

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

Delivering Personalised Advertising in IMS-Based IPTV through Direct Marketing

Declaration

I hereby declare that the content of this document is my own work and that I have not plagiarised any other work. I have also declared any other work that I have used in this document.

This document is submitted to the Department of Electrical Engineering at the University of Cape Town.

This document is submitted to the Department of Electrical Engineering at the University of Cape Town.



Department of Electrical Engineering
University of Cape Town

Prepared by: Phillipa R. Wilson
Supervised by: Neco Ventura

A thesis submitted to the Department of Electrical Engineering,
University of Cape Town, in fulfilment of the requirements
for the degree of Master of Science in Electrical Engineering.

29 April 2010

Declaration

I know the meaning of plagiarism and declare that all the work in the document “*Delivering Personalised Advertising in IMS-Based IPTV through Direct Marketing*”, save for that which is properly acknowledged, is my own.

This thesis is being submitted for the degree of Master of Science in Electrical Engineering at the University of Cape Town.

This thesis has not been submitted before for any degree or examination in any other university.

Signed by candidate

Phillippa R. Wilson

Date 29 April 2010

Acknowledgements

I would like to thank the following people who were instrumental in the completion of this thesis:

My supervisor, Mr Neco Ventura, for your valuable input and guidance throughout the duration of my MSc degree.

To all the CRG members who showed interest in my research work, sat through all my presentations and got as excited as I did when the implementation started to take shape. A special thank you to Vitalis Oziyani for your dedicated help and support. I could not have done it without you.

Thank you to Telkom for providing me with the necessary financial assistance to complete this degree.

To my twin sister, Sarah, for your constant support and motivational words throughout the duration of my MSc degree. I could not have completed this thesis without your help. Last, but not least, thank you to my parents, Gordon and Cathrine, and sister Fiona, for their emotional support throughout my academic endeavours.

Abstract

Multimedia applications and communication services are offered to users free of charge over the open Internet. However, since the Internet is a best effort network, these services are not associated with any Quality of Service (QoS) and Quality of Experience (QoE) guarantees. Furthermore, security cannot be guaranteed when using these services over the open Internet.

Next Generation Networks (NGN) enable the delivery of Internet-based services coupled with QoS, QoE and security guarantees. This is possible through the use of managed Service Delivery Platforms (SDPs) and an all-IP control layer such as the IP Multimedia Subsystem (IMS). The IMS provides the necessary control functionality required to run managed SDPs over NGN networks. Operators are moving away from the theoretical approach, towards actual implementations of complete or partial NGN and IMS networks. However, due to the high level of management and control which is required to deliver these NGN/IMS services over managed SDPs, services are coupled with high operational expenses. Furthermore, NGN and IMS deployment requires large capital expenses.

New revenue streams must be identified to shoulder these costs and overcome the problem of the declining Average Revenue Per User (ARPU). IMS-based IP Television (IPTV) has been identified as a lucrative service due to its ability to offer Video on Demand (VoD) services, live TV and recording services (PVR), while reserving and enforcing certain QoS and QoE levels; security is also guaranteed when using the IMS. However, without a solution to shoulder the large operational expenses of such a service, subscription costs will be too high to compete with free services offered over the open Internet and ensure wide-scale adoption.

Advertising is a proven revenue booster. A number of service providers use advertising as a crucial component of their business models to subsidise service costs. However, due to increased adoption of PVR subscriptions, advertising models are being forced to evolve since subscribers are able to skip, leave out or fast forward through advertisements. This is not attractive to marketers and as a result, network operators and service providers will

miss out on valuable revenue which could potentially be earned from marketers.

Since consumers are demanding more control over services, it is important that advertising is not perceived as obtrusive and unentertaining. Offering personalised advertising is a way to ensure consumers only receive relevant advertisements. A technique known as direct marketing is able to deliver advertisements directly to the target audience. This targeting is proven to be perceived as less obtrusive and more entertaining than traditional broadcast advertising models in standard television services.

This thesis proposes a personalised advertising framework for IMS-based IPTV to increase revenue for service providers, subsidise service costs and increase advertisement entertainment for users and to ensure effective advertising for marketers. This framework must not degrade the user's QoE of the IPTV service. An evaluation platform was implemented to test the effect on users' QoE. This was evaluated by looking at service latency, service features and service quality. The evaluation platform uses the Fraunhofer Fokuz Open IMS Core, UCT IMS Client, UCT Advanced IPTV and UCT IPTV Charging.

Proof of concept tests validated the evaluation platform as a suitable testing environment for the proposed advertising framework. Performance tests were carried out to evaluate the effect of the proposed framework on users' QoE of the IPTV service. Analysis of test results show success of the advertising framework, i.e., no major additional latency in session setup, staying under the standard expected delay; good service features such as easy user profile modification, easy selection of a pricing plan, trick play functions on IPTV media and easy channel selection; and good media quality due to service delivery over a managed SDP.

Future work was identified as a convenient point of departure from this thesis. Such work includes the addition of the wireless dimension to the proposed framework by testing its performance over a wireless access network, such as WiMAX or WiFi. The integration of a recommendation system to make use of the IPTV user profile to not only deliver personalised advertising, but to recommend programmes which the user may be interested in. Lastly, to integrate automatic metadata creation into the framework. In this way, the proposed framework will be fully automated and less prone to errors in metadata assignment.

Contents

Declaration	i
Acknowledgements	ii
Abstract	iii
Glossary	xi
1 Introduction	1
1.1 Research Motivation	4
1.1.1 Problem Definition	4
1.1.2 Research Questions	6
1.2 Thesis Objectives	6
1.3 Scope and Limitations	7
1.4 Thesis Outline	9
2 Related Work	11
2.1 Online Multimedia and Communication Services	12
2.2 Marketing and Advertising	14
2.2.1 The Electronic Media Market	15
2.2.2 The Marketing Value Chain	16
2.2.3 Evolution of the Advertising World	17
2.2.4 Direct Marketing	18
2.3 Marketing in Multimedia/Communication Services	19
2.3.1 Online Advertising	19
2.3.2 Multimedia and Communication Services using Marketing	20
2.4 Digital Television Solutions	22

2.4.1	Web-based Video	22
2.4.2	Digital Video Broadcast	22
2.4.3	Digital Television Advertising	23
2.5	Next Generation Networks and the IMS	23
2.6	IP Television	26
2.6.1	Dedicated IPTV Systems	26
2.6.2	IMS-Based IPTV	26
2.7	Chapter Discussion	29
3	Proposed Personalised Advertising Framework for IMS-Based IPTV	32
3.1	Design Considerations	33
3.2	Architectural Requirements	35
3.2.1	IMS Control Functions	36
3.2.2	Application Servers	36
3.2.3	Databases	37
3.2.4	User Equipment	38
3.2.5	Media Functions	38
3.2.6	Charging Functions	39
3.3	Proposed Personalised Advertising Framework for IMS-Based IPTV Architecture	39
3.4	Chapter Discussion	43
4	The Evaluation Platform - Design and Architecture	45
4.1	Evaluation Objectives	47
4.2	Evaluation Requirements	48
4.3	Limitations of the Evaluation Platform	50
4.4	Architecture of the Evaluation Platform	51
4.5	Operation of the Evaluation Platform	53
4.6	Chapter Discussion	58
5	The Evaluation Platform	59
5.1	Verification of the Evaluation Platform	59
5.2	Evaluation of the Proposed Framework	64
5.2.1	Service Latency	65

5.2.2	Service Features	68
5.2.3	Service Quality	69
5.3	Chapter Discussion	71
6	Conclusions and Recommendations	73
6.1	Conclusions	73
6.2	Recommendations for Future Work	74
A	IMS IPTV Functional Entities, Reference Points and Protocols	76
B	Example Scenario	79
C	Test Bed Hardware and Software	82
C.1	Software	82
C.2	Hardware	83
D	Accompanying CD-ROM	88
	Bibliography	89

List of Figures

1.1	Global advertising spend [8]	2
1.2	USA advertising spend growth of television and Internet marketing [8]	2
1.3	The stages of a hype cycle	4
2.1	USA domestic growth of digital services [46]	11
2.2	USA advertising growth comparison [46]	15
2.3	Expected impact on the marketing value chain [8]	17
2.4	The shift to impact based advertising [8]	18
2.5	High level diagram of the NGN architecture	24
2.6	ETSI TISPAN IMS-based IPTV architecture	27
2.7	The need for personalised advertising	30
3.1	Convergence of players' requirements	34
3.2	Proposed personalised advertising framework for IMS-based IPTV	40
3.3	Categorising algorithm run by the Advertisement AS	41
3.4	Signalling diagram for the proposed framework	42
4.1	QoE dimension [27]	47
4.2	Preference modification page on IMS client	49
4.3	Advert button and banner advertisement	50
4.4	Modified UCT IMS test-bed with advertising and charging	52
4.5	Profiles look-up table for advertisement database	54
4.6	Adverts look-up table for advertisement database	54
4.7	Sending preferences in SDP contents of SIP INVITE	55
4.8	Signalling diagram for the modified IPTV session	56
5.1	Signalling diagram for scenario 1 - Bob	61

5.2	Signalling diagram for scenario 2 - Alice	62
5.3	VoD window during a banner advertisement	63
5.4	Signalling diagram for scenario 3 - Charlie	66
5.5	Session setup latency results for three scenarios	66
5.6	Averaged latencies with standard deviations	67
5.7	User GUI of the UCT IMS Client	69
5.8	VoD trick play functions	70
5.9	Charging preferences	71
A.1	ETSI TISPAN functional IMS-based IPTV architecture [17]	76
B.1	Profiles look up table for advertisement database	79
B.2	Adverts look up table for advertisement database	79
B.3	Adding a user profile	81
B.4	Editing a user profile	81
B.5	Adding an advertisement	81
B.6	Editing an advertisement	81

List of Tables

4.1	Performance targets for audio and video applications [29]	46
5.1	Typical latencies for VoD functionalities [31]	65
5.2	Averaged latency results	67
A.1	Interfaces and protocols for communication between IMS IPTV entities [18]	77

Glossary

3GPP	Third Generation Partnership Project
ACA	Accounting Answer
ACR	Accounting Request
ARPU	Average Revenue Per User
AS	Application Server
ATIS	Alliance for Telecommunications Industry Solutions
AVI	Audio Visual Interleaved
B2BUA	Back-to-Back User Agent
BBC	British Broadcasting Corporation
CAPEX	Capital Expenses
CCA	Credit Control Answer
CCR	Credit Control Request
CDF	Charging Data Function
CDP	C Diameter Peer
CSCF	Call Session Control Function
CTF	Charging Trigger Function
DVB	Digital Video Broadcast
DVB-C	Cable DVB
DVB-S	Satellite DVB
DVB-T	Terrestrial DVB
DVR	Digital Video Recorder
EPG	Electronic Program Guide
ETSI	European Telecommunications Standards Institute
GUI	Graphical User Interface
HSS	Home Subscriber Server
I-CSCF	Interrogating CSCF
IM	Instant Message
IMPU	IMS Public User identity

IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPTV	IP Television
ITU	International Telecommunications Union
ITU-T	Telecommunication Standardisation Sector of ITU
MCF	Media Control Function
MDF	Media Delivery Function
MVNO	Mobile Virtual Network Operator
NGN	Next Generation Network
NSP	Network Service Provider
OCS	Online Charging System
OIPF	Open IPTV Forum
OPEX	Operational Expenses
PC	Personal Computer
P-CSCF	Proxy CSCF
PLR	Packet Loss Ratio
PPC	Pay Per Click
PVR	Personal Video Recorder
QoE	Quality of Experience
QoS	Quality of Service
RIFF	Resource Interchange File Format
ROI	Return on Investment
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
SCF	Service Control Function
S-CSCF	Serving CSCF
SDF	Service Discovery Function
SDP	Service Delivery Platform
SDP	Session Description Protocol
SIP	Session Initiation Protocol
SSF	Service Selection Function
STB	Set Top Box
Telco	Telephone Company
TISPAN	Telecoms and Internet Converged Services and Protocols for Advanced Networking
TV	Television
UA	User Agent
UCT	University of Cape Town

UE	User Equipment
USA	United States of America
VLC	VideoLAN Client
VoD	Video on Demand
VoIP	Voice over IP
WebTV	Web Television

Chapter 1

Introduction

The Internet explosion has made the flow of information more powerful and the access to content ubiquitous. The value of the Internet lies in its ability to connect directly to consumers when and where they want. This provides content and service providers the ability to reach consumers across multiple platforms [46]. The introduction of telecommunication services over the Internet has increased the demand for reliable communication services. IP-based telecommunication networks have been designed to provide rich value-added multimedia communication services to subscribers. These services, which are offered over highly managed Service Delivery Platforms (SDPs), offer guaranteed Quality of Service (QoS) and Quality of Experience (QoE) levels. However, these guarantees are typically coupled with high service costs, where the inducement lies in offering rich value-added services. However, users are able to access multimedia communication services over the Internet, free of charge. It is therefore important for fixed line operators to offer these reliable services at a competitively low cost [39]. This is possible by subsidising service costs through advertising, i.e., by provisioning advertising of third party products and services. This has been proven to achieve better than average returns for telephone companies (telcos) [22][23][46]. As a result, telcos will not only rely on subscription fees to offset their Operational Expenses (OPEX).

In 2006, over \$350 billion was spent on advertising [8]. This included print, television and digital marketing. This \$350 billion market is in transition - the world of advertising is changing. This is mainly due to three factors: evolving technologies, increasingly empowered consumers and more self-reliant advertisers. Figure 1.1 shows the global advertising costs between 2002 - 2006 and projected until the year 2010. This analysis was performed by the IBM Institute for Business Value [8]. Focusing on the trend 2006 - 2010, the graph shows a fairly steady growth in new advertising formats such as mobile, Internet and interactive marketing, as well as a relatively flat trend in traditional advertis-

ing formats such as broadcast, radio and print marketing. Of this \$350 billion market in 2006, approximately \$100 billion was spent on television advertising. This is the second largest category, which accounts for almost 30% of the entire global advertising spend.

Figure 1.2 shows the growth in advertising spend in the United States of America for television and Internet advertising. It can be seen that the growth of Internet advertising spend is increasing at a much faster rate than that of television advertising, with the latter approaching a steady value. In a separate survey [39], Internet advertising was found to be claiming the fastest revenue growth, with a 28% increase from 1998 to 2004. Advertising revenue of broadcast TV increased by 4.8% and newspapers grew by just 1.8%. The obvious question then is, what is causing these trends in advertising spend?

