to the network's capability to effectively launch new services and pricing strategies into an ever changing telecommunications environment. The following sub criteria were selected to represent this main criterion and for the reasons given.

Pre paid opening clients

Well performing networks have a large number of clients and in emerging markets that means a large number of pre paid clients. Pre paid opening clients refer to the opening balance of the total amount of pre paid subscribers to a mobile phone network on the specified date the measurement is done.

Pre paid Average Revenue Per User (ARPU)

A higher ARPU compared to an ARPU from the previous month, means clients are showing increased spending patterns in that specific month. This is a result of satisfied clients and improved economic conditions. A high ARPU also results in high deferred revenues, leading to high revenues.

Total on network

This represents the total amount of network traffic generated on MTNCI's network and their network only. Again here it is found that successful systems and processes lead to positive network traffic on MTNCI's network itself.

Total off network

This represents the total amount of network traffic generated from MTNCI's network to other phone networks. This could be international calls, calls to fixed line operators or calls made to other mobile phone networks. Traffic is either generated on MTNCI's network or off of MTNCI's network. Both are directly affected by improved systems processes, but at different sides of the spectrum.

Operating income per pre paid client

This is a reflection of income received from operations that affect the pre paid subscribers/clients. This income can be generated through the sale of handsets, accessory, airtime and a whole lot more. It is therefore an average of sales that take place in support of the mobile phone network's pre paid clients. Therefore an indication of how well marketing is performing and how good the tools are that allow the personnel to accomplish this.

OPEX per pre paid client

OPEX has already been discussed under the profitability main criterion. OPEX per pre paid client is an indication of how marketable the mobile phone network is.

Total pre paid clients

This is a collective indication of where the mobile phone network is going and how efficient they are in what they do within the pre paid market environment of a country's total population of pre paid clients.

Pre paid market share

Pre paid market share is a percentage that gives the mobile phone network an indication of how well it is performing in comparison to its competitors in the country. Sometimes competitors are also doing well. This is normally due to positive environmental factors contributing to good growth. If mobile phone networks outgrow their competitors it is normally an indication of a mobile phone network being more effective and efficient than its competitors and vice versa.

Pre paid penetration rate

A country's penetration rate is an indication of how much further a network can grow. If the penetration rate is high, there is not much more growth opportunity left in that country and mobile phone networks should start focussing on acquiring additional subscribers/clients from their competitors. Subscribers moving from one network to another are normally referred to as churning from the one to the other. When a lot of churning away from the network is taking place, as a result of a high penetration rate, this means the network is doing something wrong with regards to its service delivery.

4.2.4 Network optimization

Last, but not least, of the four main criteria is network optimization. The network optimization criterion is represented within MTNCI, by the business intelligence department, networking department, infrastructure department and one or two other smaller business units, all within the department collectively known as the IS department. It is required that networks manage their infrastructure in such a way as to optimize the use thereof. It would be senseless and a waste of good resources and money if a network does not grow with its clientele. Just as the network should not be over geared, it should not be under geared either. This main criterion's sub criteria that were selected are also elaborated on below.

Total pre paid outgoing billable traffic

Although traffic volumes have already been discussed to great length with regards to the marketability main criterion, this sub criterion is only concerned with billable traffic. Billable traffic (as opposed to unbilled traffic) is traffic that actually reaches the billing platform where rating of the calls, SMSs and data takes place. Unbilled traffic is traffic that never reaches the billing platform (or is simply not billed because of problems with the billing platform) due to systems within the network environment not performing well. Good billable traffic volumes are a result of positive mobile phone network management and the use of tools that help the network in obtaining it.

Total pre paid incoming traffic

Incoming traffic is a result of calls originating somewhere else. Mobile phone networks charge each other a fee for terminating the other's calls on its network. The more incoming traffic a mobile phone network has, the better it is for revenues and the well-being of the organization. Calls can also only be terminated if a positive network environment exists.

Billing system availability (retail pre paid)

The availability of the billing system is probably one of the most impactful sub criteria mentioned here. So many factors depend on a healthy billing system. Rating, charging and payments to mention but a few. The billing system is the heart of any mobile phone network's environment without which the mobile phone network cannot make money. The availability of the pre paid billing system is also respected and a lighter load is imposed on an efficient system used for the calculation of deferred revenue.

There exist a causal relationship between each main criterion and the remaining other three. Without marketability, there can be no profitability. Without network optimization, there can be no service delivery and so forth.

4.3 Obtaining synthesis values for criteria when using the AHP

After the criteria for use in the AHP model have been defined, weights need to be assigned to all of the criteria in use. As there are sub criteria involved which influences the main criteria, weighting of the sub criteria will be done first, then the main criteria will be weighted and finally the synthesis values for each sub criterion will be determined. Synthesis values are relative weights obtained for sub criteria, by multiplying each sub criterion weight with the main criterion weight it is grouped under [11]. This is done so that all sub criteria reflect the relative importance of the department (main criterion) it has been assigned to. Scoring and consistency of the two methods with respect to these criteria follows in Section 4.4 and Section 4.5 respectively.

Suppose that there exists n_l sub criteria in a specific main criterion l. The key personnel members from each department started by constructing a so-called $n \times n$ pairwise comparison matrix which will be an indication of how much more important one criterion is to another. To construct such a matrix a value scale first needs to be identified to use as interpretation for the pairwise comparison of matrix elements. For example the entry in row i and column j of a pairwise comparison matrix L_l (l_{ij}) indicates how much more important criterion i is than criterion j. Table 4.2 represents such a scale. In this instance a 9-point scale was used to transform the verbal judgements made into numerical quantities representing the values of l_{ij} [11].

Value of l_{ij}	**Interpretation**
1	Criteria *i* and *j* are of equal importance
3	Criteria *i* is weakly more important than criteria *j*
5	Experience and judgement indicate that criteria *i* is strongly more important than criteria *j*
7	Criteria *i* is very strongly or demonstrably more important than criteria *j*
9	Criteria *i* is absolutely more important than criteria *j*
2,4,6,8	Intermediate values for the above criteria interpretations

Table 4.2: *Interpretation of entries in a pairwise comparison matrix L_l [20].*

Values are assigned for each pairwise comparison between two sub criteria in a specific business unit (department) by a key personnel member, normally a senior manager of the particular business unit at MTNCI, under the guidance of an expert. The resulting pairwise comparison matrix L_A for the service delivery sub criteria are given in Table 4.3.

CRITERIA MATRIX (L_A)	A1	A2
Days to deliver invoice (A1)	1.0000	3.0000
Cost per productive hour (A2)	0.3333	1.0000

Table 4.3: *Pairwise comparison matrix L_A for the service delivery sub criteria.*

The same exercise was repeated to deliver the pairwise comparison matrix L_B for the profitability sub criteria as given in Table 4.4.

CRITERIA MATRIX (L_B)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Pre paid total revenue (B1)	1.00	1.00	5.00	7.00	6.00	4.00	7.00	4.00	3.00
EBITDA (B2)	1.00	1.00	4.00	6.00	5.00	3.00	6.00	3.00	2.00
Mobile handset and accessory sales (B3)	0.20	0.25	1.00	2.00	4.00	2.00	4.00	3.00	2.00
License and management fees (B4)	0.14	0.17	0.50	1.00	1.00	1.00	0.50	3.00	3.00
OPEX (B5)	2.00	1.00	0.20	1.00	1.00	1.00	1.00	1.00	1.00
Bad debt provisioning (B6)	0.25	0.33	0.50	1.00	1.00	1.00	1.00	1.00	1.00
Taxes (B7)	0.14	0.17	0.25	2.00	1.00	1.00	1.00	1.00	1.00
Dealer commissions (B8)	0.25	0.33	0.33	0.33	1.00	1.00	1.00	1.00	1.00
Creditors and accounts payable (B9)	0.33	0.50	0.50	0.33	1.00	1.00	1.00	1.00	1.00

Table 4.4: *Pairwise comparison matrix L_B for the profitability sub criteria.*

Table 4.5 contains the values obtained in a similar way for the pairwise comparisons done with regards to the marketability sub criteria, namely matrix L_C. In Table 4.6 matrix L_D contains the pairwise comparisons performed on the network optimization sub criteria. Finally pairwise comparison of the main criteria were performed and these are shown in Table 4.7 as matrix L_E. The pairwise comparisons of the main criteria were done in conjunction with MTNCI department heads / senior managers under the guidance of an expert. The Revenue Assurance (RA) department at MTNCI also contributed greatly to this part of the project by providing valuable input relating to the calculation of deferred revenue. The field of RA and the effect that a RA department of an organization have, are relatively

new to mobile phone networks, but they perform critical tasks within the organizational framework without which no mobile phone network can operate efficiently [28]. Each department head / senior manager assigned a value to each pairwise comparison between two main criteria. The values assigned were then summed and divided by four to form an average between the values assigned by the various department heads / senior managers to each pairwise comparison. The averaged values were used to populate matrix L_E as represented in Table 4.7.

CRITERIA MATRIX (L_C)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Pre paid opening clients (C1)	1.00	0.50	7.00	6.00	0.50	7.00	1.00	1.00	4.00
ARPU (C2)	2.00	1.00	5.00	4.00	1.00	8.00	1.00	4.00	6.00
Total on network (C3)	0.14	0.20	1.00	0.25	5.00	0.67	0.33	0.25	0.50
Total off network (C4)	0.17	0.25	4.00	1.00	0.20	3.00	3.00	3.00	3.00
Operating income per pre paid client (C5)	2.00	1.00	0.20	5.00	1.00	7.00	1.00	1.00	1.00
OPEX per pre paid client (C6)	0.14	0.13	1.50	0.33	0.14	1.00	0.33	0.25	0.50
Total pre paid clients (C7)	1.00	1.00	3.00	0.33	1.00	3.00	1.00	0.50	1.00
Pre paid market share (C8)	1.00	0.25	4.00	0.33	1.00	4.00	2.00	1.00	3.00
Pre paid penetration rate (C9)	0.25	0.17	2.00	0.33	1.00	2.00	1.00	0.33	1.00

Table 4.5: *Pairwise comparison matrix L_C for marketability sub criteria.*

CRITERIA MATRIX (L_D)	D1	D2	D3
Total pre paid outgoing billable traffic (D1)	1.0000	9.0000	5.0000
Total pre paid incoming traffic (D2)	0.1111	1.0000	0.2000
Pre paid billing system availability (D3)	0.2000	5.0000	1.0000

Table 4.6: *Pairwise comparison matrix L_D for network optimization sub criteria.*

CRITERIA MATRIX (L_E)	E1	E2	E3	E4
Service delivery (E1)	1.0000	0.1429	0.2000	3.0000
Profitability (E2)	7.0000	1.0000	5.0000	9.0000
Marketability (E3)	5.0000	0.2000	1.0000	5.0000
Network optimization (E4)	0.3333	0.1111	0.2000	1.0000

Table 4.7: *Pairwise comparison matrix L_E for the main criteria.*

Each of the matrices represented by Table 4.3 to Table 4.7 (i.e. matrix L_A through to matrix L_E) are normalized by dividing each entry in column j of a matrix by the sum of the

entries in column *j*. This yields a new set of matrices $L_{A,\text{norm}}$ through to $L_{E,\text{norm}}$, in which the sum of the entries in each column for any of the matrices L_A through to L_E equals 1. The resulting normalized matrices are

$$L_{A,\text{norm}} = \begin{pmatrix} 0.7500 & 0.7500 \\ 0.2500 & 0.2500 \end{pmatrix},$$

$$L_{B,\text{norm}} = \begin{pmatrix} 0.1880 & 0.2105 & 0.4071 & 0.3387 & 0.2857 & 0.2667 & 0.3111 & 0.2222 & 0.2000 \\ 0.1880 & 0.2105 & 0.3256 & 0.2903 & 0.2381 & 0.2000 & 0.2667 & 0.1667 & 0.1333 \\ 0.0376 & 0.0526 & 0.0814 & 0.0968 & 0.1905 & 0.1333 & 0.1778 & 0.1667 & 0.1333 \\ 0.0269 & 0.0351 & 0.0407 & 0.0484 & 0.0476 & 0.0667 & 0.0222 & 0.1667 & 0.2000 \\ 0.3760 & 0.2105 & 0.0163 & 0.0484 & 0.0476 & 0.0667 & 0.0444 & 0.0556 & 0.0667 \\ 0.0470 & 0.0702 & 0.0407 & 0.0484 & 0.0476 & 0.0667 & 0.0444 & 0.0556 & 0.0667 \\ 0.0269 & 0.0351 & 0.0204 & 0.0968 & 0.0476 & 0.0667 & 0.0444 & 0.0556 & 0.0667 \\ 0.0470 & 0.0702 & 0.0271 & 0.0161 & 0.0476 & 0.0667 & 0.0444 & 0.0556 & 0.0667 \\ 0.0627 & 0.1053 & 0.0407 & 0.0161 & 0.0476 & 0.0667 & 0.0444 & 0.0556 & 0.0667 \end{pmatrix},$$

$$L_{C,\text{norm}} = \begin{pmatrix} 0.1298 & 0.1113 & 0.2527 & 0.3412 & 0.0461 & 0.1963 & 0.0938 & 0.0882 & 0.2000 \\ 0.2597 & 0.2226 & 0.1805 & 0.2275 & 0.0922 & 0.2243 & 0.0938 & 0.3529 & 0.3000 \\ 0.0185 & 0.0445 & 0.0361 & 0.0142 & 0.4611 & 0.0187 & 0.0313 & 0.0221 & 0.0250 \\ 0.0216 & 0.0557 & 0.1444 & 0.0569 & 0.0184 & 0.0841 & 0.2813 & 0.2647 & 0.1500 \\ 0.2597 & 0.2226 & 0.0072 & 0.2844 & 0.0922 & 0.1963 & 0.0938 & 0.0882 & 0.0500 \\ 0.0185 & 0.0278 & 0.0542 & 0.0190 & 0.0132 & 0.0280 & 0.0313 & 0.0221 & 0.0250 \\ 0.1298 & 0.2226 & 0.1083 & 0.0190 & 0.0922 & 0.0841 & 0.0938 & 0.0441 & 0.0500 \\ 0.1298 & 0.0557 & 0.1444 & 0.0190 & 0.0922 & 0.1121 & 0.1875 & 0.0882 & 0.1500 \\ 0.0325 & 0.0371 & 0.0722 & 0.0190 & 0.0922 & 0.0561 & 0.0938 & 0.0294 & 0.0500 \end{pmatrix},$$

$$L_{D,\text{norm}} = \begin{pmatrix} 0.7627 & 0.6000 & 0.8065 \\ 0.0847 & 0.0667 & 0.0323 \\ 0.1525 & 0.3333 & 0.1613 \end{pmatrix} \text{ and}$$

$$L_{E,\text{norm}} = \begin{pmatrix} 0.0750 & 0.0983 & 0.0313 & 0.1667 \\ 0.5250 & 0.6878 & 0.7813 & 0.5000 \\ 0.3750 & 0.1376 & 0.1563 & 0.2778 \\ 0.0250 & 0.0764 & 0.0313 & 0.0556 \end{pmatrix}.$$

For each criterion i a weight needs to be estimated. The weight for criterion i in matrix L_l is depicted by $w_{l,i}$ which is simply the average of the entries in row i of matrix L_l. Table 4.8 summarizes the results of this step for every sub criterion within the specified business unit as well as for the main criteria ($L_{E,\text{norm}}$) associated with the specific business units. In Table 4.8 a synthesis value for each sub criterion is obtained by multiplying the sub criterion weight obtained in the last step with the main criterion weight also obtained during the previous step.

Main criteria	Main criteria weight	Sub criteria code	Sub criteria to main criteria	Sub-criteria weight	Synthesis value
Service delivery	0.09279	A1	Days to deliver invoice	0.7500	0.0696
		A2	Cost per productive hour	0.2500	0.0232
Profitability	0.62351	B1	Pre paid total revenue	0.2700	0.1683
		B2	EBITDA	0.2244	0.1399
		B3	Mobile handset and accessory sales	0.1189	0.0741
		B4	License and management fees	0.0727	0.0453
		B5	Operational Expenditure (OPEX)	0.1036	0.0646
		B6	Bad debt provisioning	0.0541	0.0338
		B7	Taxes	0.0511	0.0319
		B8	Dealer commissions	0.0490	0.0306
		B9	Creditors and accounts payable	0.0562	0.0350
Marketability	0.23665	C1	Pre paid opening clients	0.1622	0.0384
		C2	Pre paid ARPU	0.2171	0.0514
		C3	Total on network	0.0746	0.0177
		C4	Total off network	0.1197	0.0283
		C5	Operating income per pre paid client	0.1438	0.0340
		C6	OPEX per pre paid client	0.0266	0.0063
		C7	Total pre paid clients	0.0938	0.0222
		C8	Pre paid market share	0.1088	0.0257
		C9	Pre paid penetration rate	0.0536	0.0127
Network optimization	0.04706	D1	Total pre paid outgoing billable traffic	0.7231	0.0340
		D2	Total pre paid incoming traffic	0.0612	0.0029
		D3	Pre paid billing system availability	0.2157	0.0102

Table 4.8: *Weights assigned to main and sub criteria for calculation of the sub criteria synthesis values.*

4.4 Finding the score of an alternative for each criterion using the AHP

It is required to derive at a score for both alternatives in terms of all criteria used. For ease of explanation reference will be made to 2 alternatives here as *System 1* (historical or IN method for the calculation of deferred revenue) and *System 2* (proposed method for the calculation of deferred revenue). Each department head / senior manager constructed a pairwise comparison matrix for each criterion in which the rows and columns are the two alternatives. The 23 2×2 matrices constructed by the various departments' personnel are shown in Appendix E. It may be seen that *System 1* and *System 2* are weighted against each other for each criterion identified in Section 4.2. As done in Section 4.3, a normalized matrix for each of the criteria matrices is computed. Each row within each normalized criteria matrix is then averaged to determine the specific method's score for the particular criteria. Finally, these scores are each multiplied with the synthesis value for the specific criterion as identified in Table 4.8, and the resulting values are added to arrive at the final score for both methods to determine deferred revenue.

Table 4.9 shows the results obtained from multiplying the synthesis value of each criterion with the score for *System 1* and *System 2* with regards to the specific criterion. For example 0.0087 is obtained as the *System 1* weighted score for the days to deliver invoice criterion. Finally both columns are added to obtain the final score for *System 1* and *System 2*. The following results summarize the scores obtained from implementation of the model in each weighting instance. In the first instance each department only compare the sub criteria applying to its department independently. A final score of 0.3188 for the method as implemented by *System 1* and 0.6812 for the method as implemented by *System 2*, were obtained. This indicates a preference in the deferred revenue calculated through the use of a BSS, as opposed to when calculated not using a BSS at all. The specific sub criteria within each main criterion (business unit/department) were selected from the complete list of KPIs provided since quantifiable changes can be noticed in these sub criteria when switching from one method for calculation of deferred revenue to the other [15]. It is not that deferred revenue so much impacts on the criteria; it is rather that the BSS implemented impacts on the criteria that in turn impacts on deferred revenue and the effectiveness thereof.

Business unit/department senior managers assigned the comparison values that apply to sub criteria and synthesis values were calculated once the main criteria were weighted. Having secured the sources of information that are impacted on through the implementation of a BSS and identifying the positive results that this has on the calculation of deferred revenue, an estimate of just how well deferred revenue were reported on through the use of the BSS can be determined. It should be clear that the implementation of a BSS increases the effectiveness of calculated deferred revenue considerably.

Criteria	System 1	System 2
Days to deliver invoice	0.0087	0.0609
Cost per productive hour	0.0058	0.0174
Pre paid total revenue	0.0281	0.1403
EBITDA	0.0350	0.1049
Mobile handset and accessory sales	0.0371	0.0371
License and management fees	0.0340	0.0113
OPEX	0.0484	0.0161
Bad debt provisioning	0.0068	0.0270
Taxes	0.0046	0.0273
Dealer commissions	0.0051	0.0255
Creditors and accounts payable	0.0088	0.0263
Pre paid opening clients	0.0048	0.0336
ARPU	0.0086	0.0428
Total on network	0.0088	0.0088
Total off network	0.0142	0.0142
Operating income per pre paid client	0.0170	0.0170
OPEX per pre paid client	0.0031	0.0031
Total pre paid clients	0.0111	0.0111
Pre paid market share	0.0129	0.0129
Pre paid penetration rate	0.0063	0.0063
Total pre paid outgoing billable traffic	0.0043	0.0298
Total pre paid incoming traffic	0.0005	0.0024
Pre paid billing system availability	0.0051	0.0051
FINAL SYSTEM SCORES	**0.3188**	**0.6812**

Table 4.9: *Results obtained from multiplying criteria synthesis values with the system score for that criterion and final scores obtained for System 1 (historical or IN method) and System 2 (proposed method) for the calculation of deferred revenue.*

4.5 Checking for consistency when using the AHP

The pairwise comparison values have to be checked for consistency to determine if the various key personnel members were consistent in their assignment of sub criteria comparisons measuring the individual criteria importance up against all other sub criteria in the same business unit. The department head's / senior manager's assignment of comparisons amongst the main criteria is checked for consistency by applying the same procedure as applied for the sub criteria. Finally, the 23 comparison matrices of the two systems with regards to each of the 23 sub criteria are checked for consistency. Consistency checking is done by using the Consistency Ratio (CR) proposed by Saaty and the Geometric Consistency Index (GCI) proposed by Crawford and Williams. These two are the most used measures for consistency checking [2].

4.5.1 Using the CR for consistency checking

Defining the consistency of a positive reciprocal pairwise comparison matrix, L_l (l_{ij}), as the cardinal transitivity between judgements, that is to say, $l_{ij}l_{jk} = l_{ik}$, for $i, j, k = 1,...,n_l$, Saaty proposed the use of the CR_l [1]. The CR_l for each pairwise comparison matrix is calculated by the following four-step procedure for validation of the decision-maker's comparisons [11]. For each matrix L_A through to L_E the following is done.

Step 1: Compute $L_l\boldsymbol{w}_l^T$ where L_l is the relevant comparison matrix and the n_l-dimensional row vector $\boldsymbol{w}_l$ denotes the estimate of the weights for the sub criteria in the specific department (main criterion) l.

Step 2: For each matrix L_l (i.e. $l = A, B, C, D, E$) compute the value:

$$\alpha_l = \frac{1}{n_l}\sum_{i=1}^{n_l} \ (i\text{th entry in } L_l\boldsymbol{w}_l^T)/(i\text{th entry in } \boldsymbol{w}_l^T) \ .$$

These values to compute α_l for the matrices L_A, L_B , L_C, L_D and L_E are given in Table 4.10. Computing α_A for matrix L_A yields $\alpha_A = 2.0000$. Similarly, $\alpha_B = 9.0789$, $\alpha_C = 10.3783$, $\alpha_D = 3.1200$ and $\alpha_E = 4.3068$.

Matrix	**Criteria**		
	Service delivery	**i^{th} entry of $L_A w_A^T$**	**(i^{th} entry of $L_A w_A^T$)/$w_{A,i}$**
L_A	Days to deliver invoice	1.5000	2.0000
L_A	Cost per productive hour	0.5000	2.0000
	Profitability	**i^{th} entry of $L_B w_B^T$**	**(i^{th} entry of $L_B w_B^T$)/$w_{B,i}$**
L_B	Pre paid total revenue	3.1582	11.6969
L_B	EBITDA	2.6525	11.8225
L_B	Mobile handset and accessory sales	1.3609	11.4467
L_B	License and management fees	0.7071	9.7272
L_B	Operational expenses (OPEX)	1.1749	11.3436
L_B	Bad debt provisioning	0.5885	10.8705
L_B	Taxes	0.5651	11.0562
L_B	Dealer commissions	0.5202	10.6069
L_B	Creditors and accounts payable	0.5999	10.6763
	Marketability	**i^{th} entry of $L_C w_C^T$**	**(i^{th} entry of $L_C w_C^T$)/$w_{C,i}$**
L_C	Pre paid opening clients	2.1204	13.0760
L_C	Pre paid ARPU	2.4692	11.3758
L_C	Total on network	0.3404	4.5618
L_C	Total off network	1.3501	11.2813
L_C	Operating income per pre paid client	1.6100	11.1945
L_C	OPEX per pre paid client	0.3158	11.8917
L_C	Total pre paid clients	0.9376	9.9991
L_C	Pre paid market share	1.1313	10.4006
L_C	Pre paid penetration rate	0.5158	9.6277
	Network optimization	**i^{th} entry of $L_D w_D^T$**	**(i^{th} entry of $L_D w_D^T$)/$w_{D,i}$**
L_D	Total pre paid outgoing billable traffic	2.3527	3.2538
L_D	Total pre paid incoming traffic	0.1847	3.0169
L_D	Pre paid billing system availability	0.6665	3.0894
	Main criteria	**i^{th} entry of $L_E w_E^T$**	**(i^{th} entry of $L_E w_E^T$)/$w_{E,i}$**
L_E	***Service delivery***	0.3704	3.9913
L_E	***Profitability***	2.8798	4.6187
L_E	***Marketability***	1.0606	4.4818
L_E	***Network optimization***	0.1946	4.1354

Table 4.10: *The i^{th} entry of $L_l \mathbf{w}_l^T$ and the (i^{th} entry of $L_l \mathbf{w}_l^T$)/$w_{l,i}$ for each of the criteria matrices L_A through to L_E.*

Step 3: Compute the consistency index (CI_l) for each comparison matrix L_l as follows:

$$CI_l = \frac{\alpha_l - n_l}{n_l - 1} \quad .$$

Computing CI_A for L_A yields CI_A = 0.0000. Similarly, CI_B = 0.2534, CI_C = 0.1723, CI_D = 0.0600 and CI_E = 0.1023.

Step 4: The CR_l is calculated through comparison of CI_l to the so-called random index (RI_l) for the appropriate value of n_l.

For a perfectly consistent decision-maker, the i^{th} entry in $L_l \boldsymbol{w}_l^T = n_l$, which is also the i^{th} entry of $\boldsymbol{w}_l^T$. This implies that a perfectly consistent decision-maker has $CI_l = 0$. The values of RI_l give the average value of CI_l if the entries in the matrix L_l were chosen at random [45]. These values of RI_l are given in Table 4.11.

To give useful estimates of the weights for the decision-maker's criteria it is necessary that the following conditions must hold as well:

- For all i in matrix L_l, it is necessary that $l_{ii} = 1$.
- Furthermore, if $l_{ij} = m$, then for consistency it is necessary that $l_{ji} = 1/m$.

n_l	RI_l
2	0.0000
3	0.5800
4	0.9000
5	1.1200
6	1.2400
7	1.3200
8	1.4100
9	1.4500

Table 4.11: *RI_l values for various values of n_l [20].*

If CI_l is sufficiently small, the business unit's decision-maker made comparisons that are probably consistent enough to give useful estimates of the weights for his or her criteria. If $CI_l/RI_l \lesssim 0.1$ the degree of consistency is satisfactory, but if $CI_l/RI_l \gtrsim 0.1$ serious inconsistency may exist, and the AHP may not yield meaningful results [45]. The ratio CI_l/RI_l is referred to as the CR_l. The CR_l values for matrix L_A through to L_E are given in Table 4.12.

l	**Matrix**	**CR_l**
A	L_A	0.0000
B	L_B	0.1748
C	L_C	0.1189
D	L_D	0.1035
E	L_E	0.1136

Table 4.12: *The CR_l for the pairwise comparison matrices done by department heads / senior managers on sub criteria assigned to their own business units / departments.*

By observing the values in the criteria matrices in Tables 4.3, 4.4, 4.5, 4.6 and 4.7, as well as the CR_l values in Table 4.12, it is concluded that all three conditions for consistency above are approximately met for the criteria matrices.

It is noted that the value obtained for the CR_l, when pairwise comparisons were done by the finance department's key personnel member on all the sub criteria belonging to that department, is quite a bit greater than 0.1. Even though this value of 0.1748 was obtained, it was decided to leave the pairwise comparison weightings for this department as is. Rather it is shown in Section 4.6 that our model maintains consistency, even if a small amount of inconsistent input is present, as this does not have an effect on the final scores. In the next section, the threshold that makes the consistency measure in the AHP operative and that enables the fixing of a tolerance level with an interpretation analogous to that considered for the CR_l, is calculated.

4.5.2 Using the GCI as a consistency measure

Given a pairwise comparison matrix, L_l with $i, j = 1,...,n_l$, and the vector of priorities, $\boldsymbol{\omega}_l$, the GCI_l is defined as

$$GCI_l = \frac{2}{(n_l - 1)(n_l - 2)} \sum_{i<j} (\log e_{ij} - \log 1)^2,$$

where $e_{ij} = l_{ij} w_{l,j} / w_{l,i}$ is the error obtained when the ratio $\omega_{l,i}/\omega_{l,j}$ is approximated by l_{ij} [1].

In Table 4.13 the results when computing GCI_l for each of the matrices L_B through to L_E are shown. The GCI_l for each matrix is interpreted by comparing it to the approximated thresholds as proposed in Table 4.14 [1]. Table 4.14 shows the corresponding CR_l thresholds for the GCI_l computed for pairwise comparison matrices with $n_l = 3$, $n_l = 4$ and $n_l > 4$ and matrix L_A has only 2 sub criteria and therefore no threshold exists for its GCI_l to be measured against. When the value of the GCI_l for a specific pairwise comparison matrix, containing a specified number of sub criteria, is greater than the corresponding threshold in Table 4.14, there exists some inconsistency and this would normally need to be addressed through modification of the assigned weights to the specific pairwise comparison matrix being measured for consistency [1].

By observing the values in Tables 4.13 and 4.14 and using the GCI_l computed for L_B in Table 4.13 as an example, it is shown in Table 4.14 that the GCI_l for L_B, where $n_l > 4$, corresponds to a value for CR_l between 0.01 and 0.05.

l	***Matrix***	***GCI_l***
B	L_B	0.0749
C	L_C	0.1726
D	L_D	0.0672
E	L_E	0.0749

Table 4.13: *The obtained results when computing GCI_l for each matrix L_B through to L_E.*

Through further comparison it can be stated that all the pairwise comparison matrices L_B through to L_E are consistent in their weightings, as through comparison it is clear that all pairwise comparison matrices realise a GCI_l threshold value corresponding to $0.01 < CR_l < 0.05$. This implies, that according to the GCI_l, all pairwise comparison matrices are at least below the 5% threshold for inconsistency.

CR_l	**0.01**	**0.05**	**0.1**	**0.15**
GCI_l (n_l = 3)	0.0314	0.1573	0.3147	0.4720
GCI_l (n_l = 4)	0.0352	0.1763	0.3526	0.5289
GCI_l (n_l > 4)	~0.037	~0.185	~0.370	~0.555

Table 4.14: *The approximated thresholds for the GCI_l.*

4.6 Departmental dependency and consistency

As opposed to each department under review only weighting the criteria that applies to that specific department, each department under review was asked to weight all of the criteria in use. This was done in an attempt to form a sensitivity analysis of the AHP model as discussed in this chapter. Having shown that all sub criteria were carefully selected from the list of available KPIs used, to avoid double counting and other issues related to inconsistent input, which would render the model to be skewed, the expanded evaluation of the model will still only include these 23 criteria. For an elaborative data presentation, refer to the digital contents of the compact disk as explained in Appendix A or reference Appendix F through to Appendix I for relevant data sets and results obtained.

The key personnel member of each department is asked to evaluate the entire set of 23 available sub criteria regardless of what department he/she represents. The personnel member then compares all sub criteria within a department independently from the other departments. The same weights obtained for the main criteria are used in order to obtain the synthesis values for each of the sub criterion. This can be done, because the main criteria were weighted by a management committee of MTNCI representatives from each department and

their respective figureheads at MTN Group who represent the wellbeing of MTN Group stakeholders.

4.6.1 Weighting according to the commercial department (service delivery)

In Appendix F the normalized pairwise comparison matrices drawn up by the key personnel member of the commercial department at MTNCI for all 23 sub criteria within their respective main criterion under review, are shown. In Appendix F the service delivery normalized sub criteria matrix is presented in Table F.1 (matrix L_{A1}), profitability normalized sub criteria matrix in Table F.2 (matrix L_{B1}), marketability normalized sub criteria matrix in Table F.3 (matrix L_{C1}) and network optimization normalized sub criteria matrix in Table F.4 (matrix L_{D1}). The normalized matrix entries are obtained as before. Note that $L_{A1} = L_{A,\text{norm}}$. The normalized matrix is validated by assuring that the sum of entries in each column is one.

In Table 4.15 the weights and synthesis values obtained for each of the sub criterion as weighted by the commercial department's key personnel member are summarized. As before, weights are obtained by averaging each row, representing a single sub criterion, in the specific normalized matrix. The set of sub criteria weights has to be checked for consistency to determine if the commercial department was consistent in its assignment of sub criteria weights. Consistency checking was done according to the steps described in Section 4.5 and from Table 4.24 it can be seen that the $CR_l \leq 0.1$ half the time. As further motivation, the GCI_l for each of the pairwise comparison matrices as weighted by the commercial department was also calculated and it is noted from Tables 4.13 and 4.23 that according to the GCI_l, all pairwise comparison matrices are at least below the 5% threshold for inconsistency. Furthermore,

- for all i in the commercial department's pairwise comparison matrix L, $l_{ii} = 1$ for $L = L_{B1}, L_{C1}$ and L_{D1}.
- The condition that if $l_{ij} = p$, then $l_{ji} = 1/p$, is also satisfied for all the commercial department's pairwise comparison matrices.

The key personnel member of each department was also asked to compare the two alternatives (*System 1* and *System 2*) with respect to each criterion. The results of this step are

summarized in Table 4.16. According to the pairwise comparison done by the commercial department *System 2* is also preferred to *System 1*.