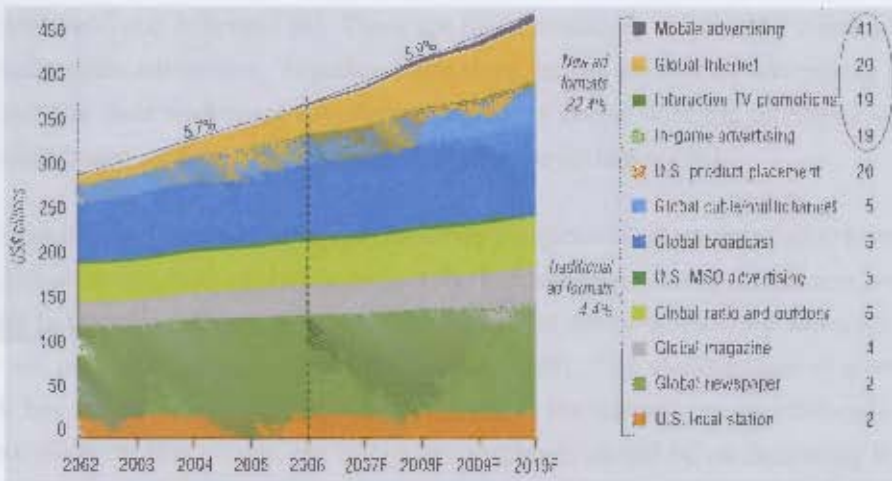


Figure 1.1: Global advertising spend [8]

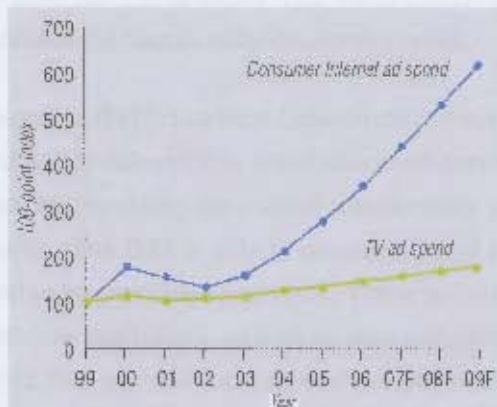


Figure 1.2: USA advertising spend growth of television and Internet marketing [8]

Studies have shown that over the past ten years, more digital television viewers are moving towards a Digital Video Recorder (DVR) or Personal Video Recorder (PVR) and Video on Demand (VoD) style of watching television [46]. The Open IPTV Forum (OIPF) predicts that approximately 50% of American TV households will have PVRs by the year 2010 [25]. Furthermore, in a survey conducted by Parks Associates [39], 62% of respondents indicated that one of the top benefits of a PVR is its ability to fast forward or skip advertisements. PVR capabilities also allow viewers to set their set top boxes (STBs) to automatically leave out advertisements when recording a television program. Furthermore, VoD services can eliminate advertisements altogether [30]. For this reason, media owners and advertising agencies have had to re-evaluate the way in which television advertising is delivered to consumers. In addition to these evolving digital television technologies, two other factors are influencing a change in the way advertising in general is sold, created, consumed and delivered [8]. These are the increasingly empowered consumers and more self-reliant advertisers. Together, these three factors are forcing advertising players to re-evaluate their traditional advertising models to evolve with the increased adoption of Internet-based services and continue to engage the audience [38].

It has been claimed that, on average, a consumer is exposed to more than 3,000 advertising messages everyday, both explicitly and subtly. Furthermore, a lot of consumers are found to “tune in but turn off” when it comes to traditional media advertising when advertisements are intrusive, irrelevant and unentertaining [39]. The re-evaluation of advertising models has shown that it is not just about delivering the advertisements efficiently over a network platform that counts, but rather, the emphasis should be on delivering the right advertisements to the right consumers, and at the right time [8]. A type of marketing, known as *direct marketing*, uses market segments to deliver advertisements to relevant target audiences. This technique has been adopted in a number of business models. In some cases, companies have been established with direct marketing as their sole purpose, or use it to subsidise multimedia communication service costs.

The IP Multimedia Subsystem (IMS) is a Next Generation Network (NGN) control framework which is designed to provide reliable communication services and multimedia applications to subscribers, by providing the control functionality required to run managed SDPs over NGN networks. The IMS is able to provide critical enhancements to service delivery when compared to Internet-based services. These include QoS and QoE guarantees, convergence of services and billing, as well as personalisation of services. The IMS is an IP-based framework that enables convergence and personalisation of services. For this reason, it was chosen as the platform for a personalised advertising framework which is proposed in this thesis to deliver targeted advertisements efficiently over an IP network.

IP Television (IPTV) is a system whereby digital television content is delivered over an IP network infrastructure. It differs from Web-based digital television services in that it is a highly managed system. Over 160 million television households are expected to be using Internet video on their televisions by the year 2011 and 81 million IPTV subscribers are expected by the year 2013. Furthermore, by the year 2014, all television sets are expected to have an Internet connection [25]. IPTV was chosen as the vehicle for the personalised advertising framework to incorporate video advertisements into requested IPTV media and subsidise service costs.

1.1 Research Motivation

This thesis proposes and investigates a framework which is able to deliver advertisements efficiently, using the IMS as the control platform, through IPTV as the vehicle, to targeted consumers using direct marketing. This section describes the motivation behind the research work.

1.1.1 Problem Definition

The hype phase, or *peak of inflated expectations*, of the IMS is over. Figure 1.3 shows the stages in a typical hype cycle. Currently, the IMS is in the final stage, the *plateau of productivity*. This means that operators are now moving towards actual implementations, i.e., complete or partial live IMS networks, and away from the theoretical approach. This requires large investments in both Capital Expenses (CAPEX) and OPEX. Furthermore, such investments require a guarantee on the time frame of the Return on Investment (ROI).

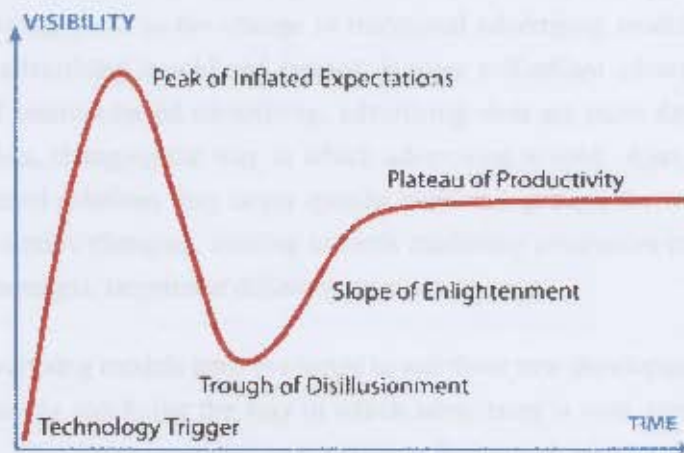


Figure 1.3: The stages of a hype cycle

Further hindrances include the declining Average Revenue Per User (ARPU) and the absence of a so-called *killer application* for IMS. Telcos have been experiencing a decline in ARPU for basic services such as voice. This is mainly due to the fact that voice services are offered at a very low cost, or even free of charge, over the Internet using Voice over IP (VoIP) services. The lack of a killer application for IMS means that revenue needs to be boosted on other services in order to meet the ROI requirements and offset CAPEX and OPEX. The offering of low cost, or free, services over the Internet makes this more difficult, and offering rich value-added services is not enough of an incentive to ensure these IMS-based services are adopted on a wide scale. For these reasons, an alternative incentive needs to be identified to subsidise service costs for subscribers and boost revenue for network operators and service providers.

Network operators and service providers have been provisioning advertising of third party products and services to generate additional revenue [2][6][9][11][14][19][24]. This is due to the proven ability of marketing to provide better than average returns and substantially increase cash flow [46]. An example of such an implementation is marketing text messages. Currently, changes in the advertising world are taking place. This is due to the three factors mentioned earlier: evolving technologies, increasingly empowered consumers, and more self-reliant advertisers.

Evolving technologies are influencing a change in the way advertising is delivered due to an increase in demand for VoD and PVR type services. Another factor influencing a shift in current advertising models, affecting the way in which advertising is consumed, is a change in consumer behaviour. Consumers are demanding more control over services and, as a result, they are getting increasingly more empowered. Marketing should ideally be consumed on the customer's terms, i.e., when and what they want to see. The final factor playing a role in the change in traditional advertising models, affecting the way in which advertising is sold and created, is more self-reliant advertisers. With the introduction of Internet-based advertising, advertising slots are more flexible than rigid broadcast models, changing the way in which advertising is sold. Also, due to the fact that Internet-based solutions may target specific consumer groups, the way in which advertising is created is changing, moving towards marketing companies creating multiple advertising campaigns, targeted at different consumer groups.

Traditional advertising models need to change to suit these new developments. These factors are collectively redefining the way in which advertising is sold, created, consumed and delivered. This thesis proposes an advertising framework which takes these factors into account to provide a solution which suits these new developments. Revenue gener-

ated from this advertising framework will offset CAPEX and OPEX for telcos and subsidise IPTV service costs for subscribers.

1.1.2 Research Questions

This thesis aims to overcome the above mentioned problems and incentivise IMS roll out by monetising IPTV through a personalised advertising system over IMS-based IPTV. In particular, it will answer the following research questions:

- How can advertising be adapted in IMS-based IPTV to suit the paradigm shift in marketing which is taking place due to evolving technologies, increasingly empowered consumers and more self-reliant advertisers?
- Is personalised advertising a feasible business model to encourage the roll out of IMS-based IPTV by increasing revenue for telcos and subsidising IPTV service costs for subscribers?
- Given that advertising will increase revenue for telcos and subsidise service costs for subscribers, how will the introduction of an advertising framework affect the user's QoE of the IPTV service?

1.2 Thesis Objectives

The objective of this thesis is to propose an advertising framework for IMS-based IPTV that will suit the shifts in the advertising world caused by evolving technologies, increasingly empowered consumers and more self-reliant advertisers. Further, this thesis aims to investigate and analyse the suitability of such a personalised advertising framework, for both the telco and the subscriber. For the telco, suitability refers to the feasibility of offering such a platform. For the subscriber, it refers to the effect on QoE of the IPTV service. Secondary to this investigation and analysis, the framework should be analysed through an evaluation platform. More specifically, the objectives of this thesis are to:

- Propose a personalised advertising framework for IMS-based IPTV to overcome the problems of consumers using PVRs to skip advertisements; consumers demanding more control over services; and the need for flexible advertising slots.
- Analyse the feasibility of integrating a personalised advertising platform into IMS-based IPTV from the telco's perspective, i.e., to investigate related works based on generating revenue through provisioning advertising of third party products and services.

- Investigate the effect of a personalised advertising framework on the user's QoE of the IPTV service, based on related works and surveys of consumer's views on advertising.
- Analyse the effect of a personalised advertising framework on the user's QoE through the use of an evaluation platform. The user's QoE should be measured using three parameters. These are *service latency*, more specifically session setup delay; *service features*, such as personalisation; and *service quality*, which specifically looks at the quality of the IPTV video content.

In order to evaluate success or failure of the proposed framework, two metrics are defined to measure the degree of success. These are *revenue* and *QoE*. Revenue is evaluated by investigating related works on the ability of advertising to increase revenue for network and service providers and current implementations of working multimedia and communication services using advertising to subsidise service costs. The user's QoE is assessed through related works investigating users' views on advertising and is measured using an evaluation platform.

1.3 Scope and Limitations

The scope of this thesis is limited specifically to the broadcast traditional advertising model and Internet marketing as a new marketing technique. It looks at the growth rates of these categories and what factors are causing these changes in growth rates.

Although this thesis investigates different digital television solutions and marketing techniques, it focuses on IPTV, using the IMS as the control platform; and on direct marketing to deliver personalised advertisements to IPTV subscribers. Furthermore, although the motivation behind using the IMS is discussed, versus using the open Internet to offer IPTV, this is not the focus of this thesis. The aim is not to motivate the advantages of using the IMS, though these are mentioned, but rather to motivate the use of an advertising framework in order to monetise IMS based IPTV, and further, to ensure that this does not negatively affect the user's QoE.

Within the broad category of IPTV, there are three types of services available. These are broadcast services, on demand services and PVR services. The problem of advertisement skipping is only relevant to on demand (VoD) and PVR services. Advertising in the PVR model is delivered much the same as broadcast services, the difference being that subscribers are able to fast forward through the advertisements. To overcome this problem,

trick play functions could be disabled during commercials, preventing viewers from skipping them. With VoD services, advertisements could be embedded into the VoD content and similar trick play inhibiting could be used to ensure advertisements are not skipped. However, this would negatively affect the user's QoE. This thesis focuses on the VoD service model to propose an alternative way of delivering and viewing advertisements, to ensure they are not easily skipped, but also so as not to degrade the user's QoE. Due to the similarities between the PVR and VoD models, the proposed framework could be migrated to the PVR model.

The charging mechanism used for the proposed framework and evaluation platform is event based charging, since it is best suited for VoD services. However, there is support for other charging mechanisms such as session based charging, which is best suited for broadcast services. Event based charging causes a once-off charge to be levied when a VoD channel request occurs. The proposed framework and evaluation platform is able to support both online and offline charging. However, online charging is used for all testing scenarios to account for the worst case in session setup latency since online charging causes a delay in service delivery with credit checks taking place after the service request. This is not the case for offline charging.

This thesis does not investigate scalability issues of the proposed framework and the IMS. The focus is on the motivation behind proposing this framework and the requirements that are necessary for both the telco and user. Motivation from the telco's perspective focuses on feasibility, i.e., revenue generation from advertising; and for the user, focuses on the effect on QoE. Furthermore, automatic metadata generation and the corresponding collection and analyses of such information, which can be used to identify and deliver targeted advertisements to consumers, is not investigated since it is beyond the scope of this thesis. The framework proposed in this thesis relies on manual metadata creation for advertisements, where information such as a suitable age range and gender for a particular advertisement is specified and entered into a database. The matching process is performed automatically using look-up tables, requiring no data collection and analysis.

To quantify and measure users' QoE of the IPTV service, three parameters were identified. These are service latency, service features and service quality. Underlying factors that affect QoE from the transport layer, such as available network bandwidth, buffering techniques, media coding and QoS classes, are not considered in this thesis. It is assumed that the network has sufficient bandwidth to cater for the VoD service. Furthermore, since service latency is analysed, it is assumed that there are sufficient network resources available if latencies fall within the standard expected delays.

1.4 Thesis Outline

The remainder of this thesis is structured as follows:

Chapter 2 investigates related work and current research on marketing, online multimedia and communication services and digital television solutions. It also elaborates on the IMS and IPTV and describes how they are suitable to host the proposed framework. The background of marketing and advertising is explained by exploring the electronic media market, the marketing value chain, the evolution of the advertising world and the direct marketing technique. Implementations of marketing used in communication and multimedia services are discussed, along with online and digital television advertising.