Main criteria	Main criteria weight	Sub criteria code	Sub criteria to main criteria	Sub-criteria weight	Synthesis value
Service delivery	0.09279	A1	Days to deliver invoice	0.7500	0.0696
		A2	Cost per productive hour	0.2500	0.0232
Profitability	0.62351	B1	Pre paid total revenue	0.2058	0.1283
		B2	EBITDA	0.1535	0.0957
		B3	Mobile handset and accessory sales	0.1339	0.0835
		B4	License and management fees	0.0445	0.0278
		B5	Operational expenses (OPEX)	0.0428	0.0267
		B6	Bad debt provisioning	0.0887	0.0553
		B7	Taxes	0.1252	0.0781
		B8	Dealer commissions	0.1015	0.0633
		B9	Creditors and accounts payable	0.1040	0.0648
Marketability	0.23665	C1	Pre paid opening clients	0.1533	0.0363
		C2	Pre paid ARPU	0.1792	0.0424
		C3	Total on network	0.0884	0.0209
		C4	Total off network	0.1613	0.0382
		C5	Operating income per pre paid client	0.1079	0.0255
		C6	OPEX per pre paid client	0.0310	0.0073
		C7	Total pre paid clients	0.0870	0.0206
		C8	Pre paid market share	0.1168	0.0276
		C9	Pre paid penetration rate	0.0750	0.0178
Network optimization	0.04706	D1	Total pre paid outgoing billable traffic	0.4917	0.0231
		D2	Total pre paid incoming traffic	0.3681	0.0173
		D3	Pre paid billing system availability	0.1403	0.0066

Table 4.15: *Weights assigned to main and sub criteria by the commercial department for the calculation of sub criteria synthesis values.*

Criteria	System 1	System 2
Days to deliver invoice	0.0087	0.0609
Cost per productive hour	0.0039	0.0193
Pre paid total revenue	0.0214	0.1069
EBITDA	0.0239	0.0000
Mobile handset and accessory sales	0.0417	0.0417
License and management fees	0.0208	0.0069
OPEX	0.0200	0.0067
Bad debt provisioning	0.0111	0.0442
Taxes	0.0112	0.0669
Dealer commissions	0.0105	0.0527
Creditors and accounts payable	0.0162	0.0486
Pre paid opening clients	0.0121	0.0242
ARPU	0.0141	0.0283
Total on network	0.0042	0.0167
Total off network	0.0286	0.0095
Operating income per pre paid client	0.0085	0.0170
OPEX per pre paid client	0.0037	0.0037
Total pre paid clients	0.0082	0.0124
Pre paid market share	0.0079	0.0197
Pre paid penetration rate	0.0071	0.0107
Total pre paid outgoing billable traffic	0.0058	0.0174
Total pre paid incoming traffic	0.0087	0.0087
Pre paid billing system availability	0.0053	0.0013
FINAL SYSTEM SCORES	**0.3036**	**0.6246**

Table 4.16: *Results obtained from the commercial department by multiplying criteria synthesis values with normalized criteria matrix averages and final scores obtained for System 1 (historical or IN method) and System 2 (proposed method) for the calculation of deferred revenue.*

4.6.2 Finance department (profitability) weighting

In Appendix G the normalized pairwise comparison matrix drawn up by the key personnel member from the finance department at MTNCI for all 23 sub criteria under review, are shown. In Appendix G the service delivery normalized sub criteria matrix is presented in Table G.1 (matrix L_{A2}), profitability normalized sub criteria matrix in Table G.2 (matrix L_{B2}), marketability normalized sub criteria matrix in Table G.3 (matrix L_{C2}) and network optimization normalized sub criteria matrix in Table G.4 (matrix L_{D2}). The normalized matrix entries are obtained as before. Note that $L_{B2} = L_{B,\text{norm}}$. The normalized matrix is validated by

assuring that the sum of entries in each column equals one. Table 4.17 summarizes the weights and synthesis values obtained for each of the sub criteria as weighted by the finance department's key personnel member. Consistency checking was done according to the steps described in Section 4.5 and from Table 4.24 it can be seen that $CR_l > 0.1$ in most instances.

Main criteria	Main criteria weight	Sub criteria code	Sub criteria to main criteria	Sub-criteria weight	Synthesis value
Service delivery	0.09279	A1	Days to deliver invoice	0.1667	0.0155
		A2	Cost per productive hour	0.8333	0.0773
Profitability	0.62351	B1	Pre paid total revenue	0.2700	0.1683
		B2	EBITDA	0.2244	0.1399
		B3	Mobile handset and accessory sales	0.1189	0.0741
		B4	License and management fees	0.0727	0.0453
		B5	Operational expenses (OPEX)	0.1036	0.0646
		B6	Bad debt provisioning	0.0541	0.0338
		B7	Taxes	0.0511	0.0319
		B8	Dealer commissions	0.0490	0.0306
		B9	Creditors and accounts payable	0.0562	0.0350
Marketability	0.23665	C1	Pre paid opening clients	0.1810	0.0428
		C2	Pre paid ARPU	0.2046	0.0484
		C3	Total on network	0.0936	0.0221
		C4	Total off network	0.1653	0.0391
		C5	Operating income per pre paid client	0.1092	0.0258
		C6	OPEX per pre paid client	0.0259	0.0061
		C7	Total pre paid clients	0.0719	0.0170
		C8	Pre paid market share	0.0937	0.0222
		C9	Pre paid penetration rate	0.0549	0.0130
Network optimization	0.04706	D1	Total pre paid outgoing billable traffic	0.5332	0.0251
		D2	Total pre paid incoming traffic	0.3503	0.0165
		D3	Pre paid billing system availability	0.1166	0.0055

Table 4.17: *Weights assigned to main and sub criteria by the finance department for the calculation of sub criteria synthesis values.*

The *GCI* for each of the pairwise comparison matrices as weighted by the finance department was also calculated and it is again noted from Tables 4.13 and 4.23 that according to the GCI_l, all pairwise comparison matrices are at least below the 5% threshold for inconsistency. It was therefore decided to leave the pairwise comparison matrices for the finance department unchanged.

In Table 4.18 the final scores obtained by the finance department are given. *System 1* scored 0.3420 and *System 2* scored 0.5530. According to the pairwise comparison done by the finance department *System 2* is also preferred to *System 1*.

Criteria	System 1	System 2
Days to deliver invoice	0.0019	0.0135
Cost per productive hour	0.0193	0.0580
Pre paid total revenue	0.0281	0.1403
EBITDA	0.0350	0.0000
Mobile handset and accessory sales	0.0371	0.0371
License and management fees	0.0340	0.0113
OPEX	0.0484	0.0161
Bad debt provisioning	0.0068	0.0270
Taxes	0.0046	0.0273
Dealer commissions	0.0051	0.0255
Creditors and accounts payable	0.0088	0.0263
Pre paid opening clients	0.0143	0.0286
ARPU	0.0161	0.0323
Total on network	0.0044	0.0177
Total off network	0.0293	0.0098
Operating income per pre paid client	0.0086	0.0172
OPEX per pre paid client	0.0031	0.0031
Total pre paid clients	0.0068	0.0102
Pre paid market share	0.0063	0.0158
Pre paid penetration rate	0.0052	0.0078
Total pre paid outgoing billable traffic	0.0063	0.0188
Total pre paid incoming traffic	0.0082	0.0082
Pre paid billing system availability	0.0044	0.0011
FINAL SYSTEM SCORES	**0.3420**	**0.5530**

Table 4.18: *Results obtained from the finance department by multiplying criteria synthesis values with normalized criteria matrix averages and final scores obtained for System 1 (historical or IN method) and System 2 (proposed method) for the calculation of deferred revenue.*

4.6.3 Marketing department (marketability) weighting

In Appendix H the normalized comparison matrix drawn up by the key personnel member from the marketing department at MTNCI for all 23 sub criteria under review, are shown. In Appendix H the service delivery normalized sub criteria matrix is presented in Table H.1 (matrix L_{A3}), profitability normalized sub criteria matrix in Table H.2 (matrix L_{B3}), marketability normalized sub criteria matrix in Table H.3 (matrix L_{C3}) and network optimization normalized sub criteria matrix in Table H.4 (matrix L_{D3}). The normalized matrix entries are obtained as before. Note that $L_{C3} = L_{C,\text{norm}}$. Table 4.19 summarizes the weights and synthesis values obtained for each of the sub criteria as weighted by the marketing department's key personnel member. Consistency checking was done according to the steps described in Section 4.5 and again from Table 4.24 it can be seen that $CR_l \leq 0.1$ only half the time. The GCI_l for each of the pairwise comparison matrices, as weighted by the marketing department was determined. When these values from Table 4.24 are compared to the thresholds in Table 4.13, it show that all pairwise comparison matrices, except for the weighting done on the IS department's sub criteria are at least below the 5% threshold for inconsistency. The weighting done by the marketing department on the IS department's sub criteria realized a GCI_l value of 0.2251, which is below the 10% threshold for inconsistency and according to Saaty [2] this is consistent enough.

The scores as obtained by the marketing department and as can be seen in Table 4.20 were 0.3097 for *System 1* and 0.6061 for *System 2*, implying that according to the pairwise comparison done by the marketing department *System 2* is also preferred to *System 1*.

4.6.4 IS department (network optimization) weighting

The final department to weight all sub criteria in use was the IS department. In Appendix I the normalized comparison matrix drawn up by the IS department key personnel member at MTNCI for all 23 sub criteria under review, are shown. In Appendix I the service delivery normalized sub criteria matrix is presented in Table I.1 (matrix L_{A4}), profitability normalized sub criteria matrix in Table I.2 (matrix L_{B4}), marketability normalized sub criteria matrix in

Table I.3 (matrix L_{C4}) and network optimization normalized sub criteria matrix in Table I.4 (matrix L_{D4}). The normalized matrix entries are obtained as before. In Table 4.21 the weights and synthesis values obtained for each sub criterion as weighted by the IS department's key personnel member are summarized. Consistency checking was done according to the steps described in Section 4.5 and from Table 4.24 it can be seen that the $CR_l \lesssim 0.1$ in most cases. The GCI_l for each of the pairwise comparison matrices as weighted by the IS department was also calculated and it is noted from Tables 4.13 and 4.23 that according to the GCI_l, all pairwise comparison matrices are at least below the 5% threshold for inconsistency.

Main criteria	Main criteria weight	Sub criteria code	Sub criteria to main criteria	Sub-criteria weight	Synthesis value
Service delivery	0.09279	A1	Days to deliver invoice	0.1667	0.0155
		A2	Cost per productive hour	0.8333	0.0773
Profitability	0.62351	B1	Pre paid total revenue	0.2481	0.1547
		B2	EBITDA	0.1800	0.1123
		B3	Mobile handset and accessory sales	0.1505	0.0938
		B4	License and management fees	0.0458	0.0286
		B5	Operational expenses (OPEX)	0.0419	0.0261
		B6	Bad debt provisioning	0.0800	0.0499
		B7	Taxes	0.1008	0.0629
		B8	Dealer commissions	0.0780	0.0486
		B9	Creditors and accounts payable	0.0749	0.0467
Marketability	0.23665	C1	Pre paid opening clients	0.1622	0.0384
		C2	Pre paid ARPU	0.2171	0.0514
		C3	Total on network	0.0746	0.0177
		C4	Total off network	0.1197	0.0283
		C5	Operating income per pre paid client	0.1438	0.0340
		C6	OPEX per pre paid client	0.0266	0.0063
		C7	Total pre paid clients	0.0938	0.0222
		C8	Pre paid market share	0.1088	0.0257
		C9	Pre paid penetration rate	0.0536	0.0127
Network optimization	0.04706	D1	Total pre paid outgoing billable traffic	0.6091	0.0287
		D2	Total pre paid incoming traffic	0.3130	0.0147
		D3	Pre paid billing system availability	0.0779	0.0037

Table 4.19: *Weights assigned to main and sub criteria by the marketing department for the calculation of sub criteria synthesis values.*

Criteria	System 1	System 2
Days to deliver invoice	0.0019	0.0135
Cost per productive hour	0.0193	0.0580
Pre paid total revenue	0.0258	0.1289
EBITDA	0.0281	0.0000
Mobile handset and accessory sales	0.0469	0.0469
License and management fees	0.0214	0.0071
OPEX	0.0196	0.0065
Bad debt provisioning	0.0100	0.0399
Taxes	0.0090	0.0539
Dealer commissions	0.0081	0.0405
Creditors and accounts payable	0.0117	0.0350
Pre paid opening clients	0.0128	0.0256
ARPU	0.0171	0.0342
Total on network	0.0035	0.0141
Total off network	0.0212	0.0071
Operating income per pre paid client	0.0113	0.0227
OPEX per pre paid client	0.0031	0.0031
Total pre paid clients	0.0089	0.0133
Pre paid market share	0.0074	0.0184
Pre paid penetration rate	0.0051	0.0076
Total pre paid outgoing billable traffic	0.0072	0.0215
Total pre paid incoming traffic	0.0074	0.0074
Pre paid billing system availability	0.0029	0.0007
FINAL SYSTEM SCORES	**0.3097**	**0.6061**

Table 4.20: *Results obtained from the marketing department by multiplying criteria synthesis values with normalized criteria matrix averages and final scores obtained for System 1 (historical or IN method) and System 2 (proposed method) for the calculation of deferred revenue.*

The IS department's scores are summarized in Table 4.22, with *System 2* again outscoring *System 1* by 0.6143 to 0.3116. According to the pairwise comparison done by the IS department *System 2* is also preferred to *System 1*.

4.6.5 Conclusion

In the second instance each department was asked to weight all sub criteria in use. In Table 4.24 a summary of the values obtained for the CR_l and GCI_l are shown, for each

pairwise comparison matrix in the independent departmental weighting done by key personnel members of each department, regardless of what departments they represent. The results that followed were consistent and it is therefore concluded that the model does not contain inconsistent input, having an effect on the final scores. In all cases *System 2* outperformed *System 1*. A summary of the departmental scoring when weighting all sub criteria is shown in Table 4.23.

Main criteria	Main criteria weight	Sub criteria code	Sub criteria to main criteria	Sub criteria weight	Synthesis value
Service delivery	0.09279	A1	Days to deliver invoice	0.1064	0.0099
		A2	Cost per productive hour	0.8936	0.0829
Profitability	0.62351	B1	Pre paid total revenue	0.2135	0.1331
		B2	EBITDA	0.1585	0.0988
		B3	Mobile handset and accessory sales	0.1370	0.0854
		B4	License and management fees	0.0448	0.0279
		B5	Operational expenses (OPEX)	0.0427	0.0266
		B6	Bad debt provisioning	0.0872	0.0543
		B7	Taxes	0.1208	0.0753
		B8	Dealer commissions	0.0971	0.0606
		B9	Creditors and accounts payable	0.0985	0.0614
Marketability	0.23665	C1	Pre paid opening clients	0.1700	0.0402
		C2	Pre paid ARPU	0.1948	0.0461
		C3	Total on network	0.0925	0.0219
		C4	Total off network	0.1607	0.0380
		C5	Operating income per pre paid client	0.1088	0.0257
		C6	OPEX per pre paid client	0.0280	0.0066
		C7	Total pre paid clients	0.0784	0.0186
		C8	Pre paid market share	0.1035	0.0245
		C9	Pre paid penetration rate	0.0633	0.0150
Network optimization	0.04706	D1	Total pre paid outgoing billable traffic	0.7231	0.0340
		D2	Total pre paid incoming traffic	0.0612	0.0029
		D3	Pre paid billing system availability	0.2157	0.0102

Table 4.21: *Weights assigned to main and sub criteria by the IS department for the calculation of sub criteria synthesis values.*

Criteria	System 1	System 2
Days to deliver invoice	0.0012	0.0086
Cost per productive hour	0.0207	0.0622
Pre paid total revenue	0.0222	0.1109
EBITDA	0.0247	0.0000
Mobile handset and accessory sales	0.0427	0.0427
License and management fees	0.0209	0.0070
OPEX	0.0200	0.0067
Bad debt provisioning	0.0109	0.0435
Taxes	0.0108	0.0646
Dealer commissions	0.0101	0.0505
Creditors and accounts payable	0.0153	0.0460
Pre paid opening clients	0.0134	0.0268
ARPU	0.0154	0.0307
Total on network	0.0044	0.0175
Total off network	0.0285	0.0095
Operating income per pre paid client	0.0086	0.0172
OPEX per pre paid client	0.0033	0.0033
Total pre paid clients	0.0074	0.0111
Pre paid market share	0.0070	0.0175
Pre paid penetration rate	0.0060	0.0090
Total pre paid outgoing billable traffic	0.0085	0.0255
Total pre paid incoming traffic	0.0014	0.0014
Pre paid billing system availability	0.0081	0.0020
FINAL SYSTEM SCORES	**0.3116**	**0.6143**

Table 4.22: *Results obtained from the IS department by multiplying criteria synthesis values with normalized criteria matrix averages and final scores obtained for System 1 (historical or IN method) and System 2 (proposed method) for the calculation of deferred revenue.*

Business unit / department	*System 1* score	*System 2* score
Commercial	0.3036	0.6246
Finance	0.3420	0.5530
Marketing	0.3097	0.6061
IS	0.3116	0.6143

Table 4.23: *System scores obtained from applying the model with departmental weighting of all sub criteria.*

Business unit / department	Matrix	CR_I	GCI_I
Commercial	L_{A1}	0.0000	0.0000
	L_{B1}	0.0816	0.0535
	L_{C1}	0.1970	0.1225
	L_{D1}	0.1324	0.0858
Finance	L_{A2}	0.0000	0.0000
	L_{B2}	0.1748	0.0749
	L_{C2}	0.2495	0.1490
	L_{D2}	0.1905	0.1227
Marketing	L_{A3}	0.0000	0.0000
	L_{B3}	0.0842	0.0540
	L_{C3}	0.2780	0.1641
	L_{D3}	0.3559	0.2251
IS	L_{A4}	0.0000	0.0000
	L_{B4}	0.0807	0.0528
	L_{C4}	0.2216	0.1347
	L_{D4}	0.1034	0.0672

Table 4.24: *The CR_I and GCI_I values obtained for each pairwise comparison matrix in the independent departmental weighting done by key personnel members of each department, regardless of what departments they represent.*

4.7 ELECTRE as an outranking method

4.7.1 Differences between the AHP and outranking methods

When considering ELECTRE as opposed to the AHP, the outranking weights assigned to alternatives based on specific criteria do not represent tradeoffs between the various criteria. Rather it should be a measurement of how important a specific criterion is when considering it as a contributing factor to the preference function associated with the outranking method used. After assigning weights to criteria, for any pair of alternatives *a* and *b*, each criterion in effect votes for or against the assertion that "*a* is at least as good as *b*". The proportion of the total votes which support the assertion that "*a* is at least as good as *b*" provides a measure of concordance or evidence supporting this assertion. It is said that *a* outranks *b* if there is enough evidence to conclude that *a* is at least as good *b* when all criteria was considered.