Chapter 3 presents the design considerations and architectural requirements of a personalised advertising framework for IMS IPTV before detailing the proposed architecture. It first analyses the requirements of the different players: the user, telco and advertiser, to identify a personalised advertising framework as a solution to address the research problem and gaps in the current market. Design considerations are then discussed, followed by the architectural requirements of the proposed framework. Design considerations were deduced from success elements observed in related works and current trends in the advertising sector. Architectural requirements were deduced from current standards and specifications on IMS-based IPTV. The proposed architecture is based on ETSI TISPAN IMS-based IPTV and is integrated with IMS charging to award credits to users who choose to view video advertisements. The framework was designed according to the design considerations and architectural requirements.

Chapter 4 details the design and implementation of the evaluation platform for the proposed framework. The platform is designed to analyse the effect of a personalised advertising framework on the user's QoE of the IPTV service. The framework was implemented in the UCT IMS test bed, using the Fokus Open IMS Core. The UCT IMS Client, UCT Advanced IPTV and UCT IPTV Charging were modified to suit the requirements of the proposed framework. The requirements and limitations of the test bed are introduced, along with the test bed architecture. Details of the test bed's software and hardware are included in Appendix C.

Chapter 5 analyses the evaluation platform. Two types of tests were performed - proof of concept tests and performance tests. The proof of concept tests ensure that the architectural requirements are met and serve to validate the evaluation platform as a suitable testing environment. The performance tests ensure that the addition of the advertising and charging frameworks to the IPTV system does not degrade the user's QoE. Specifically,

the impact on the user's QoE is evaluated by looking at service latency, service features and service quality. Service latency is evaluated using three scenarios and comparing session setup delay obtained for 20 instances in each scenario. The first scenario tests service latency with plain IPTV, i.e., before any advertising and charging functionality was added. Scenario two tests service latency with advertising and charging enabled, but no advertisements are delivered to the user. The final scenario tests service latency with advertising and charging enabled and with targeted advertisements delivered to the user.

Chapter 6 presents the conclusions and recommendations of this thesis. The conclusions answer the research questions which were introduced earlier, based on the work investigated in the literature review and on the evaluation of the proposed framework. It also introduces some future work which is recommended as a point of continuation of this thesis.

Chapter 2

Related Work

Over the past ten years, there has been an increase in subscriptions for three digital services: digital television, high speed data and wireless services [46]. Figure 2.1 illustrates this growth in the United States of America's domestic market, where an increase in demand for all three digital services can clearly be seen.

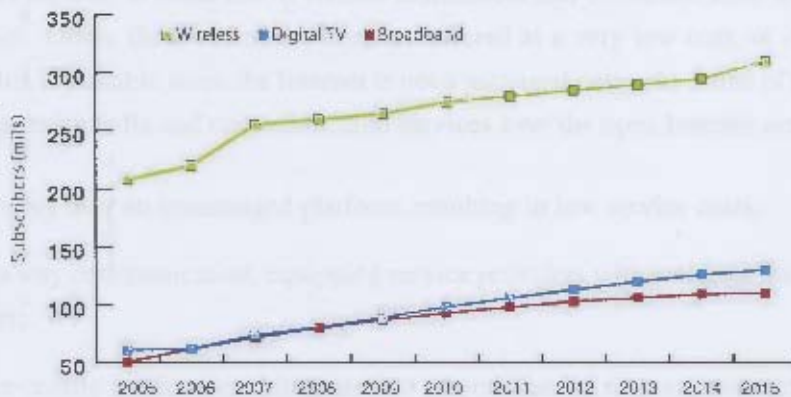


Figure 2.1: USA domestic growth of digital services [46]

Broadband subscriptions increased from 50 million in 2005 to 75 million two years later in 2007, and is expected to reach 100 million by 2015. A similar growth rate can be seen for digital television. This growth has increased the value of service providers in the advertising supply chain and initially increased revenue for Network Service Providers (NSPs). However, as subscription levels continued to grow and competition increased, service costs were driven lower, forcing NSPs to seek additional sources of revenue.

When it comes to advertising, the Internet is particularly useful. Its value lies in the ability to reach a specific target group in fewer tries than broadcast or mass advertising. Another

benefit is its ability to quantify results, as opposed to other marketing techniques which rely on post analysis of a sample audience to estimate the actual size of the consumer group that has been reached. This leads to a delay in the availability of results. This is not the case with Internet advertising since consumer results are available in real time, creating a more efficient market. These advantages also improve advertisers' Return on Investment (ROI) [13]. Furthermore, the data which is collected from IP transactions can be used to build user profiles which can be used in targeted advertising. This further enhances the efficacy of the Internet as a direct marketing medium.

This chapter investigates multimedia and communication services which are currently offered over the Internet. It also examines marketing and advertising in general and implementations of marketing in multimedia and communication services. Lastly, it looks at digital television solutions, as well as the IMS and IPTV.

2.1 Online Multimedia and Communication Services

Consumers are able to make use of various multimedia and communication services over the Internet. Often, these online services are offered at a very low cost, or even free of charge. This is possible since the Internet is not a managed network. Some of the benefits of offering multimedia and communication services over the open Internet are:

- Services over an unmanaged platform, resulting in low service costs;
- Two way communication, equipping service providers with real time feedback from users;
- User-centric services, enabling users to personalise the user experience;
- Dynamic delivery platform, allowing services to be adapted/modified on the fly.

This section describes the most prevalent multimedia and communication services which are offered free of charge over the Internet today.

Streaming Video Services

Consumers are able to access free streaming video services via a number of online providers. The most common are YouTube and iPlayer. YouTube [51] hosts millions of videos, ranging from short clips to longer videos. All content is user generated and uploaded for public viewing. New videos are constantly being uploaded. It is estimated that over 20 hours

of video is uploaded on YouTube every minute [43]. However, YouTube does place restrictions on uploaded content; there is a limit of 100 megabytes, or 10 minutes, on all uploads. This is mainly in an effort to stop copyright infringement. However, trusted uploaders and YouTube partners are allowed to exceed these restrictions. Generally, due to the size limit and the fact that content is user generated, video quality is fairly low.

iPlayer [5] is an online service offered by the British Broadcasting Corporation (BBC) in the United Kingdom. Viewers are able to catch up on the last week of television and radio shows from any PC with an Internet connection. Episodes are available on iPlayer after they have aired on television or radio. It was setup to discourage copyright infringement on the BBC's programmes and no subscription is required. The video quality is higher than that of YouTube and features full length programmes. However, the user's QoE is entirely dependent on the speed of their Internet connection. Slow speeds will cause the content to be interrupted and not appear as a continuous flow, since the stream is buffered. Since its launch in December 2007, over 3.5 million programmes have been watched on iPlayer [43], showing that users are moving towards a more personalised way of watching television.

Voice and Video Communication Services

Communication services are also offered over the Internet using VoIP and video over IP. Both voice and video communication are supported and offered free of charge by Skype and Gtalk, among others. This means that users are able to host voice and video conference sessions as well as one-to-one communication. Skype [41] is free software that can be downloaded to a PC or mobile phone. It works with an Internet or data connection to offer free Skype-to-Skype voice and video calls. It also allows calls to mobile numbers and fixed lines at costs which are typically lower than rates offered by telephony and mobile operators [40].

Gtalk [21] may be used as a standalone client, or built-into Google's Gmail. It allows voice and video communication between PCs in the same way as Skype. It also allows file transfer between gtalk clients.

Data Communication Services

Another extremely popular IP-based service is Instant Messaging (IM). This is a text-based real time communication service. Both Skype and Gtalk, among others, may be used for IM purposes. It is estimated that over 23 billion instant messages are sent each day [43].

In addition to the above mentioned online services, there are several others which are growing in popularity. These are social networking sites such as facebook and twitter; blogging sites such as myspace; and multimedia sharing sites such as Flickr. The popularity of these services is constantly growing. Currently, there are over 130 million blogs in operation and over 4 million photos are uploaded each day on Flickr [43].

This is all very attractive to users, given the wide range of services which are available and that the majority can be accessed at no cost to the user. However, since these services are offered over the open Internet, which is a best effort network, communication is unreliable and can often be intermittent. This is not ideal for business conference calls, and can be extremely annoying to the end user. Furthermore, security cannot be guaranteed over an unmanaged platform. It is possible to offer reliable and secure IP based services by using managed service delivery platforms. This merges the benefits of IP-based services with the reliability of telecommunication services. However, this management and reliability comes at a cost, to both the NSP and the subscriber.

To shoulder some of the operating costs of managing an SDP, many service providers have turned to marketing as a solution. The next section describes some multimedia and communication services which are subsidised by marketing, after detailing some background on marketing and advertising.

2.2 Marketing and Advertising

Advertising has the proven ability to improve revenue. This can substantially increase cash flow [46]. Furthermore, offering targeted advertising can further increase revenue [8][22][23][39]. In addition to this, targeted advertising results in higher QoE for the user as irrelevant advertisements are not shown [38].

Broadcast advertising over media such as television can be costly. Typically, for a company which advertises on television, 60% of their marketing budget is spent on broadcast advertising [8] due to high broadcast costs. With this type of marketing, there is no way to know who you are reaching and how effective your advertising campaign is. Furthermore, consumers have increasing control over marketing messages; they are able to choose how to interact with marketing messages and how to filter and block them. For this reason, it is important to make sure marketing messages are reaching the intended customers to be effective [7][8], i.e. the right advertisements delivered to the right people at the right time. According to a survey conducted in February 2009 on behalf of TRUSTe [42], 72% of

those surveyed found online advertising to be intrusive and annoying when the products and services being advertised were not relevant to them.

Direct marketing uses market segments to target relevant advertisements at the appropriate audience. However, to design an advertising framework which will suit the current trends in the media market and consumer behaviour, it is necessary to first look at the current state of the electronic media market and the marketing value chain.

2.2.1 The Electronic Media Market

There are three entities in the electronic media market; these are television, Internet and wireless (mobile/cell) phone advertising).

Television

On average, Americans watch television five times more than they use the Internet [25]. Television still makes up the largest share of the electronic media market today [46], despite the shift towards Internet based models. This is due to its ability to reach a large audience and deliver high entertainment value. Figure 2.2 shows the growth in revenue received from television advertising in comparison to newspaper and online advertising in the USA's domestic market.

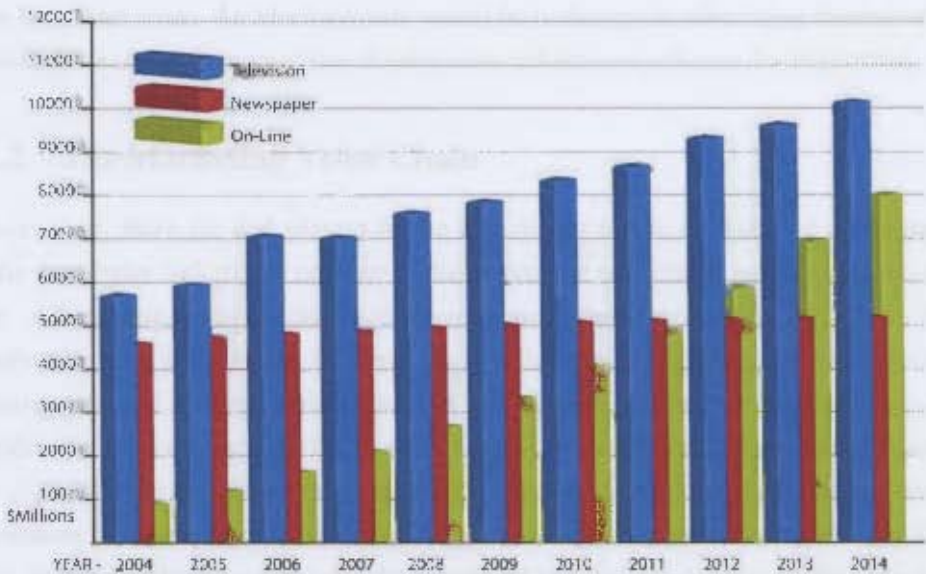


Figure 2.2: USA advertising growth comparison [46]

Television advertising revenue is at a higher value than newspaper and online advertising. However, online advertising revenue is growing at a faster rate than television advertising.

Internet

The reason for the fast growth in Internet advertising revenue is the ability of the Internet to provide an advertisement network which is able to measure the effectiveness of an advertising campaign in real time. Furthermore, the advertiser need only pay for the actual impact on the consumers, rather than incurring large broadcast costs that results in the campaign reaching a large unintended audience. This is possible with methods such as Google AdSense which uses a Pay Per Click (PPC) technique. In an experiment [12], it was discovered that 83% of advertisers' money was wasted due to marketing messages reaching unintended consumers.

Wireless

Wireless advertising revenue is on the increase since it adds a further benefit to the Internet based model. This is mobility, meaning that users can be reached anytime and anywhere.

It can be seen that television is able to deliver the highest entertainment value and capture the largest audience. However, the Internet provides a more efficient platform for an advertising framework since it is able to measure the effectiveness of an advertising campaign in real time, target relevant advertisements at the right people and eliminate large broadcast costs. An ideal solution would be to design an advertising framework that combines the entertainment value of television and Internet efficacy for marketing.

2.2.2 The Marketing Value Chain

In television, there are five players in the advertising media market: the consumer, the media distributor (telco), the content/media owner, the advertising agency, and the advertiser. Advertising agencies purchase advertisement slots from media owners on behalf of advertisers. Traditionally, this process is rather rigid, requiring advertising slots to be purchased and scheduled six months in advance [37]. However, as mentioned in the introduction, the way advertising is sold, created, consumed and delivered is changing. The shift is towards a user-centric approach, providing an interactive, personalised and permission based experience. As a result, there is a need for a flexible advertising framework, in which advertisements may be scheduled and delivered dynamically. The shift in advertising models has an effect on the marketing value chain. Figure 2.3 illustrates what economic shifts are expected to take place for the five players.



Figure 2.3: Expected impact on the marketing value chain [8]

The impact is expected to result in positive economic shifts for advertisers and consumers, as well as for interactive media buyers and media distributors. This is expected due to the current shifts in the media market and consumer behaviour. Moderate increases are expected for traditional media distributors such as telcos. However, for traditional agencies and broadcasters, no positive shifts are expected. As consumers, interactive players and advertisers continue to gain power, these traditional players will lose their impact on the value chain, unless they evolve to suit these trends [8].

2.2.3 Evolution of the Advertising World

Due to the current trends in the media market and consumer behaviour, there has been a shift in the advertising world. This has been necessary for advertisers to continue to reach their desired audiences and design effective advertising campaigns [4]. The shift has been from disruptive and non targeted broadcast advertising to targeted and interactive advertising [23]. This model suits the evolving technologies towards DVRs and PVRs; the increasingly empowered consumers demanding more control over what they want to watch and when; and the more self-reliant advertisers requiring flexible advertising slots.

More effective advertising for advertisers means better targeting, higher interactivity, proof of play at the consumer end, improved analytics and greater agility in advertising slots. While for the consumer, more effective advertising means more personalised and interactive advertising campaigns [37]. An IP based solution is able to achieve this.

There is a migration from impression based advertising towards impact-based advertising [8]. Television uses impression-based advertising, where advertising slots are purchased based on an estimate of the number of viewers or impressions which are expected for a

particular program. The size of the audience is estimated after the program has aired, based on a sample size. This type of measurement is not accurate and accounts are only settled well after the program has aired. Whereas, impact-based advertising, which is used in the Internet, is a more efficient method, using performance based metrics such as cost per click to directly measure the impact of the advertising campaign. Figure 2.4 shows the expected migration towards impact-based advertising and the time frame associated with the migration. This prediction is based on IBM advertising industry executive interviews and panel discussions which took place in 2007.

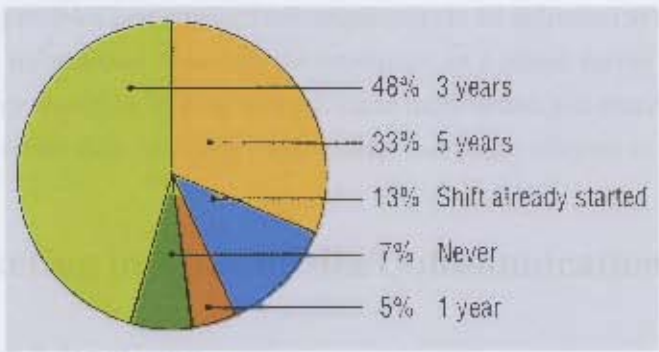


Figure 2.4: The shift to impact based advertising [8]

It can be seen that at this stage, 13% of advertising revenue had already started to shift towards impact-based formats.

The move towards personalised and interactive advertising means leaving behind traditional mass marketing and broadcast models, and moving towards a more targeted approach. This will cut broadcast costs for advertisers since target markets are reached directly and in so doing increase turnover for telcos. A technique known as *direct marketing* is able to reach target audiences directly using market segments, thereby eliminating large broadcast costs and delivering personalised advertisements.

2.2.4 Direct Marketing

The aim of mass marketing is to broadcast a message to reach the largest possible audience. This technique ignores market segments and targets the whole market with one offer. Media such as radio, television and print are typically used for mass marketing. It relies on high sales at low prices since the costs associated with broadcasting mass marketing messages are extremely high. As a result, mass marketing can mean a low turnover for advertisers and hence low revenue for telcos.

Direct marketing on the other hand aims to focus marketing messages at a specific group of people. It uses market segments to focus offers at relevant audiences. Typically, media such as email, post and telephony are used for direct marketing. High sales are not required since there are no broadcast costs and the target market is reached directly, therefore direct marketing usually results in a higher turnover than mass marketing [38], i.e., direct marketing is a higher revenue booster and thus more of a commodity for telcos [8] since advertisers could receive 5 - 10 times better response rates with direct marketing when compared to non targeted advertising [23]. This marketing method suits the paradigm shift in advertising since the movement is towards personalised advertising. Direct marketing enables personalised advertisements to be delivered to the relevant consumers by using information shared by the consumer. In a recent survey [39], consumers indicated that they would be willing to share some information and receive more targeted advertisements, rather than watching commercials that aren't relevant to them.

2.3 Marketing in Multimedia/Communication Services

2.3.1 Online Advertising

Since the Internet is able to offer targeted advertising and enables measurement and analysis of user interaction, it is a popular advertising medium. Implementations such as Google AdSense [20], Yahoo! Search Marketing [50] and Microsoft adCenter [33] all work on a pay per click basis. This means that advertisers only pay for the actual impact that the advertising campaign delivers, rather than paying for the message to reach thousands of people who are not interested in what is being advertised [12]. Advertisers pay each time the advertisement is clicked on by a user. Furthermore, only relevant advertisements are placed on web pages. Keywords identified in the body of the web page are used to place relevant text, image or video advertisements on that page.

This type of marketing allows advertisers to create tailored advertising campaigns, making multiple versions of an advertising campaign to suit different keywords which may be identified on a website. This boosts ROI for telcos since advertisers will receive better response rates due to targeted advertising [8][23][38].

Amazon [3] and eBay [15] are other examples of online personalised advertising services. Their personalised advertising and recommendation systems use distributed user profiles to recommend other products that the user may be interested in. These decisions are made based on profile information which is shared, as well as purchase and browsing history.

2.3.2 Multimedia and Communication Services using Marketing

Advertising is a crucial component in the business models of a number of multimedia and communication companies around the world. One such example is a WiFi service provider which offers free WiFi access at Denver Airport in Colorado to users who choose to watch a 30 second video advertisement. Another example is Turtle Entertainment in Germany, an online gaming company; the majority of their revenue is made through marketing messages which are targeted at their users. 67% of their total revenue is made from advertising sponsorship alone [36]. A survey from Points North Group and Horowitz Associates in the USA concluded that 75% of respondents would choose to view advertisements with video content if it meant watching the video at no cost, rather than paying for the video content without advertisements, if they had the choice [26]. The remainder of this section discusses other services which use marketing and advertising as a crucial part of their business models.

YouTube

YouTube introduced video advertisements in 2007. They are designed to be as unobtrusive as possible since disruptive advertisements tend to be non effective [30]. Text boxes appear over a video 15 seconds into playback. They occupy 20% of the video window and disappear after 10 seconds if it is not clicked on. The text advertisement is related to the video being watched and contains a link which is connected to another video advertising a product. Video advertisements on websites are expected to be valued at \$4.3 billion in 2011 in the USA [6].

E-Plus

E-Plus is a German mobile carrier. Together with Alcatel-Lucent and a subsidiary, Gettings, E-Plus offers a cheaper mobile service to subscribers in exchange for receiving advertisements [24]. Alcatel-Lucent provides the equipment that sends advertisements to mobile devices. This is done based on demographic information provided by Gettings, a subsidiary of the mobile carrier. Customers can opt in and get free minutes and texts as a reward for receiving advertisements. Three different plans are available that send between 10 and 25 advertisements per week. All advertisements are targeted; when subscribers sign up, they select topics of interest from a checklist.

Alcatel-Lucent's Advertising Selection Server provides service providers with control over the management and delivery of mobile targeted advertisements [11]. The server

contains targeting algorithms to enable service providers to offer advertisers highly focused advertising campaigns. Mobile marketing messages can be delivered via SMS, MMS and WAP and are interactive and personalised. The mobile advertising market is growing; it is expected to grow from \$160 million in 2008 to \$3.1 billion in 2013 [2].

Alcatel-Lucent's Advertising Selection Server has the ability to increase IPTV revenue by enabling advertisements to reach targeted customers on IPTV networks [11]. This solution uses subscriber profiles, service usage and demographic information to select relevant advertisements.

Blyk

Blyk is a Finnish mobile company which originally started up as an ad-funded Mobile Virtual Network Operator (MVNO) [14]. They offered free calls and texts to subscribers between the ages of 16 and 24 in exchange for receiving advertisements. A maximum of 6 messages were sent each day to subscribers in exchange for 217 free texts and 43 free minutes per month. This attracted 200,000 UK customers and advertisers such as Coca-Cola, Adidas, Xbox and McDonalds. Blyk announced a shift in focus in July 2009 to expand their company's borders [9]. They partnered with Vodafone and Orange to deliver mobile advertisements to their subscribers.

Argela

Argela Technologies is a Turkish IMS application developer. They developed an ad-subsidised VoIP platform to lower subscription costs that plays advertisements while the subscriber is waiting for their VoIP call to connect [19]. When a call is made, the Session Initiation Protocol (SIP) client on the mobile phone, which is required for VoIP calls, connects to the Argela server and delivers an appropriate advertisement instead of a ringing tone. When the called party answers the call, the advertisement is stopped and the call is connected.

It is clear that advertising is a worthy revenue booster. Many service providers are using marketing to increase revenue and to subsidise service costs for subscribers. The trend in the above discussed services is towards delivering targeted and interactive advertising. This further increases revenue since service providers are able to offer focused marketing campaigns to advertisers. Furthermore, subscribers benefit since irrelevant advertisements are not seen.

A number of key success elements were identified in the above discussed solutions:

- Targeted/personalised advertising messages, to increase revenue from advertisers and increase QoE for the user;
- Unobtrusive and non disruptive advertising, so as not to degrade the user's QoE;
- A permission based system, allowing subscribers to opt in or opt out, or to choose between different pricing plans;
- A reward for viewing advertisements, to encourage subscribers to opt in;
- Interactive advertisements, to encourage participation from the subscriber.

2.4 Digital Television Solutions

Digital television solutions can be divided into Web-based video and Digital Video Broadcast (DVB). Both types offer access to digital video media, although their approaches differ.

2.4.1 Web-based Video

Web-based video is IP based and may be accessed through any PC with an Internet connection. As mentioned earlier, this limits QoS due to the best effort nature of the open Internet. Furthermore, the user's QoE is limited due to the size and resolution of the PC screen and the low quality video that is generally delivered over the Internet. Broadcast television is not supported by web-based solutions. Content is either user generated or on demand. These services do not generally require a subscription. YouTube [51] and iPlayer [5] are examples of Web-based video implementations.

2.4.2 Digital Video Broadcast

Three types of DVB services exist, these are Satellite DVB (DVB-S), Cable DVB (DVB-C) and Terrestrial DVB (DVB-T). DVB services may be accessed through a STB connected to a television and either a satellite, cable or terrestrial connection. Both broadcast and on demand services are supported by DVB solutions. Since these services are offered over a closed and managed platform, unlike Web-based video, they do not suffer from limited QoS and QoE levels, but they do require a subscription.

Implementations of Web-based video have also moved to television sets, requiring a STB, an Internet connection and a subscription. This is more of a hybrid solution, merging web-based video and DVB, e.g., WebTV [32]. Such implementations support broadcast and

on demand video and can be classified as IPTV solutions. They are standalone services, falling into the category of dedicated IPTV systems. These systems are generally bundled with broadband services, allowing some level of convergence. However, for complete service convergence, IMS-based IPTV is required.

2.4.3 Digital Television Advertising

Marketing in Web-based video may be personalised since it is an IP based service. Online targeted advertising may be used to place relevant advertisements on the web page offering access to video content. In DVB and WebTV, marketing is broadcast-based with a linear advertisement insertion model. Similarly, on demand content in DVB and WebTV has embedded advertisements, conforming to the same linear model. Some level of targeting is done. For example, sport equipment advertisements are placed during a football match, accessed either by live broadcast or VoD. This is done using metadata [7], which is information that describes the content of a television programme, e.g., audience demographics and the program title. Metadata may be created manually or automatically. However, due to the linear advertisement insertion model, all TV sets receive the same advertisements, are shown to a schedule and they interrupt television programmes [26]. This negatively affects users' QoE. Hence, there is a trade-off between Web-based video and DVB/WebTV: Web-based video has the possibility of personalised advertising, but suffers from limited QoS and QoE. Whereas, DVB and WebTV does not have these limitations, but personalised advertising is not a possibility. It would therefore be ideal to combine the benefits of targeted online advertising with the QoE and QoS of DVB and WebTV. This would ensure maximum entertainment and QoE for the subscriber and boosted revenue from targeted marketing campaigns for service providers.

With IPTV, this is possible. It is an IP based service, but is offered over a highly managed SDP, giving the QoS and QoE of Digital Video Broadcast television. In order to deliver personalised advertising efficiently over the IMS, a direct marketing platform must be incorporated into the standard operation of IMS-based IPTV. The following sections discuss the background and operations of the IMS and IPTV.

2.5 Next Generation Networks and the IMS

The IP Multimedia Subsystem (IMS) is an architectural framework which provides the necessary control functionality required to run managed SDPs over NGN networks. All-IP networks, enabled by the IMS and SDPs, offer possibilities for reliable and secure

communication services and multimedia applications for subscribers. The IMS was originally standardised by the 3GPP [1] as a service control layer to run over their IP-based 3G networks.

The converged IP core in NGN networks, which forms the control plane, constitutes the IMS. For this reason, the control plane is also known as the IMS layer. NGN networks are heterogeneous, allowing access to the IMS layer through various access networks. This enables support for both fixed and mobile users. Its architecture is divided into four planes: the application plane, control plane, transport plane and access plane. Figure 2.5 shows a high level schematic of the NGN architecture.

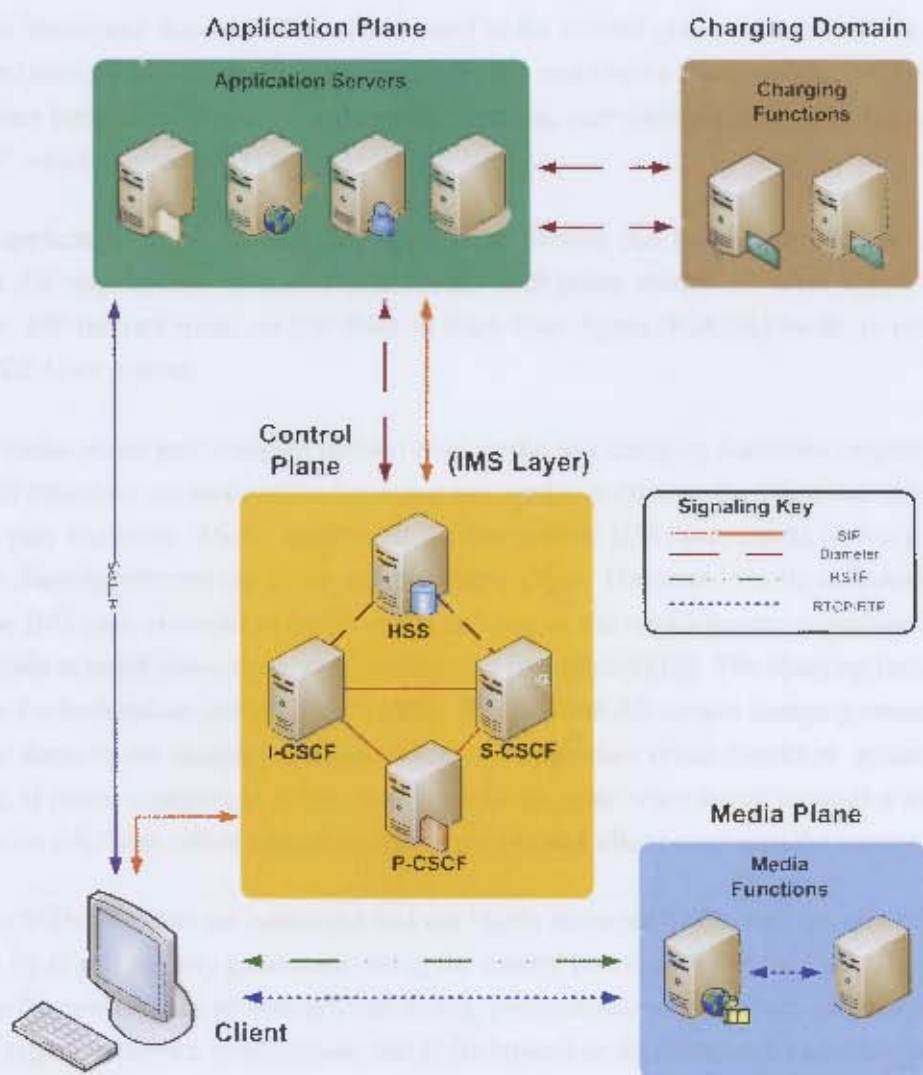


Figure 2.5: High level diagram of the NGN architecture

The IMS core is made up of SIP servers called Call Session Control Functions (CSCFs) that are responsible for session control. There are three types of CSCFs, namely the Proxy CSCF (P-CSCF), the Interrogating CSCF (I-CSCF) and the Serving CSCF (S-CSCF). The P-CSCF handles the control functions of the SIP-based communication and is the first point of contact between the client and the IMS network. It acts as a SIP proxy server and forwards SIP requests and responses in the appropriate direction. It also performs security related functions. The I-CSCF retrieves user location information and routes the SIP requests to the appropriate destination, typically to an S-CSCF. The S-CSCF is the central node of the control plane. All the SIP signalling in the IMS traverses the allocated S-CSCF. It inspects every SIP message and determines whether the SIP signalling should visit one or more Application Servers (AS) on its way towards its final destination. The Home Subscriber Server (HSS), also located in the control plane, contains all the user-related subscription information required to handle multimedia sessions. This information includes location information, security information, user profile information and the S-CSCF which is allocated to the user [10].