The ELECTRE method consists of the evaluation of two indices, namely the concordance index and the discordance index. Belton and Stewart [5] define, for each pair of options *a* and *b*, these two principles as follows:

- If *a* is demonstrably as good as or better than *b* according to a sufficiently large weight of criteria, then this is considered to be evidence in favour of *a* outranking *b* (the concordance principle);
- If *b* is very strongly preferred to *a* on one or more criteria, then this is considered to be evidence against *a* outranking *b* (the discordance principle).

The concordance principle works on the basis of weighted pairwise voting, such that the decision maker can without reasonable doubt determine that one alternative outranks the other due to supporting evidence. The discordance principle works as follows. If the performance of alternative *a* in terms of criterion *i*, represented by $z_i(a)$, is below a predefined acceptable level, or the difference $z_i(b) - z_i(a)$ is greater than some threshold, then the conclusion that "*a* is at least as good as *b*" cannot be made, i.e. it cannot be said that *a* outranks *b.* According to Belton and Stewart [5] the discordance principle implies that the performance of *a* in terms of criterion *i* is so unacceptable, that it can never be compensated for by better performance on other criteria.

There are two main differences between outranking methods and preference modelling associated with value functions such as the AHP: (1) With preference modelling, the emphasis is on preference, rather than evidence as is typically associated with outranking methods. (2) Preference modelling does not allow for incomparable inputs, whereas outranking methods do [5]. An alternative therefore either has a definite preference over the other, two alternatives can be indifferent or incomparability might exist between two alternatives. Depicted in Figure 4.1 are incomparable alternatives that have such substantially different profiles that they are not comparable to one another. Shown in Figure 4.2 indifferent alternatives are alternatives where the differences between them are small, so that the preference for one over the other might easily be reversed if another criterion is introduced.

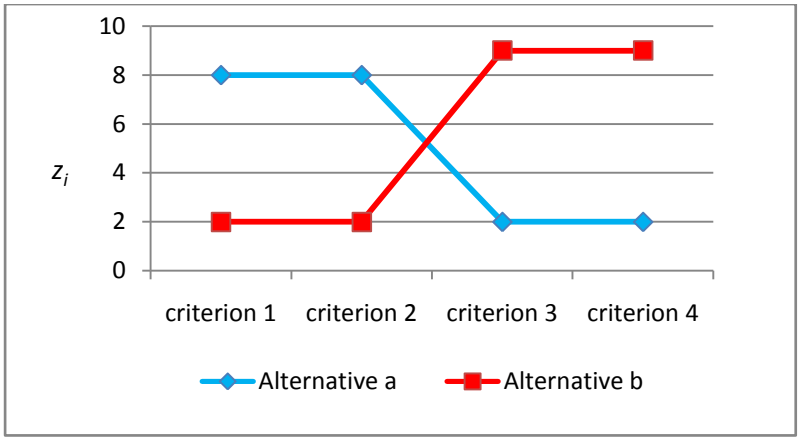

Figure 4.1: *A graphical representation of two incomparable alternatives.*

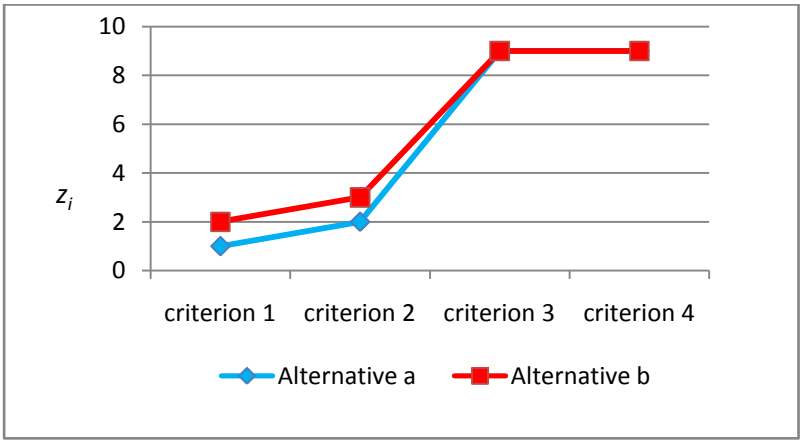

Figure 4.2: *A graphical representation of two indifferent alternatives.*

4.7.2 Outranking methods

Other than using value function methods to form a preferred selection based on predetermined criteria, preference modelling such as ELECTRE may be used as an outranking method for efficiency measurement. Outranking methods focus on pairwise comparisons of alternatives on one criterion independently of performances in terms of the other criteria [5]. These are normally applied to discrete choice problems, such as the

measurement of effectiveness of the methods described for calculation of a mobile phone network's deferred revenue.

Outranking methods usually start with a decision matrix describing the performance of the alternatives to be reviewed with respect to identified criteria. The performance measures obtained in Section 4.3 were, however, developed in the context of applying value function concepts. Outranking methods often make use of less precise inputs.

4.7.3 Weighting the criteria

In considering ELECTRE for the measurement of the specific model used for calculation of deferred revenue, The RA manager for MTN Group in Johannesburg [8] was asked to allocate each criterion an importance weight. These weights can be seen in the *Weights* column of Table 4.25. The RA manager for MTN Group [8] assigned weights based on her experience in the industry from working with many different mobile phone networks within the MTN Group and also understanding what criteria the holding company, namely MTN Group, values more than other out of all the available criteria, or in the group's case, KPIs. The RA manager for MTN Group [8] was also asked to rate each of the methods introduced at MTNCI on each criterion by means of a subjectively defined 5-point ordinal scale: Very Low (VL), Low (L), Average (Av), High (H) Very High (VH). A higher rating indicates a higher preference. The result can also be seen in Table 4.25.

4.7.4 Indices of concordance and discordance

The two broad approaches to defining an outranking relationship present when using ELECTRE, are defined by Belton and Stewart as *crisp* and *fuzzy* outranking relationships [5]. The *crisp* approach uses thresholds for the concordance and discordance indices, where alternative *a* outranks alternative *b* if the concordance index exceeds a minimum threshold and the discordance index does not exceed the threshold for the *veto* effect to be compelling enough. For purposes of determining which method for the calculation of deferred revenue

outranks the other, the *fuzzy* method is used from here on forth. By using the *fuzzy* approach, no definite conclusion is stated, but the strength of evidence is summarized by a value between 0 and 1, obtained by multiplying the concordance measure by a factor that tends to zero as discordance tends to its maximum value.

Criteria	**Weights**	***System 1***	***System 2***
Days to deliver invoice	5	VL	VH
Cost per productive hour	5	L	H
Pre paid total revenue	7	L	H
EBITDA	10	L	H
Mobile handset and accessory sales	7	Av	VH
License and management fees	5	Av	L
OPEX	8	Av	L
Bad debt provisioning	3	VL	VH
Taxes	3	VL	VH
Dealer commissions	2	Av	VH
Creditors and accounts payable	4	H	VH
Pre paid opening clients	6	Av	Av
ARPU	6	L	H
Total on network	8	Av	H
Total off network	8	Av	H
Operating income per pre paid client	9	H	H
OPEX per pre paid client	4	H	H
Total pre paid clients	5	Av	H
Pre paid market share	5	Av	H
Pre paid penetration rate	3	Av	H
Total pre paid outgoing billable traffic	6	L	H
Total pre paid incoming traffic	5	L	H
Pre paid billing system availability	7	VL	VH

Table 4.25: *Weights and system performances according to the RA manager for MTN Group in Johannesburg [8]*.

The concordance index used in ELECTRE is defined as

$$C(a,b) = \frac{\sum_{i \in Q(a,b)} w_j}{\sum_{i=1}^{m} w_j} \ ,$$

where *Q(a,b)* is the set of criteria for which *a* is equal or preferred to *b*, w_j is the criterion importance weight as assigned by the RA manager for MTN Group [8] and *m* is the total

number of criteria being evaluated. The concordance index, *C(a,b)*, measures how strong the support is for the hypothesis that *a* is at least as good as *b* in the sense that it is the proportion of criteria weights allocated to those criteria for which *a* is equal or preferred to *b.* The index takes on values between 0 and 1. A higher value indicates stronger evidence that *a* is preferred to *b.* A value of 1 is an indication that *a* performs at least as well as *b* (i.e. the same or better than *b*), on all criteria under review.

The discordance index, *D(a,b)*, in ELECTRE takes on a value of 1 for a pair of criteria *a* and *b* if a criterion *i* exists such that *b* outranks *a*, i.e.

$$D(a,b) = \begin{cases} 1 & \text{if } z_i(b) - z_i(a) \geq t_i \text{ for any } i \\ 0 & \text{otherwise} \end{cases},$$

where t_i represents the *veto* threshold for a specific criterion *i* such that *a* cannot outrank *b* if the score for *b* on any criterion is greater than the score for *a* on that criterion plus the particular threshold. The ratings performed and represented in Table 4.25 were assigned numerical values rating from 1 for a rating considered as VL and 5 for a rating considered as VH. Using the numerical values assigned, concordance and discordance indices could be obtained. These indices for the two systems to calculate deferred revenue, are shown in Table 4.26, where t_i was set at 3 for all $i = 1,...,23$.

Concordance	***System 1***	***System 2***
System 1	1.0000	0.2443
System 2	0.9008	1.0000

Discordance	***System 1***	***System 2***
System 1	-	1.0000
System 2	0.0000	-

Table 4.26: *Concordance and discordance indices of the two methods under consideration.*

As all evaluations in Table 4.25 are made according to a qualitative 5-point ordinal scale, discordance must be defined by a *veto* threshold for each criterion. Suppose that this

threshold is set at 3 scale points for all criteria. However, even if it is set to a threshold of 2 or 4, the results will still hold true.

4.7.5 Building an outranking relation

The concordance and discordance indices for each pair of options may be used to build an outranking relation. Concordance and discordance thresholds, C^* and D^*, are defined. Alternative *a* may be said to outrank alternative *b* if the concordance index $C(a,b)$ is greater than or equal to the threshold C^* and the discordance index $D(a,b)$ is less than or equal to D^*. In Figure 4.3 a graphical depiction of building an outranking relationship at the hand of two defined thresholds is given. As opposed to specifying a low value of C^* and high value of D^*, a very high value of C^* and a very low value of D^* are specified, which make it difficult for one method to outrank the other. It is a matter of experimentation to find a C^* large enough (but not too large) and a D^* small enough (but not too small) in order to define an informative and useful outranking relation. In this case of only two alternatives the final step in the decision process between the two methods for the calculation of deferred revenue is building the outranking relation. Using the graphical representation in Figure 4.3 it can easily be seen that *System 2* outranks *System 1*.

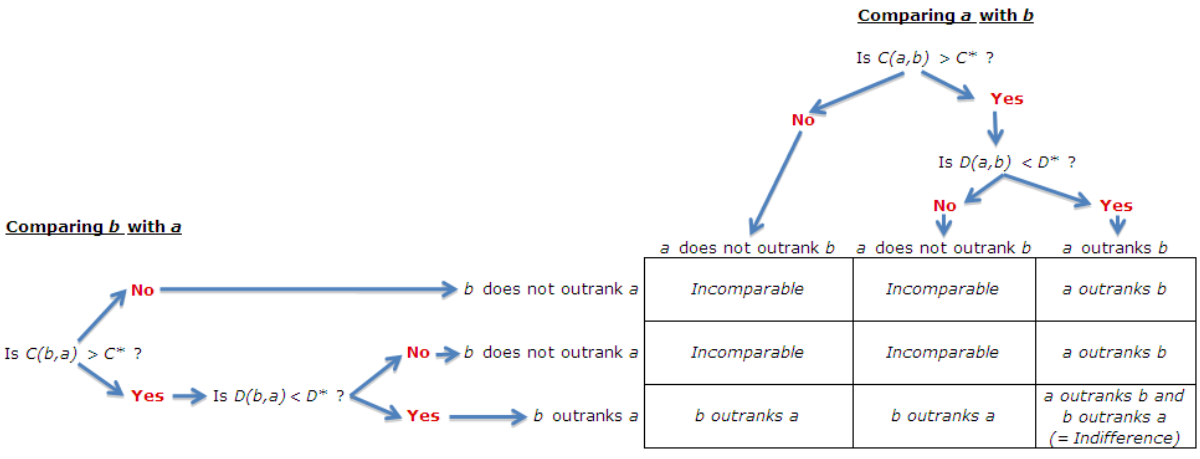

Figure 4.3: *Graphical representation of how to build an outranking relation.*

Even though ELECTRE was used as a technique for evaluation of the two methods used for measuring deferred revenue, it is obvious that *System 2* outperforms *System 1* by inspection of the values assigned by the RA manager for MTN Group [8] and presented in Table 4.25. However, the technique was formulated here for completeness and as an alternative method to the AHP.

4.8 Sensitivity and robustness analysis

Analysis should be carried out to investigate whether conclusions are robust or if they are sensitive to changes with respect to the models proposed. Changes may be made to investigate the significance of missing information, to explore the effect of a decision-maker's uncertainty about his/her assigned values and priorities or to offer a different perspective on the problem [5]. There could also be no practical or psychological motivation for changing values, in which case only robustness itself may be part of the test results. Sensitivity analysis may be viewed from three perspectives:

- **Technical perspective:** Sensitivity analysis from a technical perspective involves examining the effect on the output of a model caused by changes made to the input parameters. The input parameters consist of the value functions and weights as assigned by the decision-maker. The output is any synthesis of this information. In the AHP and ELECTRE instances, choosing the one system for measurement of deferred revenue above the other, is considered as output. A technical sensitivity analysis attempts to determine whether changes in specific input parameters have a critical influence on the overall output and therefore evaluation and selection between the two methods to calculate deferred revenue.
- **Individual perspective:** Sensitivity analysis from an individual's perspective is to provide a sounding board against which they can test their intuition and understanding of the problem.
- **Group perspective:** Sensitivity analysis within the group context is to allow the exploration of alternative perspectives on the problem. In our case, this is explored by having the heads of all departments from MTNCI assign weights in the AHP model to all the available criteria and not only the criteria pertaining to their own departments.

Sensitivity analysis from an individual and group perspective received attention throughout this document. Thus the technical perspective is considered next. It may be viewed as impractical, because of the number of judgements involved, but also as a consequence of the use of the *eigen vector* method to derive normalized comparison matrices for comparative purposes of the criteria in use. When considering sensitivity analysis of the AHP there has been extensive practical and theoretical concerns, these include:

1. **The interpretation of criteria weights:** In using the AHP and because it is an additive model, the weight parameters $w_{l,i}$ define the desirable levels of tradeoffs between performances of the different criteria. Two alternatives can easily be equally preferred to one another if two alternatives *a* and *b* differ only on criteria *i* and *k*, for example, and $v_i(a) > v_i(b)$ but $v_k(b) > v_k(a)$. The reason for this is because of the scaling of the partial scores to sum to 1 [5]. Therefore one alternative does not enjoy a preference to the other because of its absolute preference in specific criteria. Because it is an additive model and not an outranking model a total or average score determines its position based on all the different criteria used together. It is not always evident that when decision-makers express relative weight ratios, they have this interpretation in mind.
2. **The assumption of a ratio scale of preference:** The AHP assumes that all comparisons can be made on a ratio scale [5]. This means that if comparing *a* to *b* preference for the one over the other could be stated as a ratio. In doing so the distance of *a* and *b* from a natural reference point, such as zero, is determined and used as basis for comparison. For variables such as length, area, weight, etc. it makes sense, but not for considerations such as comfort, image or quality of life, for which no clear reference level exists.
3. **Numerical interpretation of the semantic scale:** Concern has been expressed about the appropriateness of the conversion from the semantic to the numeric scale used by Saaty as a measure of strength of preference [5]. The general view, supported by experimental work and also shown when using ELECTRE as opposed to the AHP, is that the extreme point of the scale defined semantically as absolute preference is more consistent with a numeric ratio of 1:3 or even 1:5 than the 1:9 used in the AHP.

Sensitivity and robustness analysis is an important part of the decision process. Unfortunately, it is not possible to do this in any automated or interactive way. Bear in mind that decision-makers using the models proposed are helped to make sense of an issue, to

better understand the organizational context, to explore their own values and priorities and to appreciate the perspectives of other parties to the decision.

4.9 Conclusion

In this chapter some assumptions for the specification of the model was made. The criteria chosen for evaluation of the two methods used in the determination of deferred revenue were identified. The four main criteria had been identified by MTN Group for evaluation of their subsidiary mobile phone networks. These criteria are representative of each of the main business units within the group's subsidiary mobile phone networks. Mobile phone industry experts did comparisons and synthesis values were determined. The assigned weights were evaluated for consistency and on acceptance thereof, scores for each system being measured were obtained by finding each method's criteria weights. In tems of sensitivity analysis an exercise was done whereby each department's representatives weighted all of the criteria chosen, even those from other departments, and this was modelled to show that departmental dependency and consistency is maintained by the AHP. The AHP scores obtained for each method under review were then analyzed. This chapter ends with an introduction to ELECTRE for contested deferred revenue method ranking and then sensitivity and robustness analysis to substantiate the evidence obtained, was discussed.

The analysis of the scores yields positive results towards the measurement of deferred revenue through the use of a BSS.

Chapter 5

Conclusion

This chapter commences with a summary of the work done in this study and is concluded with some recommendations and ideas for future studies.

5.1 Thesis summary

The problem area is introduced in Chapter 1 and the significance of doing a study in the effectiveness of determining deferred revenue motivated. The objectives are set out, namely that of introducing a novel approach to the calculation of deferred revenue and more importantly to measure how effective the new approach is when measured against the legacy approach. It was identified that various external and internal factors contribute to the complexity of the network environment and that these factors impact on the day-to-day operation of a mobile phone network. Not only does it affect the network operations, but it also has a direct effect on the shareholder value of the organization. The shareholder value is affected by the performance of the pre paid product. Inefficiencies will thus eventually reflect negatively on the share price. This alone is more than enough reason for a holding company with 23 subsidiaries (such as MTN Group has at date of writing this thesis) to implement strong performance guidelines and to assure that KPIs are met to the best of the industry's capability.

In Chapter 2 insightful knowledge into the industry is provided. The airtime bearing products were identified and discussed, as these products and their distribution pattern have an impact on deferred revenue. The network environment or systems that interact with the pre paid channel of an emerging market mobile phone network, was explained. Revenue was addressed and the importance of revenue reporting, in particular deferred revenue, was

highlighted. The specific focus was on the historic method for the calculation of deferred revenue.

The functionalities of a BSS were identified in Chapter 3 and a proposed method for the calculation of deferred revenue using the functionalities provided by a BSS was proposed. The components of deferred revenue using the new method was elaborated and a functional comparison with the historic method, showing where sources of information overlap, was done. Chapter 3 focuses on attainment of the first objective, introducing a novel approach for the measurement of deferred revenue. The new approach is explained in detail and why its effectiveness needs to be measured is motivated.

In Chapter 4 a model for the measurement of effectiveness using the two methods for the calculation of deferred revenue was introduced. This chapter focuses on attainment of the primary objective introduced in Chapter 1, namely to estimate how effective the new approach is when compared to the legacy approach. Using the AHP algorithm proposed by Saaty, main and sub criteria were identified after collaboration with industry experts. The criteria comparison matrices drawn up by the departmental / business unit personnel were checked for consistency using proposed methodologies and then a scoring was done by finding weights for the two alternatives for the calculation of deferred revenue using the identified criteria. The scores obtained, through implementation of the model, were evaluated and consistency checking was performed. Departmental dependency was also investigated and final scores were analyzed. To motivate the findings of the previous section, ELECTRE (as an outranking method) was used to support this notion. The ELECTRE method realized similar results.

5.2 Suggestions and recommendations

The effectiveness of deferred revenue as reported through the use of a BSS is greatly due to improved processes. A BSS streamlines and automates many of the processes that are involved with or impact on deferred revenue. These processes are mostly human driven processes or if machine driven, not fully automated due to the mass and complexity of

information that has to be managed. Once a BSS is fully operational within the pre paid channel of a mobile phone network, the BSS is able to identify systems and inter departmental shortcomings. This is due to the fact that a BSS is pre programmed to expect specified data from specified sources and checks and balances are programmed to reconcile the input data instantaneously. If preconditions are not met, administrators of the BSS can be alerted immediately, allowing them to react in real time.

Reacting in real time motivates the later part of the argument. Now that it has been identified, the weakness can be addressed so that it is not exploited again. This continuous process of evaluating data, people, departments and processes results in efficient progress with regards to the effectiveness of the reported deferred revenue over time. The scores for both system alternatives were assigned from criteria used in the model of Chapter 4, seven months after the first implementation date of a BSS. The BSS was first implemented on 1 December 2007 and scores were determined at the end of June 2008. During the 7 months since the first implementation date, various process shortcomings were identified and addressed. A few of the most significant issues identified during analysis of the mobile phone network environment and specifically issues that impacted on deferred revenue are listed below. These issues, when addressed will have a noticeable positive effect on the effectiveness of deferred revenue. Process shortcomings identified and IN deficiencies that were identified by means of this study include the following:

- There is little control on the IN regarding the regulation of airtime bearing products and their activation and deactivation.
- When queries are performed on the IN to retrieve crucial information to be used in the calculation of deferred revenue, these queries are time consuming in their execution, skewing the results when used in time series data analysis.
- It is possible to do manual adjustments on the IN, for which there exist no traceable audit trail. This leaves the network vulnerable to fraudulent activity.
- There exists specific account balances on the IN that can be used to make unbilled calls. Managing these accounts incorrectly will not only deprive the network of billable traffic, but could also increase the total payment due to partner networks for terminating calls on their infrastructure.

It was also found that the POS was being ineffectively utilized due to the following reasons:

- The ineffective utilization of the POS can take place due to shortcomings in the design and logical implementation of the POS, again leaving room for fraudulent activities.
- Transactions are not done at arm's length, due to relationships that exist between mobile phone network employees and sales dealers. This skews sales reports by special benefits being granted to selected dealers who don't necessarily qualify for those benefits.

Furthermore it was found that the ERP was being ineffectively utilized, causing multiple manual input entries done on the general ledger of the ERP that are not traceable and auditable, making it difficult to reconcile data retrieved from it. Lastly the departmental shortcomings identified, included the marketing department not performing product updates on all systems simultaneously, this leading to skewed time series data sets when queried from the various systems in use.

The same trends are displayed with any kind of DSS. During the 1980's and 1990's it was the ERP trend that consumed most of large businesses' operational budgets, as opposed to BSSs repeating the trend during more recent years. In general the implementation of DSSs, flowing from research in MS and OR allows organizations, more specifically, mobile phone networks, to operate more effectively. Once a specific DSS has been introduced into an organization, it is a matter of time before all competing organizations in that industry adopts a similar technology. However, only if the technology has been proven to work. The importance of using known measurement techniques obtained from the MS and OR domains is again highlighted.

5.3 Possible future work

It would be interesting to repeat the effectiveness measurement exercise now and after process shortcomings have been addressed, to see whether the newly proposed method for the calculation of deferred revenue is still preferred to the historical method. It would also be

interesting to compare the newly proposed methods to any other methods that are born into existence.

As can be seen with the implementation of a BSS and the impact it had on the effectiveness of deferred revenue, the implementation of any other system can either have a positive or negative effect on any one of various available organizational variables. Just as one method for calculation of deferred revenue has been compared against another, the proposed models from Chapter 4 can be used to compare any system within a mobile phone network against any other. Even more challenging would be the estimation or measurement of the effectiveness of any system within a mobile phone network at the hand of specific KPIs. An even more challenging field of research would be to look at the onset of new technologies within the telecommunications sector and not specifically mobile phone networks. An example of this would be that of WiMAX and the various systems that interact with this technology for it to be commercially successfully implemented.

The goal set out to achieve, in writing of this thesis was primarily to demonstrate the effectiveness of a newly proposed method for the calculation of deferred revenue, but more specifically in emerging markets. Since deferred revenue only exists because of the presence of a pre paid value channel, this was an obvious assumption and necessity in achieving the goal. The preference modelling and outranking method results obtained in this thesis were shared with industry experts, both from an academic and industry perspective. From an industry perspective, the results obtained were shared with specific key personnel members of MTN Group. The outcomes obtained from this implementation at a single subsidiary of MTN Group during 2007, has served as motivation for 4 other implementations across the group's subsidiary networks to date. This clearly substantiates the outcome of the thesis and success of the models.

There exist feasible solutions to most of the problems posed by mobile phone networks today. However, there are a few challenges that keep solutions to future problems out of the reach of quite a few networks. The largest of these is probably the pace at which development in this specific industry is taking place. Worsened by the fact that there is no first world scenario that can provide exact case studies of where the emerging market mobile phone networks can find solutions to their own specific problems. The technology and

growth factors can be detrimental to some networks and even suppliers of services and technologies if their planning is not done diligently.

There exists a wide realm of research that can be done in African and other emerging markets globally to identify trends that can be used to react on problem areas, such as the deferred revenue dilemma as explained in this thesis, in a proactive manner. All too often emerging markets are seen to be trend followers, rather than trend setters. It will be interesting to see how the mobile phone networks react to challenges that are being imposed by the Internet Protocol (IP) threat, effectively putting low cost communications in the hands of every individual worldwide. One thing is certain however: Whatever the case, it will continue to be driven and owned by multi-million dollar organizations with one aim only, to make more revenue and declare larger profits.

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Appendices

Appendix A

Compact disc content

File AHP – Excel1.xls

<AHP – Excel1.xls> is a program that represents the base model for calculation of the AHP fundamentals as discussed in this thesis. The departmental managers weighted the sub criteria represented within each department and results were obtained accordingly. The last sheet in the Excel document, namely "CRITERIA-Summary" represents a summary of the program being used repetitively for each of the main criteria used.

<AHP – Excel1.xls> contains the following sheets:

- **CRITERIA SPECIFICATION-Step1:** User selection of the specific sub criteria to use for each of the main criteria required in this step.
- **CRITERIA MATRIX-Step2:** Pairwsie criteria comparisons by departmental managers for criteria selected for each department in the previous sheet required.
- **CRITERIA SPEC MATRIC-Step3:** Weighting of two systems against one another for each of the criteria selected in the first step.
- **CRITERIA RESULTS-Step4:** A table containing the i^{th} entry of $L_l\boldsymbol{w}_l^T$, the (i^{th} entry of $L_l\boldsymbol{w}_l^T$)$/w_{l,i}$ and final results based on calculations performed on the "CRITERIA-Summary" sheet.
- **CRITERIA-Summary:** Summarizes all the calculations used in this thesis for the implementation of the model using the AHP algorithm.

Files AHP – Excel2_1.xls through to AHP – Excel2_4.xls

The key personnel member from the commercial department is asked to evaluate the entire set of 23 available sub criteria regardless of what department he/she represents. The personnel member then compares all sub criteria independently from the other departments.

<AHP – Excel2_1.xls> represents the weighting done between sub criteria belonging to the commercial department or service delivery main criterion.

<AHP – Excel2_2.xls> represents the weighting done between sub criteria belonging to the finance department or profitability main criterion.

<AHP – Excel2_3.xls> represents the weighting done between sub criteria belonging to the marketing department or marketability main criterion.

<AHP – Excel2_4.xls> represents the weighting done between sub criteria belonging to the IS department or network optimization main criterion.

File AHP – Excel2_tmp.xls

<AHP – Excel2_tmp.xls> summarizes the results obtained from <AHP – Excel2_1.xls> through to <AHP – Excel2_4.xls> as performed by the commercial department's key personnel member.

Files AHP – Excel3_1.xls through to AHP – Excel3_4.xls

These files contain the results of the evaluation of the entire set of 23 available sub criteria by the key personnel member from the finance department. The personnel member then compares all sub criteria independently from the other departments.

<AHP – Excel3_1.xls> represents the weighting done between sub criteria belonging to the commercial department or service delivery main criterion.

<AHP – Excel3_2.xls> represents the weighting done between sub criteria belonging to the finance department or profitability main criterion.

<AHP – Excel3_3.xls> represents the weighting done between sub criteria belonging to the marketing department or marketability main criterion.

<AHP – Excel3_4.xls> represents the weighting done between sub criteria belonging to the IS department or network optimization main criterion.

File AHP – Excel3_tmp.xls

<AHP – Excel3_tmp.xls> summarizes the results obtained from <AHP – Excel3_1.xls> through to <AHP – Excel3_4.xls> as performed by the finance department's key personnel member.

Files AHP – Excel4_1.xls through to AHP – Excel4_4.xls

The key personnel member from the marketing department was alos asked to evaluate the entire set of 23 available sub criteria. The personnel member then compares all sub criteria independently from the other departments.

<AHP – Excel4_1.xls> represents the weighting done between sub criteria belonging to the commercial department or service delivery main criterion.

<AHP – Excel4_2.xls> represents the weighting done between sub criteria belonging to the finance department or profitability main criterion.

<AHP – Excel4_3.xls> represents the weighting done between sub criteria belonging to the marketing department or marketability main criterion.

<AHP – Excel4_4.xls> represents the weighting done between sub criteria belonging to the IS department or network optimization main criterion.

File AHP – Excel4_tmp.xls

<AHP – Excel4_tmp.xls> summarizes the results obtained from <AHP – Excel4_1.xls> through to <AHP – Excel4_4.xls> as performed by the marketing department's key personnel member.

Files AHP – Excel5_1.xls through to AHP – Excel5_4.xls

The key personnel member from the IS department is asked to evaluate the entire set of 23 available sub criteria. The personnel member then compares all sub criteria independently from the other departments.

<AHP – Excel5_1.xls> represents the weighting done between sub criteria belonging to the commercial department or service delivery main criterion.

<AHP – Excel5_2.xls> represents the weighting done between sub criteria belonging to the finance department or profitability main criterion.

<AHP – Excel5_3.xls> represents the weighting done between sub criteria belonging to the marketing department or marketability main criterion.

<AHP – Excel5_4.xls> represents the weighting done between sub criteria belonging to the IS department or network optimization main criterion.

File AHP – Excel5_tmp.xls

<AHP – Excel5_tmp.xls> summarizes the results obtained from <AHP – Excel5_1.xls> through to <AHP – Excel5_4.xls> as performed by the IS department's key personnel member.

File ELECTRE – Excel1.xls

<ELECTRE – Excel1.xls> contains two sheets. The first shows the decision matrix for ranking of the methods used for calculation of deferred revenue using ELECTRE. The RA manager for MTN Group [8] completed the necessary weighting in this sheet. It also shows the determination of the concordance and discordance indices for both methods being evaluated to determine rank compared to the other. The second sheet contains a graphical representation of how to build an outranking relation graphically.

Appendix B

Complete sub criteria (KPIs) list

Index	Main criteria	Sub criteria to main criteria	Source
1	Service delivery	Number of subscribers per customer care employee	Customer Relationship Manager (CRM)
2	Service delivery	Average speed of answer	CRM
3	Service delivery	Total calls to switch	CRM
4	Service delivery	Total calls offered	CRM
5	Service delivery	Total calls handled	CRM
6	Service delivery	Call answer rate	CRM
7	Service delivery	Percentage service level	CRM
8	Service delivery	Percentage abandonment	CRM
9	Service delivery	Customer Satisfaction Index (CSI)	CRM
10	Service delivery	Average Call Hold Time (CHT)	CRM
11	Service delivery	Calls per subscriber per month	CRM
12	Service delivery	Inbound calls per Customer Service Representative (CSR) per month	CRM
13	Service delivery	Days to deliver invoice	CRM
14	Service delivery	Cost per productive hour	CRM
15	Service delivery	First call resolution	CRM
16	Service delivery	Distribution reach	CRM
17	Service delivery	Brand reference	CRM
18	Service delivery	Brand loyalty	CRM
19	Service delivery	Total calls handled by call centre Interactive Voice Response (IVR)	CRM
20	Profitability	Post paid connection fee	ERP
21	Profitability	Post paid international and national outgoing	ERP
22	Profitability	Post paid incoming	ERP
23	Profitability	Post paid monthly fee	ERP
24	Profitability	Post paid subscriber roaming	ERP
25	Profitability	Post paid VAS revenue	ERP
26	Profitability	Post paid SMS revenue	ERP
27	Profitability	Post paid data revenue	ERP
28	Profitability	Post paid total revenue	ERP
29	Profitability	Pre paid connection fee	ERP
30	Profitability	Pre paid international and national outgoing	ERP
31	Profitability	Pre paid incoming	ERP
32	Profitability	Pre paid monthly fee	ERP

33	Profitability	Pre paid subscriber roaming	ERP
34	Profitability	Pre paid VAS revenue	ERP
35	Profitability	Pre paid SMS revenue	ERP
36	Profitability	Pre paid data revenue	ERP
37	Profitability	Pre paid total revenue	ERP
38	Profitability	Mobile handset and accessories sales	ERP
39	Profitability	Miscellaneous revenue	ERP
40	Profitability	Total VAS revenue	ERP
41	Profitability	Total other revenue	ERP
42	Profitability	Handsets/spare parts cost	ERP
43	Profitability	License and management fees	ERP
44	Profitability	Staff cost (salaries, bonus, etc.)	ERP
45	Profitability	Marketing expenses	ERP
46	Profitability	Leased lines	ERP
47	Profitability	IT maintenance and repairs	ERP
48	Profitability	Network maintenance and repairs	ERP
49	Profitability	Network utilities expenses	ERP
50	Profitability	Network rent expenses	ERP
51	Profitability	Office and other rent	ERP
52	Profitability	Office and other utilities	ERP
53	Profitability	Management fees	ERP
54	Profitability	Bad debt provisioning	ERP
55	Profitability	Billing expenses	ERP
56	Profitability	Training expenses	ERP
57	Profitability	Consulting expenses	ERP
58	Profitability	Insurance expenses	ERP
59	Profitability	Business travel expenses	ERP
60	Profitability	All other OPEX items	ERP
61	Profitability	Maintenance	ERP
62	Profitability	Rent and utilities	ERP
63	Profitability	Connection incentive	ERP
64	Profitability	MTNCI Foundation	ERP
65	Profitability	Regulatory fees	ERP
66	Profitability	Service provider discounts	ERP
67	Profitability	Dealer commissions	ERP
68	Profitability	SIM cards cost	ERP

69	Profitability	Scratch card cost	ERP
70	Profitability	Total operating expenses (OPEX)	ERP
71	Profitability	OPEX percentage of revenue	ERP
72	Profitability	Earnings before interest, tax, depreciation and amortization (EBITDA)	ERP
73	Profitability	EBIDTA percentage	ERP
74	Profitability	Operating margin	ERP
75	Profitability	Foreign exchange gain/(loss)	ERP
76	Profitability	Financing costs (interest, fees, etc.)	ERP
77	Profitability	Interest received	ERP
78	Profitability	Other non operating items	ERP
79	Profitability	Taxes	ERP
80	Profitability	Net profit/(loss)	ERP
81	Profitability	Return on sales (Net profit/total revenue)	ERP
82	Profitability	Effective tax rate	ERP
83	Profitability	Dividends paid	ERP
84	Profitability	Finance department	ERP
85	Profitability	Commercial department	ERP
86	Profitability	Admin department	ERP
87	Profitability	IS department	ERP
88	Profitability	Human Resource (HR) department	ERP
89	Profitability	Marketing department	ERP
90	Profitability	Subscriber operations department	ERP
91	Profitability	General department	ERP
92	Profitability	Data revenue	ERP
93	Profitability	Total cost of sales	ERP
94	Profitability	Total operating expenses	ERP
95	Profitability	Cash and cash items	ERP
96	Profitability	Inventory	ERP
97	Profitability	Allowance for doubtful debt	ERP
98	Profitability	Total accounts receivable	ERP
99	Profitability	Accrued revenue	ERP
100	Profitability	Pre paid expenses and other current assets	ERP
101	Profitability	Total current assets	ERP
102	Profitability	Gross cellular equipment	ERP
103	Profitability	Gross other fixed assets	ERP
104	Profitability	Accumulated depreciation	ERP