The application plane contains SIP Application Servers that host and execute services. Each AS may operate in one of four modes: SIP proxy mode, SIP User Agent (UA) mode, SIP redirect mode, or SIP Back-to-Back User Agent (B2BUA) mode, to connect two SIP User Agents.

The media plane and charging domain host media and charging functions respectively. Media functions are responsible for delivering media streams to the client and allowing trick play functions. Media streams do not traverse the IMS core; media delivery takes place directly between the client and the media plane. However, it is the responsibility of the IMS core elements to facilitate the delivery of the media stream according to the available network resources and client terminal capabilities [10]. The charging functions allow for both online and offline charging. The relevant AS creates charging events and sends these to the charging domain where the appropriate credit checks or updates are done. If online charging is active, credit checks are done when a user requests a service from the AS. With offline charging, credits are updated after a user ends the session.

Since NGN networks are converged and run highly managed SDPs, they are able to offer QoS, QoE and security guarantees, using the control functionality of the IMS. They also allow for convergence of services and billing, personalisation of services and integration with legacy networks. Furthermore, due to its layered architecture, rapid service creation is possible [31]. Offering services over NGN networks, using IMS functionality, allows these services to reuse well standardised IMS components to enforce IP control.

2.6 IP Television

There are three types of IPTV services. These are broadcast/live television services; on demand/unicast services (VoD); and PVR services which allow recording, pause and time shifting of the video stream.

Many different IPTV architectures have been proposed by the various standardisation bodies and are generally vendor specific. However, they can all be classified as one of two types of architectures: dedicated IPTV or IMS-based IPTV. Although these are two different approaches, they both have the common goal of delivering managed TV and video to the user over an IP channel to enhance the traditional television experience. Enhancements include recording capabilities, time shifting and a personalised service. IPTV is able to combine the flexibility of Web-based video with the reliability of DVB and WebTV to deliver a personalised and highly managed digital TV service to the subscriber.

2.6.1 Dedicated IPTV Systems

Dedicated IPTV Systems use a dedicated subsystem within an NGN platform to provide all the required IPTV functionality, such as service control and user profile management, to subscribers [35]. These systems have the advantage of dedicated resources. However, they are closed proprietary solutions. As a result, inter-working with other NGN elements to provide a converged service becomes difficult. As a result, dedicated IPTV systems are generally used as standalone services.

2.6.2 IMS-Based IPTV

IMS-based IPTV allows the IPTV service to make use of embedded IMS functionality such as authentication, authorisation and accounting [31]. This ensures minimal wastage of resources in the network and ensures convergence, since a common IMS core is used to provide the control functionality for all NGN services. Standard bodies such as the Open IPTV Forum (OIPF) are pushing IMS/NGN based telecommunication services for convergence [25]. Other advantages of offering IPTV over the IMS are support for single sign on, subscription and session management, roaming, service personalisation and unified charging and billing [35].

The IMS-based IPTV architecture standardised by the European Telecommunications Standards Institute (ETSI) Telecoms and Internet Converged Services and Protocols for Advanced Networking (TISPAN) [16] is the most widely accepted IMS-based IPTV

The UE communicates with four entities. These are the P-CSCF, the IPTV AS, the MCF, and the MDF. Communication with the P-CSCF takes place when the user requests a service. Interaction with the IPTV AS allows service discovery, service selection and service control. The UE communicates with the MCF to achieve trick play functions such as pause and fast forward; and the MDF link is used to deliver the media stream directly to the user [49]. The MCF maps the channel request to the appropriate media file stored in the MDF and controls media delivery to the UE, through the MDF, according to user policies.

Once the P-CSCF receives a service INVITE request from the UE, it routes it through the IMS core. The P-CSCF forwards the request to the I-CSCF which queries the HSS to discover the S-CSCF. The request is then forwarded to the S-CSCF. The S-CSCF utilises the user's service profile that was downloaded from the HSS at user registration to determine the IPTV AS to which the request is forwarded. The IPTV AS then retrieves the user's subscription information from the HSS and authorises the service request. Once validated, a service request is sent to the MCF and MDF via the S-CSCF on behalf of the user. The MCF controls the media delivery, according to user policies, through the MDF, which is responsible for delivering the media stream directly to the user. The MDF is also responsible for processing, encoding and transcoding of the media to suit various terminal capabilities [48].

The IPTV AS is embedded with a Charging Trigger Function (CTF) which is responsible for detecting chargeable events arriving at the IPTV AS. Chargeable events are SIP messages which are received at the AS, such as INVITE and BYE messages. This architecture supports both online and offline charging. For online charging, the CTF detects chargeable events which are mapped to charging events created by the CTF and sent to the Online Charging System (OCS) in the charging domain. For offline charging, the CTF sends charging events to the Charging Data Function (CDF) in the charging domain. When online charging is used, there is a delay in service delivery since a check is performed to verify that the user has sufficient credits for the selected service. To do this, the CTF sends a Credit Control Request (CCR) message to the OCS when the IPTV AS receives an INVITE message. The OCS responds with a Credit Control Answer (CCA) indicating whether the user has sufficient credits. If the user has insufficient credits, the UE is notified and the session is terminated. At the end of the session, a CCR of type STOP is sent to the OCS by the CTF once the IPTV AS receives the BYE message. If offline charging is used, service delivery commences immediately after the service request message is authorised by the IPTV AS. During the session, the CTF sends information on service usage to the CDF using interim Accounting Request (ACR) messages. Account-

ing Answer (ACA) messages are received from the CDF in response to ACR messages. The charging mechanism used will determine what information is sent to the CDF, as well as the periods at which it is sent. For VoD IPTV services, event based charging is the most appropriate charging mechanism. This causes a once-off charge to be levied when a VoD channel request occurs. Communication between the application plane and charging domain uses the Diameter protocol. The Rf interface is used for communication between the CTF and CDF, and the Ro interface is used between the CTF and OCS.

For simplicity, the Service Selection Function (SSF), Service Discovery Function (SDF) and Service Control Function (SCF) are co-located within the IPTV AS in this architecture diagram. The SSF and SDF provide the user with information required to select an IPTV service, e.g., a VoD channel. The SCF handles the requests from the user and is responsible for service and session control [10].

User Profiles

Personalisation of services is a key feature in IMS-based IPTV. User profiles are used to achieve personalisation at the application level. IPTV related user profile information may enable users to receive personalised Electronic Program Guides (EPGs), advertisements and other communication services [31]. IPTV user profiles are similar to IMS user profiles. However, IMS user profiles are stored in the HSS and contain information such as private and public user identities, subscription information and filtering criteria [10]. Whereas, IPTV user profiles are usually stored in the application plane, either in the IPTV AS or in a document management server. There is an IPTV user profile for every user who subscribes to the IPTV service. This profile may be mapped to the default IMS user profile if no information is shared by the user. The IPTV user profile may contain details such as the user's age and gender. It also facilitates services such as parental control [48][49].

2.7 Chapter Discussion

Figure 2.7 summarises the chapter and illustrates the need for personalised advertising by showing current solutions, their drawbacks and the associated progression in the media market to overcome these drawbacks.

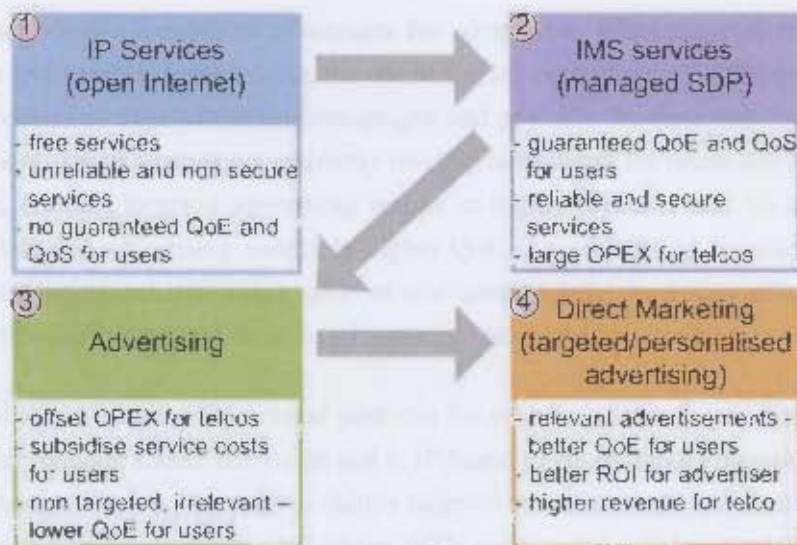


Figure 2.7: The need for personalised advertising

Users are able to access multimedia and communication services over the open Internet, free of charge. However, these services are unreliable and not secure. The IMS is able to offer reliable and secure services by providing the control functionality required to offer services over a managed SDP. The management and control of SDPs translates to large OPEX for telcos. This results in telcos having to charge high subscription fees, meaning that services are unlikely to be adopted on a wide scale.

Advertising is proven to boost revenue for service providers and has been adopted in a number of business models to alleviate the costs of offering services to subscribers over managed SDPs. This results in subsidised service costs.

However, an increasing number of users are moving towards watching digital television through DVRs and PVRs and are demanding more control over services. This means that users are able to skip, leave out or fast forward through advertisements. As a result, there is a need for traditional marketing models to evolve to ensure advertising campaigns are effective and that consumers do not just “tune in, but turn off”. To be effective, marketing messages should reach the right consumers. Direct marketing is able to deliver marketing messages directly to the target audience. Non-effective advertising campaigns result in lower revenue from advertisers for telcos and a lower QoE for users. It has been shown that providing advertisements that are relevant to consumers’ wants and needs boots their QoE of the television service. Furthermore, traditional broadcasters will lose their impact on the marketing value chain if they fail to modify their advertising models.

The Internet offers a number of advantages for advertisers. Marketing can be targeted, interactive and flexible. Furthermore, the use of the Internet allows marketers to measure the effectiveness of their advertising campaigns and pay only for the actual impact made on consumers. These advantages indirectly result in advantages for telcos and consumers. For telcos, offering targeted advertising results in higher revenue; and for consumers, receiving targeted advertising results in higher QoE. An advertising framework that is able to combine the entertainment value of television and the marketing efficacy of the Internet will therefore be beneficial to advertisers, telcos and consumers.

IMS-based IPTV is therefore an ideal platform for such an advertising framework. It is able to offer reliable, secure television and is IP-based to allow for an efficient marketing system. User profiles may be used to deliver targeted advertisements to subscribers. This will not negatively affect users' QoE of the IPTV service and will boost telcos' revenue to monetise IPTV and incentivise wide scale adoption of the service.

Chapter 3

Proposed Personalised Advertising Framework for IMS-Based IPTV

This chapter presents a personalised advertising framework for IMS-based IPTV to address the research problem identified in Chapter 1 and the gaps in the current market identified in Chapter 2. It is put forward as an effective solution to overcome the problem of PVR and DVR advertisement skipping for advertisers and to increase revenue for telcos. However, these must not be achieved at the expense of the user's QoE of the IPTV service. The effect of delivering personalised advertising on the users' QoE is investigated in the next chapter. QoE is evaluated by looking at the effect that the proposed framework has on three parameters: service latency, service features and service quality.

The proposed framework is based on the VoD service of IPTV. It uses online charging to account for the worst case service latency since this method of charging requires credit checks at session setup to ensure the user has sufficient credits for the requested service. These checks add to session setup delay. Event based charging is used as the charging mechanism since this is best suited for the VoD service as it causes a once-off charge to be levied at session setup.

Design considerations and architectural requirements for a personalised advertising framework are presented in this chapter, followed by the architecture of the proposed framework, integrating a personalised advertising platform with IMS-based IPTV and IMS charging. Design considerations are discussed from the different players' perspectives to ensure all their needs are addressed. Architectural requirements are then considered to ensure the proposed framework is in line with the 3GPP IMS specifications [1] and the ETSI TISPAN IMS-based IPTV architecture [16].

3.1 Design Considerations

To ensure the personalised advertising framework for IMS-based IPTV is suitable for all the players involved, a number of key success elements were identified. These ensure that the proposed framework includes all the necessary functionalities and satisfies the requirements of the telcos, users and advertisers. The requirements of each player are discussed below.

The Telco

High operational expenses are coupled with the roll out of IMS services due to the tight management and control which is required to offer services over managed SDPs. Telcos need to offset some of these operational expenses to increase revenue. This will also subsidise service costs for users and encourage wide scale adoption of NGN/IMS services.

Advertising is proven to increase revenue for service providers. Existing service providers are using advertising as a crucial part of their business models to subsidise service costs and increase revenue. Therefore, it is a feasible solution for telcos to monetise IMS IPTV. Furthermore, targeted advertising campaigns result in higher revenue than non targeted campaigns.

The User

Users are able to access various multimedia and communication services over the Internet, free of charge. Therefore, if a user is expected to pay for a similar service, subscription costs should be competitive and certain benefits over Internet services are required. These are reliability (guaranteed QoS) and security. A high level of QoE is also expected. Therefore, if a personalised advertising framework is to be integrated into IMS IPTV, QoE levels should not be lower than that of classic IPTV, where classic IPTV refers to IMS IPTV without a personalised advertising framework.

Related work shows that users would rather watch personalised advertising than general broadcasted advertisements which are perceived to be intrusive, irrelevant and unentertaining. As a result, delivering personalised advertising further increases the user's QoE.

The Advertiser

The shift towards a PVR and DVR style of watching television means that advertisements are being skipped. In order for advertisers to continue to design and deliver effective

• The framework should combine the entertainment value of TV with the marketing efficacy of the Internet, i.e. make use of an IP-based television system which is able

satisfy the following criteria in both the proposed architecture and evaluation platform: the media market and consumer behaviour. The proposed advertising framework should

Further requirements were identified from success elements in related works and trends in the consumers: targeted advertising was identified as a mutually beneficial solution for all the players; to boost revenue and offset IMS OPEX for telcos; to deliver reliable and secure services to users, while maintaining a high QoE; and to ensure advertisers continue to deliver effective advertising, can measure that effectiveness and only pay for the actual impact on

Figure 3.1: Convergence of players' requirements

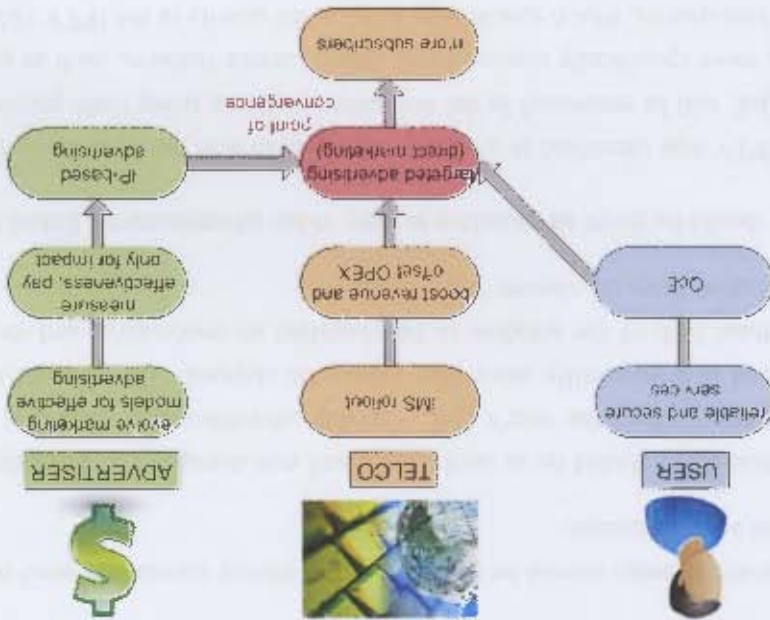


Figure 3.1 summarises and analyses the requirements of the different players and shows how they converge towards personalised advertising as a solution.

advertising campaigns, advertising models are evolving. The move is towards IP based advertising which is able to deliver relevant advertisements to users, which are less likely to be skipped. It is important to reach the right people for advertising to be effective. Further benefits include the ability to measure the effectiveness of an advertising campaign in real time and only pay for actual impact made on consumers.

to offer the same entertainment value as TV (guaranteed QoS and QoE) and make use of IP-based marketing techniques to target advertising messages.

- The advertising system should offer advertising solutions for PVR and DVR type services in which consumers normally have the ability to skip or leave out advertisements. In this case, advertisements should not be able to be skipped.
- The advertising system should be permission based, giving power to the consumer. The consumer should therefore be able to opt in or out, or choose between different pricing plans offering varying amounts of advertising.
- The advertisements should be personalised to ensure consumers need not view irrelevant advertisements.
- Advertisements should be as unobtrusive and non disruptive as possible, so as not to negatively affect the user's QoE. Overlay advertisements (banners) have been identified as a possibility since they cannot be skipped. They should not occupy more than 10% of the window to be classified as unobtrusive and should invite participation from the viewer.
- Users should be given an incentive to view video advertisements linked to banners.

IMS-based IPTV was identified as a suitable platform to host the advertising framework. The user's QoE will be measured in the evaluation platform using three parameters: service latency, more specifically session setup delay; service features, such as personalisation; and service quality, which specifically looks at the quality of the IPTV video content.

3.2 Architectural Requirements

This section details the necessary entities which are required to incorporate the above requirements into a framework that is in line with the 3GPP IMS specifications [1] and the ETSI TISPAN IMS-based IPTV architecture [16], which is presently the most comprehensive set of specifications on IMS IPTV. It is crucial that the proposed framework make use, where possible, of the standard IMS and NGN functional components, interfaces and protocols defined by the 3GPP and ETSI TISPAN, to ensure interoperability between vendor specific architectures and other IMS and NGN entities. The required elements are discussed below. Section 3.3 details the full proposed architecture which makes use of these elements. Figure 3.2 shows the proposed architecture and illustrates how the following architectural requirements are met by using standard entities, interfaces and protocols.

3.2.1 IMS Control Functions

IMS core elements are required to process SIP signalling within the IMS and to manage IPTV sessions. Three types of CSCFs are required to perform these functions. As mentioned earlier, they are the P-CSCF, I-CSCF and S-CSCF which are SIP servers and are essential nodes in NGN architectures, since they make up the control plane (IMS layer).

The P-CSCF acts as an inbound/outbound SIP proxy server between the UE and the IMS core and requires a SIP based Gm interface to communicate with the UE. A P-CSCF is allocated to a UE upon registration with the IMS core and remains assigned for the duration of that registration. The P-CSCF performs integrity protection, authentication of the user and verifies correctness of SIP messages sent by the UE. The IMS core may contain more than one P-CSCF for the sake of scalability and redundancy. However, only one P-CSCF is used in the proposed framework as scalability issues are beyond the scope of this thesis.

The I-CSCF retrieves user location information from the HSS using the Diameter protocol over a Cx interface. It routes the SIP requests received from the P-CSCF to the appropriate destination, which is usually an S-CSCF.

The S-CSCF is the central node of the control plane. All SIP signalling traverses the S-CSCF. Every message is inspected to determine if it should be sent to one or more AS. This decision is made based on filter criteria information contained in the IMS user profile which is downloaded from the HSS at registration. Communication with the AS is done over a SIP based ISC interface and communication with the HSS is done using a Diameter based Cx interface, which is also used to authenticate the user at registration, based on subscription information. Policy enforcement is also the responsibility of the S-CSCF, using subscription information. This ensures that the user may not perform unauthorised operations. The S-CSCF also performs session control, facilitating the delivery of the media stream according to the available network resources and client terminal capabilities; and acts as a SIP registrar by maintaining a binding between the user's location and SIP address. Again, the IMS core may contain more than one S-CSCF for the sake of scalability and redundancy, but this is not considered in this thesis.

3.2.2 Application Servers

Application servers provide NGN/IMS services to the user. They are SIP entities that are responsible for hosting and executing services. As mentioned in the previous chapter, they may operate in one of four modes: SIP proxy mode, SIP UA mode, SIP redirect mode,

or SIP B2BUA mode. For the purpose of an IPTV service, an IPTV AS is required, operating as a SIP proxy server. This means that the SIP session invitation is forwarded to another entity, i.e. the S-CSCF. When the IPTV AS receives a channel request message from the S-CSCF on behalf of the UE, it contacts the HSS to authorise the service request and forwards the authorised request back to the S-CSCF. The MDF starts to stream the requested media to the UE once the MCF receives the authorised service request.

The IPTV AS requires a number of interfaces: a SIP based ISC interface to the S-CSCF to receive SIP request messages, and a Diameter based Sh interface to the HSS to retrieve user profile information and authenticate the user for that service based on subscription information. An embedded CTF is required to detect chargeable events in the SIP messages arriving at the IPTV AS. Two more Diameter interfaces are required to send and receive charging information to and from the charging domain: a Rf interface to communicate with the CDF for offline charging and a Ro interface to communicate with the OCS for online charging. In addition to the CTF, an embedded Advertisement AS is required to perform the necessary advertisement related functions. Co-locating the Advertisement AS with the IPTV AS is beneficial since processing of SIP INVITE messages can be done sequentially for every channel request arriving at the IPTV AS. A categorising algorithm is run by the Advertisement AS upon receiving a SIP INVITE requesting an IPTV service. This algorithm categorises the user based on attributes shared in the IPTV user profile. These categories allow the AS to identify relevant advertisements for that category of user. The metadata corresponding to the identified advertisement is sent in the SDP body of the SIP INVITE message going back to the S-CSCF as optional attributes. This information is extracted by the MCF. The Advertisement AS also hosts a timer; upon expiry of this timer a SIP RE-INVITE is sent to the UE displaying metadata related to a second targeted advertisement at the bottom of the media window as a banner advertisement. Video advertisements are linked to banners and are streamed to the UE by the MDF, under control of the MCF, if the user interacts with the associated banner advertisement.

3.2.3 Databases

The HSS is the central repository for user-related information in the IMS which is used to handle IPTV sessions. It contains location information, security information (authentication and authorisation information), IMS user profile information and the S-CSCF allocated to the user. User profile information includes private and public user identities, subscription information and filtering criteria. An NGN network may contain more than one HSS to handle large numbers of subscribers, but this is not considered as scalability issues are beyond the scope of this thesis.

The HSS uses a Diameter based Cx interface for communication with the S-CSCF and I-CSCF to obtain user profile information during IPTV session setup and session modification. A Diameter based Sh interface is required to communicate with the IPTV AS for authorisation during session setup and modification.

An advertisement database is required to map user categories to relevant advertisements. The database stores a list of the advertisements available in the MDF and the categories for which each advertisement is best suited. Metadata for each advertisement, detailing a description of the advertisement, is also stored in the advertisement database.

3.2.4 User Equipment

An IMS terminal is required to access IMS services by the subscriber. A number of interfaces are required on the IMS terminal: A SIP based Gm interface to the P-CSCF to request an IPTV service; an HTTPS based Xa interface to the IPTV AS for service discovery and service selection and a Ut interface for service control; an RTSP based Xc interface to the MCF for trick play functions; and an RTP based Xd interface to the MDF for media delivery directly to the terminal.

An IMS client running on the terminal is required to allow IMS registration, IPTV service requests, preference changes and viewing IPTV media.

3.2.5 Media Functions

A Media Server is responsible for the storage of all IPTV media content and video advertisements and control of the media stream. Two media functions are required for an IPTV service: an MCF and MDF. These may be co-located, collectively referred to as a Media Server.

The MCF receives channel requests from the S-CSCF via a SIP based y2 interface and controls media delivery through the MDF, according to user policies, via an RTSP based Xp interface. The MCF maps the IPTV channel request to the appropriate media file stored in the MDF and controls the adaptation of the media stream to include targeted advertisements. The MCF also has an RTSP based Xc interface to communicate with the UE for trick play functions. The MDF is responsible for storing and delivering all IPTV media, under control of the MCF. The media stream is delivered to the UE via an RTP based Xd interface. An NGN network may contain more than one MDF for the sake of scalability, but this is not considered in this thesis.

3.2.6 Charging Functions

Charging functions are required to integrate IMS charging to allow the user to choose between different pricing plans and receive rewards for viewing advertisements in the form of credits. As an alternative to receiving credits for viewing advertisements, users may receive discounts for viewing IPTV media with embedded advertisements, or pay lower subscription fees for receiving more advertising. This flexibility is possible through the use of charging functions. Two charging functions, the OCS and CDF, are required in order to support online and offline charging respectively.

Both charging functions communicate with the CTF in the IPTV AS using the Diameter protocol. This is to receive charging events created by the CTF and to allow for credit checks and updates. The OCS communicates with the IPTV AS via the Ro interface and the CDF uses an Rf interface.

The next section details how these functional entities work together to form a personalised advertising framework that is in line with the 3GPP IMS specifications [1] and the ETSI TISPAN IMS-based IPTV architecture [16] and satisfies all the requirements laid out in the previous section.

3.3 Proposed Personalised Advertising Framework for IMS-Based IPTV Architecture

Figure 3.2 illustrates the architecture of the proposed advertising framework and how it interworks with both IMS IPTV and IMS charging elements. The architecture conforms to the 3GPP IMS specifications [1] and the ETSI TISPAN IMS-based IPTV architecture [16] by using standard IMS and NGN functional components, interfaces and protocols.

The framework modifies the standard IPTV operation by integrating targeted advertising into IPTV media sessions. It also makes use of IMS charging to reward subscribers with credits for viewing video advertisements. The Advertisement Application Server is co-located with the IPTV Application Server and Charging Trigger Function. This allows the Advertisement AS to further process SIP service request messages after the IPTV AS has performed its necessary processing. The MDF is responsible for hosting both the IPTV media and the video advertisements. The charging domain not only performs the standard credit checks and updates, but also keeps track of awarded advertisement credits.

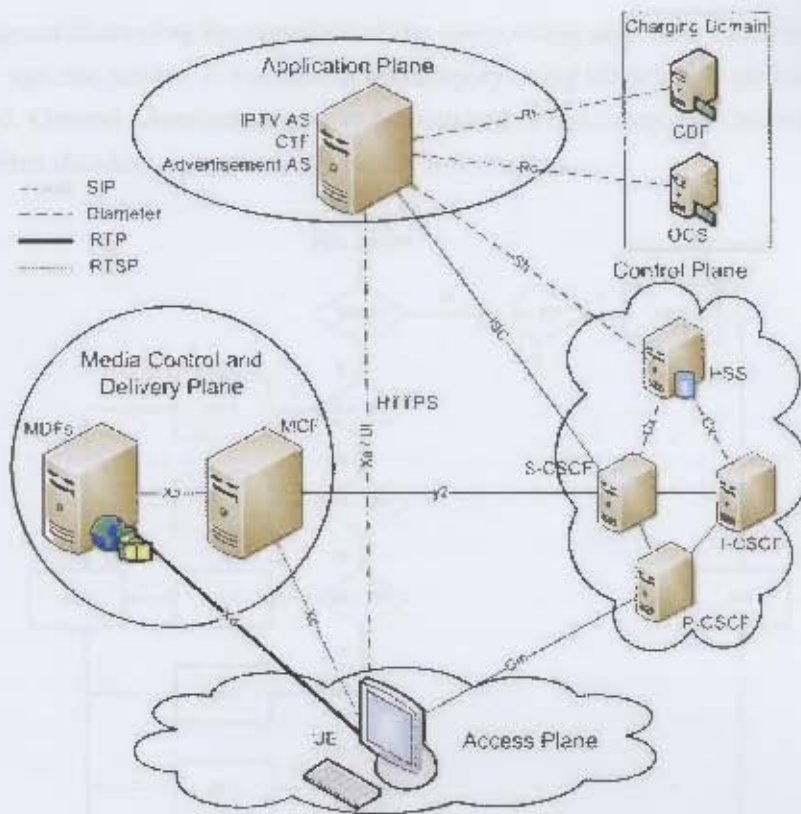


Figure 3.2: Proposed personalised advertising framework for IMS-based IPTV

During session setup, once the IPTV AS has authorised the SIP service request message received from the S-CSCF, the Advertisement AS processes the SIP message further before sending it back to the S-CSCF. It uses IPTV user profile information to identify advertisements that match the subscriber's attributes. This is done by running an algorithm to categorise the user. Advertisements are matched to certain categories before hand by the marketer. A targeted advertisement from the relevant category is then selected by the Advertisement AS. The corresponding metadata is added to the SDP body of the SIP message going to the S-CSCF. This information is extracted by the MCF to control the adaptation of the media stream to first show the selected advertisement, followed by the requested media. Subsequent advertisements are selected by the Advertisement AS periodically throughout the duration of the media session. These advertisements appear as banners across the bottom of the IPTV media screen. The user may decide to interact with these messages and earn credits or to ignore them. If ignored, the banner disappears after a timeout period. If the user decides to interact with the banner advertisement, the corresponding video advertisement is streamed to the user while the IPTV media is paused. Upon completion of the advertisement, the IPTV media resumes. Figure 3.3 shows a sim-

simplified diagram illustrating the operation of the categorising algorithm based on only two attributes: age and gender. In the case of no category being identified, a generic category is assigned. General advertisements may be matched to this category. This may occur if the subscriber decides not to share any profile information.