105	Profitability	Total tangible assets	ERP
106	Profitability	Total net fixed assets (tangible and intangible)	ERP
107	Profitability	Total assets	ERP
108	Profitability	Bank overdraft	ERP
109	Profitability	Short term debts	ERP
110	Profitability	Creditors and accounts payable	ERP
111	Profitability	Accrued CAPEX	ERP
112	Profitability	Unearned revenue	Structured query from proprietary source
113	Profitability	All other accrued expenses and other payables	ERP
114	Profitability	Total current liabilities	ERP
115	Profitability	Medium and long term financing	ERP
116	Profitability	Due to shareholders	ERP
117	Profitability	Total medium and long term liabilities	ERP
118	Profitability	Total liabilities	ERP
119	Profitability	Share capital	ERP
120	Profitability	Reserves	ERP
121	Profitability	Retained earnings	ERP
122	Profitability	Current year profit/(loss)	ERP
123	Profitability	Total shareholders equity	ERP
124	Profitability	Total liabilities and shareholders equity	ERP
125	Profitability	Debt to equity ratio	ERP
126	Profitability	Net debt/annualized EBIDTA	ERP
127	Profitability	Net debt/net worth	ERP
128	Profitability	Return on equity (annualized)	ERP
129	Profitability	Return on equity (rolling average)	ERP
130	Profitability	Return on assets (annualized)	ERP
131	Profitability	Return on assets (rolling average)	ERP
132	Profitability	Current ratio	ERP
133	Profitability	Debt to total assets	ERP
134	Profitability	Net income/(loss)	ERP
135	Profitability	Depreciation	ERP
136	Profitability	Amortization	ERP
137	Profitability	Other gain/(loss) to normalized operating profits	ERP
138	Profitability	Increase/(decrease) in current assets	ERP
139	Profitability	Increase/(decrease) in current liabilities	ERP
140	Profitability	Cash from operating activities	ERP

141	Profitability	Work in progress	ERP
142	Profitability	Land	ERP
143	Profitability	Cellular equipment	ERP
144	Profitability	Other fixed assets	ERP
145	Profitability	Intangibles	ERP
146	Profitability	Other gain/(loss) from investment disposal	ERP
147	Profitability	Cash used for investing	ERP
148	Profitability	Free cash flow	ERP
149	Profitability	Dividends	ERP
150	Profitability	Additions of debt	ERP
151	Profitability	Movement in shareholder accounts	ERP
152	Profitability	Paid in capital	ERP
153	Profitability	Cash used for financing activities	ERP
154	Profitability	Net cash surplus/(deficit)	ERP
155	Profitability	Beginning cash flow	ERP
156	Profitability	Ending cash flow	ERP
157	Profitability	Network CAPEX	ERP
158	Profitability	IT CAPEX	ERP
159	Profitability	Other tangible CAPEX	ERP
160	Profitability	Land and building	ERP
161	Profitability	Leasehold improvements	ERP
162	Profitability	Furniture and fittings	ERP
163	Profitability	Motor vehicles	ERP
164	Profitability	Office equipment	ERP
165	Profitability	Total CAPEX additions	ERP
166	Profitability	Gross CAPEX for cumulative subscriber	ERP
167	Profitability	Incremental CAPEX per net additional subscriber	ERP
168	Profitability	Incremental CAPEX as percentage of turnover	ERP
169	Profitability	Cumulative CAPEX per annual billable minute	ERP
170	Profitability	Bad debt expenses to total revenue	ERP
171	HR efficiency	Number of local employees	Structured query from proprietary source
172	HR efficiency	Number of expatriate employees	Structured query from proprietary source
173	HR efficiency	Number of temporary employees	Structured query from proprietary source
174	HR efficiency	Total staff	Structured query from proprietary source
175	HR efficiency	Cumulative subscribers per employee	Structured query from proprietary source
176	HR efficiency	Head Count (HC) turnover percentage	Structured query from proprietary source

177	HR efficiency	Staff opening base	Structured query from proprietary source
178	HR efficiency	New staff	Structured query from proprietary source
179	HR efficiency	Terminations	Structured query from proprietary source
180	HR efficiency	Voluntary staff movements (resignations)	Structured query from proprietary source
181	HR efficiency	Involuntary staff movements	Structured query from proprietary source
182	HR efficiency	Staff closing base	Structured query from proprietary source
183	HR efficiency	Total local salaries and benefits	Structured query from proprietary source
184	HR efficiency	Total staff costs as percentage of revenue	Structured query from proprietary source
185	HR efficiency	Local training costs	Structured query from proprietary source
186	HR efficiency	Overseas training costs	Structured query from proprietary source
187	HR efficiency	Remuneration per total cost	Structured query from proprietary source
188	HR efficiency	Absence rate	Structured query from proprietary source
189	HR efficiency	Termination rate	Structured query from proprietary source
190	HR efficiency	Resignation rate	Structured query from proprietary source
191	HR efficiency	Turnover rate	Structured query from proprietary source
192	HR efficiency	Recruitment rate	Structured query from proprietary source
193	HR efficiency	Training cost/remuneration	Structured query from proprietary source
194	HR efficiency	HR department cost/total cost	Structured query from proprietary source
195	HR efficiency	Average cost per hire	Structured query from proprietary source
196	HR efficiency	Training hours per Fixed Term Employee (FTE)	Structured query from proprietary source
197	HR efficiency	Remuneration/revenue	Structured query from proprietary source
198	HR efficiency	Training cost per hour	Structured query from proprietary source
199	HR efficiency	Human investment ratio	Structured query from proprietary source
200	HR efficiency	OPEX per employee	Structured query from proprietary source
201	HR efficiency	Average remuneration per employee	Structured query from proprietary source
202	HR efficiency	Revenue Generating Subscriber (RGS) per employee	Structured query from proprietary source
203	HR efficiency	Voice revenue per FTE	Structured query from proprietary source
204	HR efficiency	Data revenue per FTE	Structured query from proprietary source
205	HR efficiency	Training cost per FTE	Structured query from proprietary source
206	HR efficiency	Technical training cost per FTE	Structured query from proprietary source
207	HR efficiency	Developmental training cost per FTE	Structured query from proprietary source
208	HR efficiency	HR department cost per FTE	Structured query from proprietary source
209	HR efficiency	Revenue per employee	Structured query from proprietary source
210	HR efficiency	EBIDTA per employee	Structured query from proprietary source
211	HR efficiency	CAPEX per employee	Structured query from proprietary source
212	HR efficiency	Profit before tax per employee	Structured query from proprietary source

213	HR efficiency	Admin per employee	Structured query from proprietary source
214	HR efficiency	Salaries and staff cost per employee	Structured query from proprietary source
215	HR efficiency	Travel and entertainment per employee	Structured query from proprietary source
216	HR efficiency	RGS per employee	Structured query from proprietary source
217	HR efficiency	Number of overseas training events	Structured query from proprietary source
218	Marketability	Pre paid opening clients	Structured query from proprietary source
219	Marketability	Pre paid gross additions	Structured query from proprietary source
220	Marketability	Pre paid migrations	IN
221	Marketability	Pre paid inactive subscribers	IN
222	Marketability	Pre paid activations from dormant	IN
223	Marketability	Pre paid disconnections	IN
224	Marketability	Pre paid closing subscribers	IN
225	Marketability	Pre paid average subscribers	IN
226	Marketability	Pre paid churn percentage	IN
227	Marketability	Post paid opening subscribers	TABS
228	Marketability	Post paid gross additions	TABS
229	Marketability	Post paid migrations	TABS
230	Marketability	Post paid activations from dormant	TABS
231	Marketability	Post paid disconnections	TABS
232	Marketability	Post paid closing subscribers	TABS
233	Marketability	Post paid subscribers as a percentage of total subscribers	TABS
234	Marketability	Corporate subscribers	TABS
235	Marketability	Corporate subscriber revenue	TABS
236	Marketability	Public access subscribers	Structured query from proprietary source
237	Marketability	Public access subscriber revenue	Structured query from proprietary source
238	Marketability	Market share of gross additions	Structured query from proprietary source
239	Marketability	Overall market share	Structured query from proprietary source
240	Marketability	Pre paid Average Revenue per User (ARPU)	Structured query from proprietary source
241	Marketability	Post paid ARPU	Structured query from proprietary source
242	Marketability	Combined ARPU	Structured query from proprietary source
243	Marketability	Marginal ARPU	Structured query from proprietary source
244	Marketability	Pre paid incoming billable Mobile Operating Usage (MOU)/average subscribers	Structured query from proprietary source
245	Marketability	Pre paid outgoing billable MOU/average subscribers	Structured query from proprietary source
246	Marketability	Total pre paid billable MOU/average subscribers	Structured query from proprietary source
247	Marketability	International pre paid outgoing usage as a percentage of total pre paid outgoing usage	Structured query from proprietary source
248	Marketability	Post paid incoming billable MOU/average subscribers	Structured query from proprietary source

249	Marketability	Post paid outgoing billable MOU/average subscribers	Structured query from proprietary source
250	Marketability	Total post paid billable MOU/average subscribers	Structured query from proprietary source
251	Marketability	International post paid outgoing usage as a percentage of total post paid outgoing usage	Structured query from proprietary source
252	Marketability	Combined incoming billable MOU/average subscribers	Structured query from proprietary source
253	Marketability	Combined outgoing billable MOU/average subscribers	Structured query from proprietary source
254	Marketability	Total average combined MOU/average subscribers	Structured query from proprietary source
255	Marketability	Total on network	TABS/IN
256	Marketability	Off net fixed	TABS/IN
257	Marketability	Off net mobile	TABS/IN
258	Marketability	Off net international	TABS/IN
259	Marketability	Total off network	TABS/IN
260	Marketability	Total outgoing MOU	TABS/IN
261	Marketability	Total incoming MOU	TABS/IN
262	Marketability	Pre paid incoming call per minute average rate	IN
263	Marketability	Pre paid outgoing call per minute average rate	IN
264	Marketability	Post paid incoming call per minute average rate	TABS
265	Marketability	Post paid outgoing call per minute average rate	TABS
266	Marketability	Operating income per pre paid client	ERP/TABS/IN
267	Marketability	General and admin cost per subscriber	Structured query from proprietary source
268	Marketability	Marketing cost per net connection	Structured query from proprietary source
269	Marketability	OPEX per pre paid client	ERP/TABS/IN
270	Marketability	MTNCI total mobile subscribers	Structured query from proprietary source
271	Marketability	MTNCI total fixed subscribers	Structured query from proprietary source
272	Marketability	MTNCI total mobile subscribers	Structured query from proprietary source
273	Marketability	MTNCI total fixed subscribers	Structured query from proprietary source
274	Marketability	Orange mobile subscribers	Structured query from proprietary source
275	Marketability	Moov mobile subscribers	Structured query from proprietary source
276	Marketability	Koz mobile subscribers	Structured query from proprietary source
277	Marketability	Citelcom fixed subscribers	Structured query from proprietary source
278	Marketability	Arobase fixed subscribers	Structured query from proprietary source
279	Marketability	Population	Structured query from proprietary source
280	Marketability	MTNCI mobile market share	Structured query from proprietary source
281	Marketability	Orange mobile market share	Structured query from proprietary source
282	Marketability	Moov mobile market share	Structured query from proprietary source
283	Marketability	Koz mobile market share	Structured query from proprietary source
284	Marketability	MTNCI total market share	Structured query from proprietary source

285	Marketability	Orange total market share	Structured query from proprietary source
286	Marketability	Moov total market share	Structured query from proprietary source
287	Marketability	Koz total market share	Structured query from proprietary source
288	Marketability	Mobile penetration of total population	Structured query from proprietary source
289	Marketability	Total market subscribers	Structured query from proprietary source
290	Network optimization	Drop call rate	MSC
291	Network optimization	Handover outgoing success	MSC
292	Network optimization	Percentage BTS > 50% capacity at busy hour	MSC
293	Network optimization	Percentage BTS > 80% capacity at busy hour	MSC
294	Network optimization	Percentage BTS > 90% capacity at busy hour	MSC
295	Network optimization	Percentage BTS > 99% capacity at busy hour	MSC
296	Network optimization	Percentage of territory covered	MSC
297	Network optimization	Percentage of population covered	MSC
298	Network optimization	Critical link congestion percentage	MSC
299	Network optimization	Interconnect link congestion percentage	MSC
300	Network optimization	International link congestion percentage	MSC
301	Network optimization	All hour congestion	MSC
302	Network optimization	Busy hour congestion	MSC
303	Network optimization	Critical link availability	MSC
304	Network optimization	Interconnect link availability	MSC
305	Network optimization	International link availability	MSC
306	Network optimization	Transmission Channel (TCH) availability	MSC
307	Network optimization	Radio network high availability	MSC
308	Network optimization	All calls Answer Seizure Ration (ASR)	MSC
309	Network optimization	Interconnect calls ASR	MSC
310	Network optimization	International calls ASR	MSC
311	Network optimization	Half rate utilization	MSC
312	Network optimization	All hours control channels failure rate	MSC
313	Network optimization	All hours setup failure rate	MSC
314	Network optimization	SMS delivery success	Structured query from proprietary source
315	Network optimization	Total outgoing billable traffic pre paid	IN
316	Network optimization	Total outgoing billable traffic post paid	TABS
317	Network optimization	Total non revenue generated traffic	IN
318	Network optimization	Total outgoing traffic pre paid	TABS
319	Network optimization	Total outgoing traffic post paid	TABS
320	Network optimization	Total pre and post paid outgoing traffic	TABS

321	Network optimization	Total pre paid incoming traffic	TABS
322	Network optimization	Total post paid incoming traffic	TABS
323	Network optimization	Total pre and post paid incoming traffic	TABS
324	Network optimization	Total number of outgoing SMS by pre paid subscriber	IN
325	Network optimization	Total number of outgoing SMS by post paid subscriber	TABS
326	Network optimization	Average load of all Mobile Switching Centre (MSC) processors during busy hours	MSC
327	Network optimization	Total Home Location Register (HLR) subscribers	MSC
328	Network optimization	Maximum Visitor Location Register (VLR) subscribers	MSC
329	Network optimization	Average erlang per subscriber	Structured query from proprietary source
330	Network optimization	Incremental number of BTS sites	Structured query from proprietary source
331	Network optimization	Cumulative number of BTS sites	Structured query from proprietary source
332	Network optimization	Incremental number of GSM Transceivers (TRXS)	Structured query from proprietary source
333	Network optimization	Cumulative number of TRXS	MSC
334	Network optimization	Cumulative number of MSC	Structured query from proprietary source
335	Network optimization	Peak network erlang busy hours	Structured query from proprietary source
336	Network optimization	Service Control Point (SCP) count	Structured query from proprietary source
337	Network optimization	Service Data Point (SDP) count	Structured query from proprietary source
338	Network optimization	Site rollout	Structured query from proprietary source
339	Network optimization	Pre paid unavailability	Structured query from proprietary source
340	Network optimization	Recharge unavailability	Structured query from proprietary source
341	Network optimization	Exceptional processor load	MSC
342	Network optimization	Automatic call generator success	Structured query from proprietary source
343	Network optimization	Drive test success	Structured query from proprietary source
344	Network optimization	Subscriber activation and provisioning speed	Structured query from proprietary source
345	Network optimization	IS CAPEX	Structured query from proprietary source
346	Network optimization	IS OPEX	Structured query from proprietary source
347	Network optimization	IS headcount	Structured query from proprietary source
348	Network optimization	IS contractors	Structured query from proprietary source
349	Network optimization	IS cost as percentage of revenue	Structured query from proprietary source
350	Network optimization	IS cost per IS end user	Structured query from proprietary source
351	Network optimization	IS cost per subscriber	Structured query from proprietary source
352	Network optimization	Percentage IS projects on budget	Structured query from proprietary source
353	Network optimization	Percentage IS projects on time	Structured query from proprietary source
354	Network optimization	Billing system availability (wholesale)	Structured query from proprietary source
355	Network optimization	Billing system availability (retail post paid)	Structured query from proprietary source
356	Network optimization	Billing system availability (retail pre paid)	Structured query from proprietary source

Table B.1: *Complete sub criteria representing 361 KPIs used by MTN Group and their subsidiary mobile phone networks.*

357	Network optimization	Custer care systems availability	Structured query from proprietary source
358	Network optimization	ERP systems availability	Structured query from proprietary source
359	Network optimization	IS infrastructure availability	Structured query from proprietary source
360	Network optimization	Number of user affecting IS outages	Structured query from proprietary source
361	Network optimization	IS service desk response time	Structured query from proprietary source

Appendix C

Sub criteria that impact on deferred revenue and that applies to both methods for the calculation of deferred revenue

Index	Main criteria	Sub criteria to main criteria	Source
3	Service delivery	Total calls to switch	CRM
4	Service delivery	Total calls offered	CRM
5	Service delivery	Total calls handled	CRM
11	Service delivery	Calls per subscriber per month	CRM
13	Service delivery	Days to deliver invoice	CRM
14	Service delivery	Cost per productive hour	CRM
16	Service delivery	Distribution reach	CRM
18	Service delivery	Brand loyalty	CRM
29	Profitability	Pre paid connection fee	ERP
30	Profitability	Pre paid international and national outgoing	ERP
31	Profitability	Pre paid incoming	ERP
32	Profitability	Pre paid monthly fee	ERP
33	Profitability	Pre paid subscriber roaming	ERP
34	Profitability	Pre paid VAS revenue	ERP
35	Profitability	Pre paid SMS revenue	ERP
36	Profitability	Pre paid data revenue	ERP
37	Profitability	Pre paid total revenue	ERP
38	Profitability	Mobile handset and accessories sales	ERP
42	Profitability	Handsets/spare parts cost	ERP
43	Profitability	License and management fees	ERP
45	Profitability	Marketing expenses	ERP
54	Profitability	Bad debt provisioning	ERP
55	Profitability	Billing expenses	ERP
56	Profitability	Training expenses	ERP
57	Profitability	Consulting expenses	ERP
58	Profitability	Insurance expenses	ERP
61	Profitability	Maintenance	ERP
63	Profitability	Connection incentive	ERP
66	Profitability	Service provider discounts	ERP
67	Profitability	Dealer commissions	ERP
68	Profitability	SIM cards cost	ERP
69	Profitability	Scratch card cost	ERP
70	Profitability	Total operating expenses (OPEX)	ERP
71	Profitability	OPEX percentage of revenue	ERP

72	Profitability	Earnings before interest, tax, depreciation and amortization (EBITDA)	ERP
73	Profitability	EBIDTA percentage	ERP
79	Profitability	Taxes	ERP
80	Profitability	Net profit/(loss)	ERP
81	Profitability	Return on sales (Net profit/total revenue)	ERP
82	Profitability	Effective tax rate	ERP
92	Profitability	Data revenue	ERP
93	Profitability	Total cost of sales	ERP
94	Profitability	Total operating expenses	ERP
96	Profitability	Inventory	ERP
97	Profitability	Allowance for doubtful debt	ERP
98	Profitability	Total accounts receivable	ERP
99	Profitability	Accrued revenue	ERP
100	Profitability	Pre paid expenses and other current assets	ERP
109	Profitability	Short term debts	ERP
110	Profitability	Creditors and accounts payable	ERP
112	Profitability	Unearned revenue	Structured query from proprietary source
121	Profitability	Retained earnings	ERP
134	Profitability	Net income/(loss)	ERP
140	Profitability	Cash from operating activities	ERP
147	Profitability	Cash used for investing	ERP
148	Profitability	Free cash flow	ERP
149	Profitability	Dividends	ERP
153	Profitability	Cash used for financing activities	ERP
154	Profitability	Net cash surplus/(deficit)	ERP
155	Profitability	Beginning cash flow	ERP
156	Profitability	Ending cash flow	ERP
157	Profitability	Network CAPEX	ERP
158	Profitability	IT CAPEX	ERP
165	Profitability	Total CAPEX additions	ERP
166	Profitability	Gross CAPEX for cumulative subscriber	ERP
167	Profitability	Incremental CAPEX per net additional subscriber	ERP
168	Profitability	Incremental CAPEX as percentage of turnover	ERP
169	Profitability	Cumulative CAPEX per annual billable minute	ERP
170	Profitability	Bad debt expenses to total revenue	ERP
174	HR efficiency	Total staff	Structured query from proprietary source

175	HR efficiency	Cumulative subscribers per employee	Structured query from proprietary source
218	Marketability	Pre paid opening clients	Structured query from proprietary source
219	Marketability	Pre paid gross additions	Structured query from proprietary source
220	Marketability	Pre paid migrations	IN
221	Marketability	Pre paid inactive subscribers	IN
222	Marketability	Pre paid activations from dormant	IN
223	Marketability	Pre paid disconnections	IN
224	Marketability	Pre paid closing subscribers	IN
225	Marketability	Pre paid average subscribers	IN
226	Marketability	Pre paid churn percentage	IN
236	Marketability	Public access subscribers	Structured query from proprietary source
237	Marketability	Public access subscriber revenue	Structured query from proprietary source
238	Marketability	Market share of gross additions	Structured query from proprietary source
239	Marketability	Overall market share	Structured query from proprietary source
240	Marketability	Pre paid Average Revenue per User (ARPU)	Structured query from proprietary source
242	Marketability	Combined ARPU	Structured query from proprietary source
243	Marketability	Marginal ARPU	Structured query from proprietary source
244	Marketability	Pre paid incoming billable Mobile Operating Usage (MOU)/average subscribers	Structured query from proprietary source
245	Marketability	Pre paid outgoing billable MOU/average subscribers	Structured query from proprietary source
246	Marketability	Total pre paid billable MOU/average subscribers	Structured query from proprietary source
247	Marketability	International pre paid outgoing usage as a percentage of total pre paid outgoing usage	Structured query from proprietary source
252	Marketability	Combined incoming billable MOU/average subscribers	Structured query from proprietary source
253	Marketability	Combined outgoing billable MOU/average subscribers	Structured query from proprietary source
254	Marketability	Total average combined MOU/average subscribers	Structured query from proprietary source
255	Marketability	Total on network	TABS/IN
256	Marketability	Off net fixed	TABS/IN
257	Marketability	Off net mobile	TABS/IN
258	Marketability	Off net international	TABS/IN
259	Marketability	Total off network	TABS/IN
260	Marketability	Total outgoing MOU	TABS/IN
261	Marketability	Total incoming MOU	TABS/IN
262	Marketability	Pre paid incoming call per minute average rate	IN
263	Marketability	Pre paid outgoing call per minute average rate	IN
266	Marketability	Operating income per pre paid client	ERP/TABS/IN
267	Marketability	General and admin cost per subscriber	Structured query from proprietary source
268	Marketability	Marketing cost per net connection	Structured query from proprietary source

269	Marketability	OPEX per pre paid client	ERP/TABS/IN
270	Marketability	MTNCI total mobile subscribers	Structured query from proprietary source
272	Marketability	MTNCI total mobile subscribers	Structured query from proprietary source
274	Marketability	Orange mobile subscribers	Structured query from proprietary source
275	Marketability	Moov mobile subscribers	Structured query from proprietary source
276	Marketability	Koz mobile subscribers	Structured query from proprietary source
279	Marketability	Population	Structured query from proprietary source
280	Marketability	MTNCI mobile market share	Structured query from proprietary source
281	Marketability	Orange mobile market share	Structured query from proprietary source
282	Marketability	Moov mobile market share	Structured query from proprietary source
283	Marketability	Koz mobile market share	Structured query from proprietary source
284	Marketability	MTNCI total market share	Structured query from proprietary source
285	Marketability	Orange total market share	Structured query from proprietary source
286	Marketability	Moov total market share	Structured query from proprietary source
287	Marketability	Koz total market share	Structured query from proprietary source
288	Marketability	Mobile penetration of total population	Structured query from proprietary source
289	Marketability	Total market subscribers	Structured query from proprietary source
290	Network optimization	Drop call rate	MSC
291	Network optimization	Handover outgoing success	MSC
292	Network optimization	Percentage Base Transceiver Station (BTS) > 50% capacity at busy hour	MSC
293	Network optimization	Percentage BTS > 80% capacity at busy hour	MSC
294	Network optimization	Percentage BTS > 90% capacity at busy hour	MSC
295	Network optimization	Percentage BTS > 99% capacity at busy hour	MSC
296	Network optimization	Percentage of territory covered	MSC
297	Network optimization	Percentage of population covered	MSC
298	Network optimization	Critical link congestion percentage	MSC
299	Network optimization	Interconnect link congestion percentage	MSC
300	Network optimization	International link congestion percentage	MSC
301	Network optimization	All hour congestion	MSC
302	Network optimization	Busy hour congestion	MSC
303	Network optimization	Critical link availability	MSC
304	Network optimization	Interconnect link availability	MSC
305	Network optimization	International link availability	MSC
306	Network optimization	Transmission Channel (TCH) availability	MSC
307	Network optimization	Radio network high availability	MSC
308	Network optimization	All calls Answer Seizure Ration (ASR)	MSC

309	Network optimization	Interconnect calls ASR	MSC
310	Network optimization	International calls ASR	MSC
311	Network optimization	Half rate utilization	MSC
312	Network optimization	All hours control channels failure rate	MSC
313	Network optimization	All hours setup failure rate	MSC
314	Network optimization	SMS delivery success	Structured query from proprietary source
315	Network optimization	Total outgoing billable traffic pre paid	IN
317	Network optimization	Total non revenue generated traffic	IN
318	Network optimization	Total outgoing traffic pre paid	TABS
319	Network optimization	Total outgoing traffic post paid	TABS
320	Network optimization	Total pre and post paid outgoing traffic	TABS
321	Network optimization	Total pre paid incoming traffic	TABS
323	Network optimization	Total pre and post paid incoming traffic	TABS
324	Network optimization	Total number of outgoing SMS by pre paid subscriber	IN
326	Network optimization	Average load of all Mobile Switching Centre (MSC) processors during busy hours	MSC
327	Network optimization	Total Home Location Register (HLR) subscribers	MSC
328	Network optimization	Maximum Visitor Location Register (VLR) subscribers	MSC
329	Network optimization	Average erlang per subscriber	Structured query from proprietary source
330	Network optimization	Incremental number of BTS sites	Structured query from proprietary source
331	Network optimization	Cumulative number of BTS sites	Structured query from proprietary source
332	Network optimization	Incremental number of GSM Transceivers (TRXS)	Structured query from proprietary source
333	Network optimization	Cumulative number of TRXS	MSC
334	Network optimization	Cumulative number of MSC	Structured query from proprietary source
335	Network optimization	Peak network erlang busy hours	Structured query from proprietary source
336	Network optimization	Service Control Point (SCP) count	Structured query from proprietary source
337	Network optimization	Service Data Point (SDP) count	Structured query from proprietary source
338	Network optimization	Site rollout	Structured query from proprietary source
339	Network optimization	Pre paid unavailability	Structured query from proprietary source
340	Network optimization	Recharge unavailability	Structured query from proprietary source
341	Network optimization	Exceptional processor load	MSC
342	Network optimization	Automatic call generator success	Structured query from proprietary source
343	Network optimization	Drive test success	Structured query from proprietary source
344	Network optimization	Subscriber activation and provisioning speed	Structured query from proprietary source
345	Network optimization	IS CAPEX	Structured query from proprietary source
346	Network optimization	IS OPEX	Structured query from proprietary source
347	Network optimization	IS headcount	Structured query from proprietary source

348	Network optimization	IS contractors	Structured query from proprietary source
349	Network optimization	IS cost as percentage of revenue	Structured query from proprietary source
350	Network optimization	IS cost per IS end user	Structured query from proprietary source
351	Network optimization	IS cost per subscriber	Structured query from proprietary source
352	Network optimization	Percentage IS projects on budget	Structured query from proprietary source
353	Network optimization	Percentage IS projects on time	Structured query from proprietary source
354	Network optimization	Billing system availability (wholesale)	Structured query from proprietary source
356	Network optimization	Billing system availability (retail pre paid)	Structured query from proprietary source
357	Network optimization	Custer care systems availability	Structured query from proprietary source
358	Network optimization	ERP systems availability	Structured query from proprietary source
359	Network optimization	IS infrastructure availability	Structured query from proprietary source
360	Network optimization	Number of user affecting IS outages	Structured query from proprietary source
361	Network optimization	IS service desk response time	Structured query from proprietary source

Table C.2: *Sub criteria that impact on deferred revenue and applies to both methods for the calculation thereof.*

Appendix D

Sub criteria not duplicated through involvement with other sub criteria

Index	Main criteria	Sub criteria to main criteria	Source
13	Service delivery	Days to deliver invoice	CRM
14	Service delivery	Cost per productive hour	CRM
37	Profitability	Pre paid total revenue	ERP
38	Profitability	Mobile handset and accessories sales	ERP
43	Profitability	License and management fees	ERP
54	Profitability	Bad debt provisioning	ERP
67	Profitability	Dealer commissions	ERP
70	Profitability	Operational Expenditure (OPEX)	ERP
72	Profitability	Earnings before interest, tax, depreciation and amortization (EBITDA)	ERP
79	Profitability	Taxes	ERP
110	Profitability	Creditors and accounts payable	ERP
218	Marketability	Pre paid opening clients	Structured query from proprietary source
240	Marketability	Pre paid Average Revenue per User (ARPU)	Structured query from proprietary source
255	Marketability	Total on network	TABS/IN
259	Marketability	Total off network	TABS/IN
266	Marketability	Operating income per pre paid client	ERP/TABS/IN
269	Marketability	OPEX per pre paid client	ERP/TABS/IN
270	Marketability	Total pre paid clients	Structured query from proprietary source
280	Marketability	Pre paid market share	Structured query from proprietary source
288	Marketability	Pre paid penetration rate	Structured query from proprietary source
315	Network optimization	Total pre paid outgoing billable traffic	IN
321	Network optimization	Total pre paid incoming traffic	TABS
356	Network optimization	Pre paid billing system availability	Structured query from proprietary source

Table D.1: *Sub criteria not duplicated through the involvement with other sub criteria.*

Appendix E

Departmental pairwise comparison matrices to determine system scores

				AVERAGED WEIGHT	WEIGHT × SYNTHESIS VALUE	SYSTEM 1 SCORE	SYSTEM 2 SCORE
Days to deliver invoice	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.1429				
	SYSTEM 2	7.0000	1.0000				
Days to deliver invoice	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.1250	0.1250	0.1250	0.0087	0.0087	
	SYSTEM 2	0.8750	0.8750	0.8750	0.0609		0.0609
Cost per productive hour	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.2000				
	SYSTEM 2	5.0000	1.0000				
Cost per productive hour	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.1667	0.1667	0.1667	0.0039	0.0039	
	SYSTEM 2	0.8333	0.8333	0.8333	0.0193		0.0193
						0.0126	**0.0802**

Table E.1: C*ommercial department's pairwise comparison matrix to determine system scores.*

				AVERAGED WEIGHT	WEIGHT × SYNTHESIS VALUE	SYSTEM 1 SCORE	SYSTEM 2 SCORE
Pre paid total revenue	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.2000				
	SYSTEM 2	5.0000	1.0000				
Pre paid total revenue	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.1667	0.1667	0.1667	0.0281	0.0281	
	SYSTEM 2	0.8333	0.8333	0.8333	0.1403		0.1403
Earnings before interest, tax, depreciation and amortization (EBITDA)	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.3333				
	SYSTEM 2	3.0000	1.0000				
Earnings before interest, tax, depreciation and amortization (EBITDA)	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2500	0.2500	0.2500	0.0350	0.0350	
	SYSTEM 2	0.7500	0.7500	0.7500	0.1049		0.1049
Mobile handset and accessory sales	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	1.0000				
	SYSTEM 2	1.0000	1.0000				
Mobile handset and accessory sales	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.5000	0.5000	0.5000	0.0371	0.0371	
	SYSTEM 2	0.5000	0.5000	0.5000	0.0371		0.0371
License and management fees	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	3.0000				
	SYSTEM 2	0.3333	1.0000				
License and management fees	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.7500	0.7500	0.7500	0.0340	0.0340	
	SYSTEM 2	0.2500	0.2500	0.2500	0.0113		0.0113
Operational Expenses (OPEX)	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	3.0000				
	SYSTEM 2	0.3333	1.0000				
Operational Expenses (OPEX)	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.7500	0.7500	0.7500	0.0484	0.0484	
	SYSTEM 2	0.2500	0.2500	0.2500	0.0161		0.0161
Bad debt provisioning	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.2500				
	SYSTEM 2	4.0000	1.0000				
Bad debt provisioning	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2000	0.2000	0.2000	0.0068	0.0068	
	SYSTEM 2	0.8000	0.8000	0.8000	0.0270		0.0270
Taxes	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.1667				
	SYSTEM 2	6.0000	1.0000				
Taxes	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.1429	0.1429	0.1429	0.0046	0.0046	
	SYSTEM 2	0.8571	0.8571	0.8571	0.0273		0.0273
Dealer commissions	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.2000				
	SYSTEM 2	5.0000	1.0000				
Dealer commissions	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.1667	0.1667	0.1667	0.0051	0.0051	
	SYSTEM 2	0.8333	0.8333	0.8333	0.0255		0.0255
Creditors and accounts payable	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.3333				
	SYSTEM 2	3.0000	1.0000				
Creditors and accounts payable	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2500	0.2500	0.2500	0.0088	0.0088	
	SYSTEM 2	0.7500	0.7500	0.7500	0.0263		0.0263
						0.2077	**0.4158**

Table E.2: *Finance department's pairwise comparison matrix to determine system scores.*