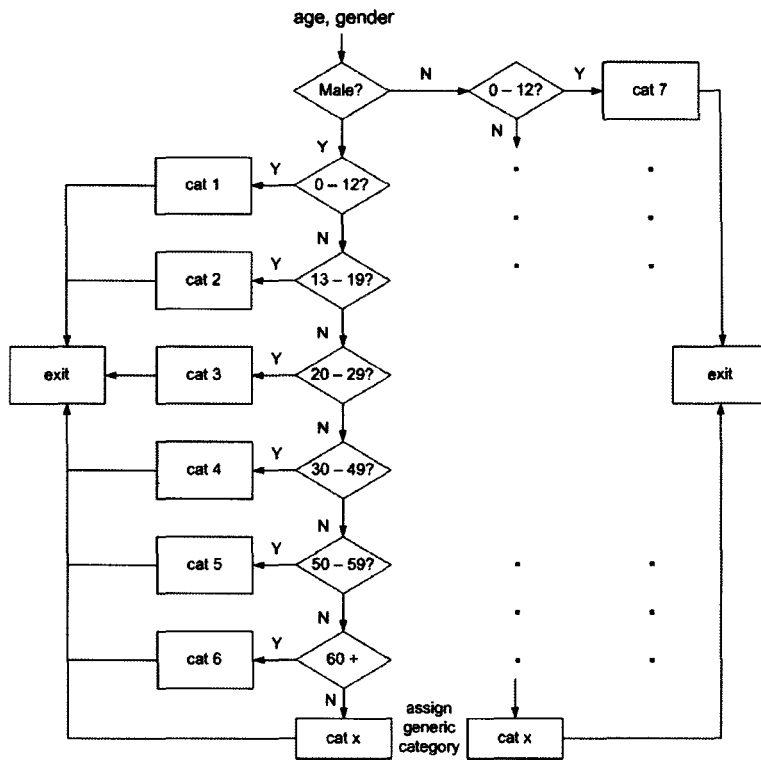


Figure 3.3: Categorising algorithm run by the Advertisement AS

The IMS charging system is integrated with the proposed architecture to enhance the effectiveness of the advertising framework. If the user chooses to interact with a banner advertisement and view the associated video advertisement, the IMS UE sends a notification to the Advertisement AS where a pre-defined number of credits get assigned. Marketers may choose how many credits are awarded for each advertisement. These credits are then transferred to the billing domain using the standard Diameter based interfaces, updating the user's account balance.

Figure 3.4 shows the signalling flow for a typical IPTV session for the proposed advertising framework. For the sake of simplicity, only the main entities are shown; OK and ACK messages after INVITE and RE-INVITE messages are not shown. This IPTV session illustrates a VoD service and uses online charging with event based charging as the charging mechanism. An initial advertisement is streamed to the UE before the IPTV

media starts. An intermittent advertisement is scheduled during the media session which causes a SIP RE-INVITE message to be sent to the UE. The user decides to view this advertisement which causes the IPTV media to be paused and resume upon completion of the advertisement.

During session setup, The S-CSCF uses the initial filter criteria (IFC), which were downloaded from the HSS at user registration, to determine which Application Server to forward the SIP INVITE to. The IPTV AS contacts the HSS to authorise the service request on receiving the forwarded SIP INVITE message. Once authorised, the embedded Advertisement AS runs the categorising algorithm using IPTV user profile information which is stored locally. It then performs a hash table look-up to select a targeted advertisement for that user category. The corresponding advertisement metadata is added to the SIP message going back to the S-CSCF. Detecting the INVITE message as a chargeable event, the embedded CTF creates and sends a charging event to the OCS, causing a once off charge to be levied after a credit check is done. No interim credit checks are performed since event based charging is used. The authorised channel request message is sent back to the S-CSCF and the advertisement timer is started. The S-CSCF forwards the authorised channel request to the Media Server.

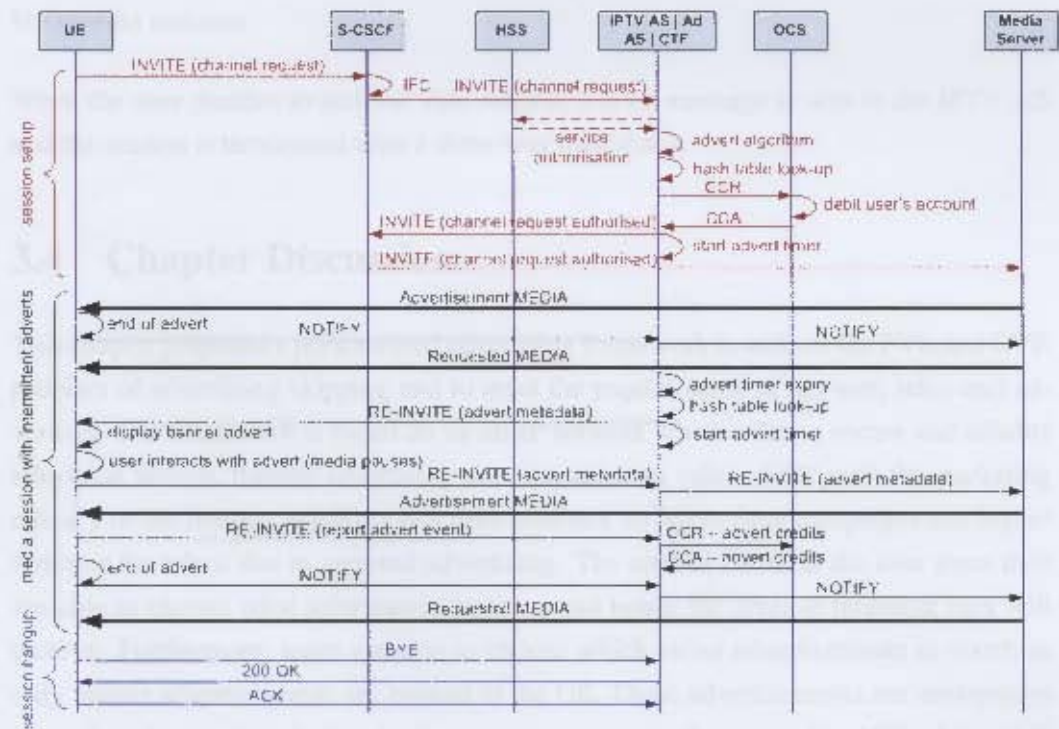


Figure 3.4: Signalling diagram for the proposed framework

The MCF in the Media Server identifies the selected advertisement, using the metadata added to the SIP INVITE at the IPTV AS, and the MDF streams it to the user. The requested media is streamed once the advertisement has ended. The MCF is responsible for mapping the channel request from the UE to the corresponding media stored in the MDF. It then controls the delivery of the appropriate media to the UE through the MDF.

During the VoD session, the advertisement timer at the Advertisement AS expires. This causes the Advertisement AS to identify a second targeted advertisement for the identified user category. A RE-INVITE message is sent to the UE containing the selected advertisement metadata. This causes a banner to be displayed at the UE, overlaid across the bottom of the VoD window. The text displayed corresponds to the metadata which was added to the SIP message by the Advertisement AS after its hash table look-up. The user decides to interact with the banner to view the associated video advertisement and earn credits. This causes the VoD media to be paused. The RE-INVITE is forwarded to the Media Server where the video advertisement is stored. Once again, the relevant advertisement is identified by the MCF and streamed to the UE by the MDF. The UE informs the IPTV AS of the advertisement event by sending a SIP session modification message, causing the embedded CTF to update the user's credits by sending a CCR message to the OCS with the awarded advertisement credits. Upon completion of the advertisement, the VoD media resumes.

When the user decides to end the VoD session, a BYE message is sent to the IPTV AS and the session is terminated after a three-way handshake.

3.4 Chapter Discussion

This chapter proposed a personalised advertising framework to address the PVR and DVR problem of advertising skipping and to meet the requirements of the user, telco and advertiser. The framework is based on an all-IP network which offers a secure and reliable television service, thereby combining the entertainment value of TV with the marketing efficacy of the Internet, enabling real time feedback on advertising campaigns and higher turnover for telcos due to targeted advertising. The control lies with the user since they are able to choose what information to share and hence the level of targeting they will receive. Furthermore, users are able to choose which video advertisements to watch as only banner advertisements are pushed to the UE. These advertisements are unobtrusive since they do not disturb the viewing experience, typically occupying 10% of the VoD window and not disrupting the continuity of the media stream. Since IMS charging is in-

tegrated into the framework, users receive an incentive for viewing video advertisements by receiving credits as a reward. These credits may be used in exchange for a free VoD session. It is also possible to offer different pricing plans for the IPTV service, allowing users to choose to receive more advertisements coupled with lower service costs, or fewer advertisements for a higher cost of service. This could be done as an alternative to awarding credits for each viewed advertisement. Video advertisements may also be embedded into the VoD media, offering lower costs for viewing such media. This flexibility is ideal for advertisers and telcos.

The framework uses standard NGN and IMS entities, interfaces and protocols as defined by the 3GPP and ETSI TISPAN. These are IMS control functions, application servers, databases, user equipment, media functions and charging functions. As a result, service convergence and interoperability between vendor specific architectures is guaranteed.

A suitable evaluation platform is needed in order to evaluate the effect of the proposed personalised advertising framework on users' QoE of the IPTV service. More specifically, to evaluate service latency, service features and service quality. The addition of an Advertisement AS, to perform additional processing on SIP INVITE messages at session setup, adds to service latency. This is evaluated in Chapter 5. Further modifications to the standard operation of IMS-based IPTV do not add to service latency perceived by the user due to the layered architecture of NGN networks. Additional processing is performed at the application plane during the media session. QoE tests would only be meaningful after a successful proof of concept is performed to validate the evaluation platform as a suitable testing environment. The next chapter details the platform which was used to evaluate the proposed framework. Chapter 5 details the proof of concept and QoE tests.

Chapter 4

The Evaluation Platform - Design and Architecture

This chapter presents the objectives, requirements and limitations of the evaluation platform used to test the effect of the proposed framework on users' QoE of the IPTV service. After which, the test-bed's topology is given, along with a brief description of the software and hardware. Finally, the operation of the evaluation platform is discussed. Full hardware and software specifications can be found in Appendix C.

The ITU-T Lead Study Group on QoS and QoE (Study Group 12) is responsible for end-to-end transmission performance of networks and terminals. The G.1010 recommendation [29] defines a model from an end user's perspective by considering user QoE expectations. This is done for a number of multimedia applications, based on network factors such as packet loss and delay. This QoE model presents user application needs as a function of error tolerance and sensitivity to overall delay from servers, networks and applications. Streaming audio and video applications such as IPTV are not sensitive to delay variation (jitter) and can tolerate a fairly large delay, since there is no conversational element. This means that the delay requirement is less stringent than for conversational services such as voice and video calling. Table 4.1 shows performance targets for audio and video applications. It can be seen that a service like IPTV, offering one-way video, has a target delay of less than 10 seconds. The typical expected data rate is 16 384 kbit/s with a Packet Loss Ratio (PLR) of less than 1%.

The user experience (QoE) is directly dependent on QoS, which, in turn, depends on a number of factors, including speed, accuracy, reliability and security of the underlying network [28]. It can therefore be said that if QoS is guaranteed, the user experience (QoE), in terms of target data rates, delay and information loss, as identified in table 4.1, is also

guaranteed. Since IMS-based IPTV is offered over a managed SDP, this thesis assumes the target bit rate and PLR are guaranteed. The underlying factors affecting QoE at the transport layer, such as buffering techniques, media coding and QoS classes, required to offer these guarantees, are beyond the scope of this thesis. As a result, the parameters of concern are those perceived by the user, i.e., service delay.

Table 4.1: Performance targets for audio and video applications [29]

Medium	Application	Degree of symmetry	Typical data rates	Key performance parameters and target values			
				One-way delay	Delay variation	Information loss (Note 2)	Other
Audio	Conversational voice	Two-way	4-64 kbit/s	<150 ms preferred (Note 1) <400 ms limit (Note 1)	< 1 ms	< 3% packet loss ratio (PLR)	
Audio	Voice messaging	Primarily one-way	4-32 kbit/s	< 1 s for playback < 2 s for record	< 1 ms	< 3% PLR	
Audio	High quality streaming audio	Primarily one-way	16-128 kbit/s (Note 3)	< 10 s	<< 1 ms	< 1% PLR	
Video	Videophone	Two-way	16-384 kbit/s	< 150 ms preferred (Note 4) <400 ms limit		< 1% PLR	Lip-synch: < 80 ms
Video	One-way	One-way	16-384 kbit/s	< 10 s		< 1% PLR	

NOTE 1 – Assumes adequate echo control.
NOTE 2 – Exact values depend on specific codec, but assumes use of a packet loss concealment algorithm to minimise effect of packet loss.
NOTE 3 – Quality is very dependent on codec type and bit-rate.
NOTE 4 – These values are to be considered as long-term target values which may not be met by current technology.

QoE is not only dependent on QoS factors, but also on human components, such as user emotions and expectations. Figure 4.1 illustrates the factors determining QoE, both objectively and subjectively. QoE is measured subjectively by the end-user and therefore may differ from one user to the other. However, it is often estimated using objective measurements [27]. Service delay is an example of an objective measurement that may be used to estimate user QoE. Factors determining the subjective component are factors such as service features and service quality [28]. To measure these parameters, available features and service quality may be compared to those offered in similar services. For example, TV and PVR services.