				AVERAGED WEIGHT	WEIGHT × SYNTHESIS VALUE	SYSTEM 1 SCORE	SYSTEM 2 SCORE
Pre paid opening clients	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.5000				
	SYSTEM 2	2.0000	1.0000				
Pre paid opening clients	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.3333	0.3333	0.3333	0.0128	0.0128	
	SYSTEM 2	0.6667	0.6667	0.6667	0.0256		0.0256
Pre paid Average Revenue per User (ARPU)	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.5000				
	SYSTEM 2	2.0000	1.0000				
Pre paid Average Revenue per User (ARPU)	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.3333	0.3333	0.3333	0.0171	0.0171	
	SYSTEM 2	0.6667	0.6667	0.6667	0.0342		0.0342
Total on network	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.2500				
	SYSTEM 2	4.0000	1.0000				
Total on network	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2000	0.2000	0.2000	0.0035	0.0035	
	SYSTEM 2	0.8000	0.8000	0.8000	0.0141		0.0141
Total off network	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	3.0000				
	SYSTEM 2	0.3333	1.0000				
Total off network	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.7500	0.7500	0.7500	0.0212	0.0212	
	SYSTEM 2	0.2500	0.2500	0.2500	0.0071		0.0071
Operating income per pre paid client	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.5000				
	SYSTEM 2	2.0000	1.0000				
Operating income per pre paid client	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.3333	0.3333	0.3333	0.0113	0.0113	
	SYSTEM 2	0.6667	0.6667	0.6667	0.0227		0.0227
OPEX per pre paid client	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	1.0000				
	SYSTEM 2	1.0000	1.0000				
OPEX per pre paid client	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.5000	0.5000	0.5000	0.0031	0.0031	
	SYSTEM 2	0.5000	0.5000	0.5000	0.0031		0.0031
Total pre paid clients	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.6667				
	SYSTEM 2	1.5000	1.0000				
Total pre paid clients	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.4000	0.4000	0.4000	0.0089	0.0089	
	SYSTEM 2	0.6000	0.6000	0.6000	0.0133		0.0133
Pre paid market share	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.4000				
	SYSTEM 2	2.5000	1.0000				
Pre paid market share	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2857	0.2857	0.2857	0.0074	0.0074	
	SYSTEM 2	0.7143	0.7143	0.7143	0.0184		0.0184
Pre paid penetration rate	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.6667				
	SYSTEM 2	1.5000	1.0000				
Pre paid penetration rate	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.4000	0.4000	0.4000	0.0051	0.0051	
	SYSTEM 2	0.6000	0.6000	0.6000	0.0076		0.0076
						0.0905	**0.1462**

Table E.3: *Marketing department's pairwise comparison matrix to determine system scores.*

				AVERAGED WEIGHT	WEIGHT × SYNTHESIS VALUE	SYSTEM 1 SCORE	SYSTEM 2 SCORE
Total pre paid outgoing billable traffic	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	0.3333				
	SYSTEM 2	3.0000	1.0000				
Total pre paid outgoing billable traffic	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.2500	0.2500	0.2500	0.0085	0.0085	
	SYSTEM 2	0.7500	0.7500	0.7500	0.0255		0.0255
Total pre paid incoming billable traffic	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	1.0000				
	SYSTEM 2	1.0000	1.0000				
Total pre paid incoming billable traffic	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.5000	0.5000	0.5000	0.0014	0.0014	
	SYSTEM 2	0.5000	0.5000	0.5000	0.0014		0.0014
Pre paid billing system availability	**MATRIX**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	1.0000	4.0000				
	SYSTEM 2	0.2500	1.0000				
Pre paid billing system availability	**ANORM**	SYSTEM 1	SYSTEM 2				
	SYSTEM 1	0.8000	0.8000	0.8000	0.0081	0.0081	
	SYSTEM 2	0.2000	0.2000	0.2000	0.0020		0.0020
						0.0181	**0.0290**

Table E.4: *IS department's pairwise comparison matrix to determine system scores.*

Appendix F

Criteria weighting according to the commercial department (service delivery)

$L_{A1,norm}$ (CRITERIA)	A1	A2
Days to deliver invoice (A1)	0.7500	0.7500
Cost per productive hour (A2)	0.2500	0.2500

Table F.1: *Normalized matrix for the commercial department's key personnel's pairwise comparison matrix* L_{A1}.

$L_{B1,norm}$ (CRITERIA)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Pre paid total revenue (B1)	0.1887	0.5208	0.2439	0.0945	0.1550	0.0901	0.1103	0.1949	0.2538
Earnings before interest, tax, depreciation and amortization (EBITDA) (B2)	0.0377	0.1042	0.2439	0.1575	0.1550	0.1803	0.1103	0.1392	0.2538
Mobile handset and accessory sales (B3)	0.0943	0.0521	0.1220	0.1575	0.1550	0.1288	0.1103	0.1949	0.1904
License and management fees (B4)	0.0943	0.0313	0.0366	0.0472	0.0465	0.0451	0.0368	0.0325	0.0305
Operational Expenses (OPEX) (B5)	0.0566	0.0313	0.0366	0.0472	0.0465	0.0601	0.0368	0.0325	0.0381
Bad debt provisioning (B6)	0.1887	0.0521	0.0854	0.0945	0.0698	0.0901	0.0441	0.0974	0.0761
Taxes (B7)	0.1887	0.1042	0.1220	0.1417	0.1395	0.2253	0.1103	0.0650	0.0305
Dealer commissions (B8)	0.0943	0.0729	0.0610	0.1417	0.1395	0.0901	0.1654	0.0974	0.0508
Creditors and accounts payable (B9)	0.0566	0.0313	0.0488	0.1181	0.0930	0.0901	0.2757	0.1462	0.0761

Table F.2: *Normalized matrix for the commercial department's key personnel's pairwise comparison matrix* L_{B1}.

$L_{C1,norm}$ (CRITERIA)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Pre paid opening clients (C1)	0.1149	0.5780	0.1425	0.0528	0.1651	0.1001	0.0884	0.0493	0.0885
Pre paid Average Revenue per User (ARPU) (C2)	0.0230	0.1156	0.2375	0.3302	0.1444	0.0876	0.2527	0.2192	0.2024
Total on network (C3)	0.0575	0.0347	0.0713	0.0357	0.2311	0.1402	0.0884	0.0658	0.0708
Total off network (C4)	0.2874	0.0462	0.2637	0.1321	0.2889	0.1752	0.0884	0.0986	0.0708
Operating income per pre paid client (C5)	0.0402	0.0462	0.0178	0.0264	0.0578	0.0412	0.1769	0.3288	0.2361
OPEX per pre paid client (C6)	0.0402	0.0462	0.0178	0.0264	0.0491	0.0350	0.0221	0.0247	0.0177
Total pre paid clients (C7)	0.1149	0.0405	0.0713	0.1321	0.0289	0.1402	0.0884	0.0658	0.1012
Pre paid market share (C8)	0.2299	0.0520	0.1069	0.1321	0.0173	0.1402	0.1327	0.0986	0.1417
Pre paid penetration rate (C9)	0.0920	0.0405	0.0713	0.1321	0.0173	0.1402	0.0619	0.0493	0.0708

Table F.3: *Normalized matrix for the commercial department's key personnel's pairwise comparison matrix* L_{C1}.

$L_{D1,norm}$ (CRITERIA)	D1	D2	D3
Total pre paid outgoing billable traffic (D1)	0.5263	0.6154	0.3333
Total pre paid incoming billable traffic (D2)	0.2632	0.3077	0.5333
Pre paid billing system availability (D3)	0.2105	0.0769	0.1333

Table F.4: *Normalized matrix for the commercial department's key personnel's pairwise comparison matrix* L_{D1}.

Appendix G

Criteria weighting according to finance department (profitability)

$L_{A2,norm}$ (CRITERIA)	A1	A2
Days to deliver invoice (A1)	0.1667	0.1667
Cost per productive hour (A2)	0.8333	0.8333

Table G.1: *Normalized matrix for the finance department's key personnel's pairwise comparison matrix* L_{A2}.

$L_{B2,norm}$ (CRITERIA)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Pre paid total revenue (B1)	0.1880	0.2105	0.4071	0.3387	0.2857	0.2667	0.3111	0.2222	0.2000
Earnings before interest, tax, depreciation and amortization (EBITDA) (B2)	0.1880	0.2105	0.3256	0.2903	0.2381	0.2000	0.2667	0.1667	0.1333
Mobile handset and accessory sales (B3)	0.0376	0.0526	0.0814	0.0968	0.1905	0.1333	0.1778	0.1667	0.1333
License and management fees (B4)	0.0269	0.0351	0.0407	0.0484	0.0476	0.0667	0.0222	0.1667	0.2000
Operational Expenses (OPEX) (B5)	0.3760	0.2105	0.0163	0.0484	0.0476	0.0667	0.0444	0.0556	0.0667
Bad debt provisioning (B6)	0.0470	0.0702	0.0407	0.0484	0.0476	0.0667	0.0444	0.0556	0.0667
Taxes (B7)	0.0269	0.0351	0.0204	0.0968	0.0476	0.0667	0.0444	0.0556	0.0667
Dealer commissions (B8)	0.0470	0.0702	0.0271	0.0161	0.0476	0.0667	0.0444	0.0556	0.0667
Creditors and accounts payable (B9)	0.0627	0.1053	0.0407	0.0161	0.0476	0.0667	0.0444	0.0556	0.0667

Table G.2: *Normalized matrix for the finance department's key personnel's pairwise comparison matrix* L_{B2}.

$L_{C2,norm}$ (CRITERIA)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Pre paid opening clients (C1)	0.1476	0.6905	0.1800	0.0694	0.1763	0.1240	0.0991	0.0517	0.0901
Pre paid Average Revenue per User (ARPU) (C2)	0.0221	0.1036	0.3001	0.4336	0.1543	0.1085	0.2830	0.2298	0.2060
Total on network (C3)	0.0554	0.0233	0.0675	0.0352	0.2469	0.1737	0.0991	0.0689	0.0721
Total off network (C4)	0.2768	0.0311	0.2498	0.1301	0.3086	0.2171	0.0991	0.1034	0.0721
Operating income per pre paid client (C5)	0.0387	0.0311	0.0127	0.0195	0.0463	0.0511	0.1981	0.3447	0.2403
OPEX per pre paid client (C6)	0.0387	0.0311	0.0127	0.0195	0.0295	0.0326	0.0248	0.0259	0.0180
Total pre paid clients (C7)	0.1107	0.0272	0.0506	0.0976	0.0174	0.0977	0.0743	0.0689	0.1030
Pre paid market share (C8)	0.2214	0.0350	0.0760	0.0976	0.0104	0.0977	0.0836	0.0776	0.1442
Pre paid penetration rate (C9)	0.0886	0.0272	0.0506	0.0976	0.0104	0.0977	0.0390	0.0291	0.0541

Table G.3: *Normalized matrix for the finance department's key personnel's pairwise comparison matrix* L_{C2}.

$L_{D2,norm}$ (CRITERIA)	D1	D2	D3
Total pre paid outgoing billable traffic (D1)	0.5814	0.6757	0.3425
Total pre paid incoming billable traffic (D2)	0.2326	0.2703	0.5479
Pre paid billing system availability (D3)	0.1860	0.0541	0.1096

Table G.4: *Normalized matrix for the finance department's key personnel's pairwise comparison matrix* L_{D2}.

Appendix H

Criteria weighting according to the marketing department (marketability)

$L_{A3,norm}$ (CRITERIA)	A1	A2
Days to deliver invoice (A1)	0.1667	0.1667
Cost per productive hour (A2)	0.8333	0.8333

Table H.1: *Normalized matrix for the marketing department's key personnel's pairwise comparison matrix* L_{A3}.

$L_{B3,norm}$ (CRITERIA)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Pre paid total revenue (B1)	0.2367	0.6431	0.3053	0.1259	0.1950	0.1127	0.1415	0.2138	0.2587
Earnings before interest, tax, depreciation and amortization (EBITDA) (B2)	0.0355	0.0965	0.3053	0.2098	0.1950	0.2253	0.1415	0.1527	0.2587
Mobile handset and accessory sales (B3)	0.0888	0.0362	0.1145	0.2098	0.1950	0.1609	0.1415	0.2138	0.1940
License and management fees (B4)	0.0888	0.0217	0.0258	0.0472	0.0585	0.0563	0.0472	0.0356	0.0310
Operational Expenses (OPEX) (B5)	0.0533	0.0217	0.0258	0.0354	0.0439	0.0751	0.0472	0.0356	0.0388
Bad debt provisioning (B6)	0.1775	0.0362	0.0601	0.0708	0.0494	0.0845	0.0566	0.1069	0.0776
Taxes (B7)	0.1775	0.0723	0.0859	0.1062	0.0987	0.1584	0.1061	0.0713	0.0310
Dealer commissions (B8)	0.0888	0.0506	0.0429	0.1062	0.0987	0.0634	0.1194	0.0802	0.0517
Creditors and accounts payable (B9)	0.0533	0.0217	0.0344	0.0885	0.0658	0.0634	0.1990	0.0902	0.0582

Table H.2: *Normalized matrix for the marketing department's key personnel's pairwise comparison matrix* L_{B3}.

$L_{эC3norm}$ (CRITERIA)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Pre paid opening clients (C1)	0.1298	0.1113	0.2527	0.3412	0.0461	0.1963	0.0938	0.0882	0.2000
Pre paid Average Revenue per User (ARPU) (C2)	0.2597	0.2226	0.1805	0.2275	0.0922	0.2243	0.0938	0.3529	0.3000
Total on network (C3)	0.0186	0.0445	0.0361	0.0142	0.4611	0.0187	0.0312	0.0221	0.0250
Total off network (C4)	0.0216	0.0557	0.1444	0.0569	0.0184	0.0841	0.2813	0.2647	0.1500
Operating income per pre paid client (C5)	0.2597	0.2226	0.0072	0.2844	0.0922	0.1963	0.0938	0.0882	0.0500
OPEX per pre paid client (C6)	0.0186	0.0278	0.0542	0.0190	0.0132	0.0280	0.0312	0.0221	0.0250
Total pre paid clients (C7)	0.1298	0.2226	0.1083	0.0190	0.0922	0.0841	0.0938	0.0441	0.0500
Pre paid market share (C8)	0.1298	0.0557	0.1444	0.0190	0.0922	0.1121	0.1875	0.0882	0.1500
Pre paid penetration rate (C9)	0.0325	0.0371	0.0722	0.0190	0.0922	0.0561	0.0938	0.0294	0.0500

Table H.3: *Normalized matrix for the marketing department's key personnel's pairwise comparison matrix* L_{C3}.

$L_{D3,norm}$ (CRITERIA)	D1	D2	D3
Total pre paid outgoing billable traffic (D1)	0.6897	0.7805	0.3571
Total pre paid incoming billable traffic (D2)	0.1724	0.1951	0.5714
Pre paid billing system availability (D3)	0.1379	0.0244	0.0714

Table H.4: *Normalized matrix for the marketing department's key personnel's pairwise comparison matrix* L_{D3}.

Appendix I

Criteria weighting according to the IS department (network optimization)

$L_{A4,norm}$ (CRITERIA)	A1	A2
Days to deliver invoice (A1)	0.1064	0.1064
Cost per productive hour (A2)	0.8936	0.8936

Table I.1: *Normalized matrix for the IS department's key personnel's pairwise comparison matrix* L_{A4}.

$L_{B4,norm}$ (CRITERIA)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Pre paid total revenue (B1)	0.1967	0.5435	0.2552	0.1000	0.1624	0.0943	0.1159	0.1987	0.2548
Earnings before interest, tax, depreciation and amortization (EBITDA) (B2)	0.0374	0.1033	0.2552	0.1667	0.1624	0.1886	0.1159	0.1419	0.2548
Mobile handset and accessory sales (B3)	0.0934	0.0491	0.1212	0.1667	0.1624	0.1347	0.1159	0.1987	0.1911
License and management fees (B4)	0.0934	0.0294	0.0345	0.0475	0.0487	0.0471	0.0386	0.0331	0.0306
Operational Expenses (OPEX) (B5)	0.0560	0.0294	0.0345	0.0451	0.0463	0.0629	0.0386	0.0331	0.0382
Bad debt provisioning (B6)	0.1868	0.0491	0.0806	0.0903	0.0660	0.0896	0.0464	0.0993	0.0764
Taxes (B7)	0.1868	0.0981	0.1151	0.1354	0.1319	0.2127	0.1101	0.0662	0.0306
Dealer commissions (B8)	0.0934	0.0687	0.0576	0.1354	0.1319	0.0851	0.1569	0.0944	0.0510
Creditors and accounts payable (B9)	0.0560	0.0294	0.0461	0.1128	0.0879	0.0851	0.2615	0.1345	0.0726

Table I.2: *Normalized matrix for the IS department's key personnel's pairwise comparison matrix* L_{B4}.

$L_{C4,norm}$ (CRITERIA)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Pre paid opening clients (C1)	0.1325	0.6439	0.1703	0.0618	0.1720	0.1140	0.0948	0.0508	0.0895
Pre paid Average Revenue per User (ARPU) (C2)	0.0225	0.1095	0.2838	0.3860	0.1505	0.0998	0.2709	0.2256	0.2045
Total on network (C3)	0.0563	0.0279	0.0724	0.0417	0.2407	0.1597	0.0948	0.0677	0.0716
Total off network (C4)	0.2816	0.0372	0.2276	0.1312	0.3009	0.1996	0.0948	0.1015	0.0716
Operating income per pre paid client (C5)	0.0394	0.0372	0.0154	0.0223	0.0512	0.0470	0.1896	0.3384	0.2386
OPEX per pre paid client (C6)	0.0394	0.0372	0.0154	0.0223	0.0370	0.0339	0.0237	0.0254	0.0179
Total pre paid clients (C7)	0.1127	0.0326	0.0615	0.1116	0.0217	0.1154	0.0806	0.0677	0.1023
Pre paid market share (C8)	0.2253	0.0419	0.0923	0.1116	0.0130	0.1154	0.1028	0.0863	0.1432
Pre paid penetration rate (C9)	0.0901	0.0326	0.0615	0.1116	0.0130	0.1154	0.0480	0.0367	0.0608

Table I.3: *Normalized matrix for the IS department's key personnel's pairwise comparison matrix* L_{C4}.

$L_{D4,norm}$ (CRITERIA)	D1	D2	D3
Total pre paid outgoing billable traffic (D1)	0.7627	0.6000	0.8065
Total pre paid incoming billable traffic (D2)	0.0847	0.0667	0.0323
Pre paid billing system availability (D3)	0.1525	0.3333	0.1613

Table I.4: *Normalized matrix for the IS department's key personnel's pairwise comparison matrix* L_{D4}.