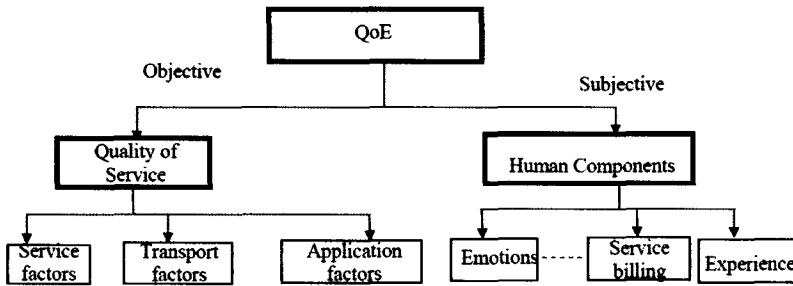


Figure 4.1: QoE dimension [27]

Recommendation G.1080 [27] from the ITU-T Study Group 12 defines user requirements for QoE for IPTV services. These requirements are from the user’s perspective and are agnostic to network architectures and transport protocols. Conducting subjective tests, where a sample group of viewers are asked to use and rate a service, are expensive and time-consuming. As a result, recommendation G.1080 [27] suggests the subjective elements of QoE may be measured by considering a number of issues: the purpose of the IPTV service, QoE level of the current broadcasting systems (which sets user expectation), compression coding scheme to be used for the service, content characteristics, content provider requirements and customer satisfaction. Aspects of media compression are beyond the scope of this thesis. The remaining factors are considered when analysing service features and service quality.

QoE requirements for metadata are also recommended in ITU-T G.1080 [27]. These are high availability to be ensured when transmitting the metadata over the network; the size of the transported data is sufficiently small, relative to factors such as the number of total services, the number of contents, and network bandwidth; and the service provider should ensure the metadata tagged to particular content is correct.

4.1 Evaluation Objectives

In order for an evaluation platform to provide meaningful test results, it is necessary to first perform proof of concept tests to test the suitability of the evaluation platform as an adequate environment for the proposed framework. Once the evaluation platform is validated, meaningful tests may be carried out. The objective of the evaluation platform is to test the effect of the framework on users’ QoE of the IPTV service, focusing on the VoD service model.

Users’ QoE will be evaluated by analysing service latency, service features and service

quality. QoE is defined as “the overall acceptability of an application or service, as perceived subjectively by the end-user” [27]. These parameters were chosen to effectively evaluate QoE from the end user’s perspective.

Service latency refers to IPTV session setup delay. This includes delays in the terminal, network, and servers. Session setup delay for a classic IPTV system, i.e. before any modifications were made in adding the advertising framework, should be compared to service latency after adding the advertising and charging functionalities. This delay should not be significantly larger than that of classic IPTV. More importantly, it should fall within the standard expected delay of less than 10 seconds. Typically, from the end user’s point of view, delay also takes into account the effect of other network parameters such as throughput. However, this is beyond the scope of this thesis.

Service features refers to the features expected by the user and their ease of use. These include channel selection; trick play functions to pause, fast forward and rewind IPTV media; user profile configuration to change user attributes; charging selection to choose between different pricing profiles; and interaction with banner advertisements to view video advertisements and earn credits.

Service quality refers to the quality of the media viewed by the user. Since the service is offered over a managed SDP and requires user subscriptions, TV quality is expected, i.e. a guaranteed QoS with high quality media.

4.2 Evaluation Requirements

To satisfy the above objectives, a number of requirements for the evaluation platform were identified. The proposed framework should be integrated with IMS-based IPTV to ensure high quality service delivery over a managed platform. Furthermore, the architectural requirements outlined in the previous chapter should be implemented in accordance with standard entities and interfaces as defined by the 3GPP and ETSI TISPAN. The entities to be implemented to test the proposed framework are: IMS control elements (CSCFs), IPTV Application Server with embedded CTF and Advertisement AS, IMS user profile database (HSS), IPTV user profile and advertisement database stored on the Advertisement AS, UE with a suitable IMS client, Media Server to store IPTV media and video advertisements, and charging elements to allow for online and offline charging (OCS and CDF respectively) and to keep track of advertisement credits earned by a user. Figure 4.4 illustrates the architecture of the evaluation platform which implements these entities.

The IMS client should have a Graphical User Interface (GUI) for ease of use of the service features described in the previous section. These are the ability to select an IPTV channel, achieve trick play functions, modify an IPTV user profile, select a pricing profile and interact with banner advertisements. Figure 4.2 shows the preferences GUI on the IMS client and the *User Profile* tab developed to enable easy profile modification for the user. Pricing selection is possible under the *Charging* tab.

A user may choose to share certain attributes to receive targeted advertising based on the shared information. Alternatively, they may choose to leave some fields unspecified, meaning that the level of targeting will be less specific. If no information is shared, no level of targeting is possible.

Figure 4.3 shows the bottom of the VoD window which was implemented on the IMS client. Users are able to easily press a button to achieve trick play functions or to interact with a banner advertisement by pressing an *advert* button.

If a user decides not to share any IPTV user profile information, the advertising system should still operate, delivering general advertisements to the user. General advertisements may be matched to all user categories, even those not sharing any profile information. If no general advertisements are located in the Media Server, the IPTV service should operate as classic IPTV with no advertisements or additional perceived latencies.



Figure 4.2: Preference modification page on IMS client



Figure 4.3: Advert button and banner advertisement

Once a user chooses to view a full video advertisement and earn credits by pressing the advert button during a banner advertisement, trick play functions should be disabled for the duration of the video advertisement. This will ensure that users are not able to choose to view an advertisement and earn credits, then fast forward through it. If the advert button is not clicked during a banner advertisement, the banner should disappear after a specified timeout period, for example, 30 seconds.

To test the operation of the advertising framework, not all of the user attributes in the *User Profile* are required. Once proven successful in proof of concept tests, the evaluation platform may be expanded to include more user attributes. Age and gender were identified as adequate attributes to test proof of concept. Targeted advertisements should be delivered to users based on these two attributes.

4.3 Limitations of the Evaluation Platform

A test-bed was chosen as the evaluation platform to test the effect of the proposed framework on users' QoE of the IPTV service. This was chosen over a simulation since users' QoE can be perceived more accurately in a practical test-bed environment. Simulations fail to consider all real world factors such as server processing delays and other hardware factors. These delays are important when testing QoE as they add to service latency. Furthermore, to properly test service features and service quality, a practical test-bed is required as both hardware and software play a role in determining these outcomes. Such a platform is therefore able to provide a more realistic analysis than a simulation in this case. Simulations are able to simulate large numbers of users which is not possible in a test-bed environment. However, it is more important to achieve accurate QoE measurements for service latency, service features and service quality. Furthermore, scalability issues are beyond the scope of this thesis.

Limitations exist in the operation of the test-bed due to software compatibility and time limitations. As a result, the operation of the test-bed differs slightly to that of the proposed framework, which is based on ETSI TISPAN's IMS-based IPTV. These differences are detailed here. However, they do not have a negative effect on the accuracy of the

evaluation, as there are no major differences between the theoretical framework detailed in the previous chapter and that of the evaluation test-bed.

The Media Server is implemented as one entity, combining the MCF and MDF. Only basic MCF and MDF functions are implemented. The MDF module stores and streams media files to the UE while the MCF module controls the streaming of media through the MDF and allows for trick play functions. In ETSI TISPAN's IMS-based IPTV, the MCF is responsible for identifying the relevant media file according to the channel request received from the S-CSCF on behalf of the UE. It then controls the delivery of the media stream from the MDF to the UE. However, since there are no real MCF functionalities implemented, the IPTV AS performs a hash table look-up to identify the relevant media file. This is done when the IPTV AS receives the service request from the S-CSCF on behalf of the UE. This information, containing the identified media file, is sent back to the UE which contacts the Media Server directly to retrieve the requested media. As a result of these changes, the IPTV AS is implemented as a SIP indirection server rather than a SIP proxy server, since the SIP session invitation is redirected to an external domain, i.e., the media plane, where the IPTV media is stored. These changes result in less processing by the MCF and MDF and slightly more processing by the IPTV AS. However, these are not significant additional processing loads to add any noticeable latencies to session setup and service delivery.

MySQL databases are implemented rather than using a categorising algorithm run by the Advertisement AS. The MySQL databases are hosted on the Advertisement AS, one for user profiles and another for advertisements. These can be seen in figures 4.5 and 4.6 respectively. The profiles database contains age and gender as the only user attributes. Instead of running a categorising algorithm and then identifying a relevant advertisement in a look-up table, the Advertisement AS retrieves the user profile information from the profiles database (age and gender) and then scans through the advertisements database to identify an advertisement that matches the profile information.

4.4 Architecture of the Evaluation Platform

The UCT IMS test-bed was used as the evaluation platform and modified to suit the evaluation requirements. Standard entities, interfaces and protocols are used as defined by the 3GPP and ETSI TISPAN. Figure 4.4 shows the architecture of the evaluation platform.

The IPTV AS operates as a SIP indirection server. This means that the SIP session invitation is redirected to an external domain, where the IPTV media is stored. When the IPTV

AS receives a channel request message from the S-CSCF on behalf of the UE, it maps the channel request to a corresponding RTSP media address and responds with a message containing this RTSP address, directing the UE to contact the Media Server in the media plane to retrieve the requested content.

The Fokus Open IMS Core [47] is used to provide all the necessary functionalities of the control plane in an NGN network. The Fokus Core consists of the P-CSCF, I-CSCF and S-CSCF and a lightweight HSS.

The UCT IMS Client [45] is used to provide the user with all the required client functionalities for the IPTV service, such as IMS registration, IPTV service selection, user profile changes, charging profile selection, viewing IPTV media and allowing trick play functions. Figure 4.1 shows the client GUI for preference changes and figure 4.2 shows the VoD media window. Ethernet is used in the access network. This was chosen to be the most appropriate and meaningful access network since the IPTV service typically uses an Ethernet connection to a STB or PC. Furthermore, the ITU-T [27] recommends the use of Ethernet in the access network to ensure adequate QoS for acceptable QoE levels.

In the application plane, the UCT Advanced IPTV system [44] is used to provide the required IPTV AS functionalities. This AS is embedded with an Advertisement AS and a CTF. The Advertisement AS hosts the IPTV user profile and advertisement databases.

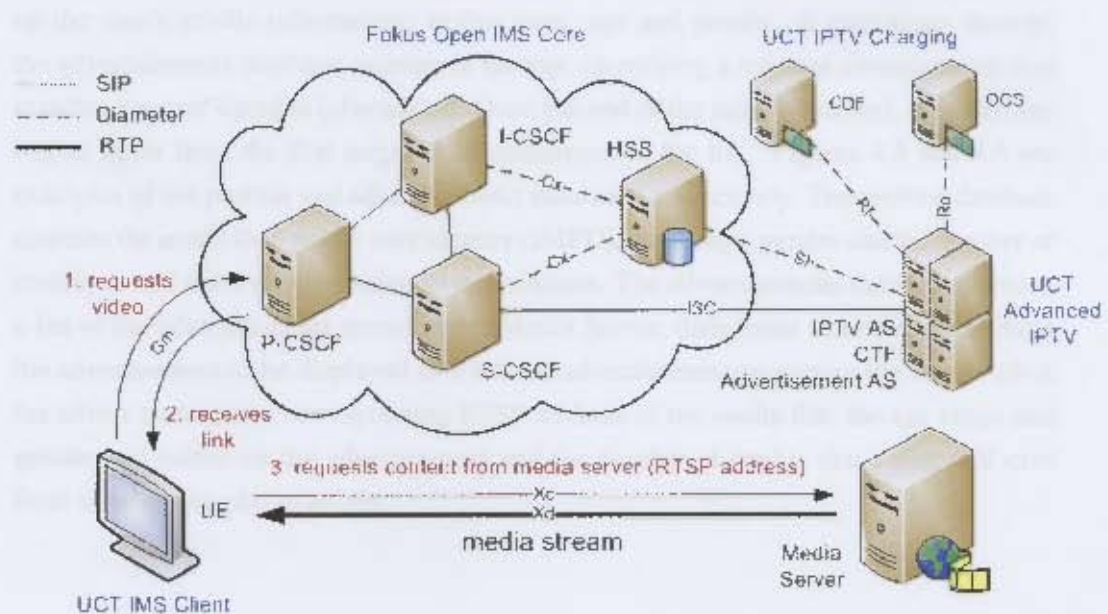


Figure 4.4: Modified UCT IMS test-bed with advertising and charging

The UCT IPTV system requires a third party Real Time Streaming Protocol (RTSP) server to act as the Media Server, i.e. to store the media files and deliver the media stream to the IMS Client running on the UE. This is located in the media plane.

In the charging domain, the UCT IPTV Charging [44] is used to provide the required OCS and CDF functions, i.e. perform credit checks and updates and to keep track of awarded advertisement credits. The Fokus C Diameter Peer (CDP) is used to implement the Diameter based Rf and Ro interfaces.

4.5 Operation of the Evaluation Platform

This section details the operation of the evaluation platform to implement the proposed framework. The architecture of the test-bed can be seen in figure 4.4. The operation of the evaluation platform differs slightly to that of the proposed framework due to test-bed limitations. These differences were detailed in section 4.3 and do not negatively affect the accuracy of the evaluation.

The IPTV User Profile and Advertisement Databases

The IPTV user profile and advertisement databases are stored on the Advertisement AS in MySQL databases. The Advertisement AS identifies relevant advertisements by looking up the user's profile information; in this case, age and gender. It then scans through the advertisements database, starting at the top, identifying a relevant advertisement that matches the user's profile information. Once the end of the table is reached, the selection begins again from the first targeted advertisement in the list. Figures 4.5 and 4.6 are examples of the profiles and advertisements databases respectively. The profiles database contains the user's IMS public user identity (IMPU), name, age, gender and the number of credits earned from viewing video advertisements. The advertisements database contains a list of the advertisements stored in the Media Server, their name (metadata describing the advertisement to be displayed as a banner advertisement prompting the user to click the advert button), the corresponding RTSP address of the media file, the age range and gender best suited for the advertisement and the number of credits that a user will earn from viewing the advertisement.

No.	IMPU	Names	Age	Gender	Credits	Update	Remove
1	alice	Alice Clarkson	32	Female	24	edit	delete
2	bob	Bob Marley	45	Male	29	edit	delete

Figure 4.5: Profiles look-up table for advertisement database

No.	Advert Name	RTP URL	Min. Age	Max. Age	Gender	Credits	Update	Remove
1	Click now to watch a Swatch advert	Rtp://tv.rcti.com:5554/channel4	10	45	All	0	edit	delete
2	Watch a Nives advert now and earn 1 credit	Rtp://tv.rcti.com:5554/channel5	10	55	Female	1	edit	delete
3	Watch a Casio advert now and earn 2 credits	Rtp://tv.rcti.com:5554/channel6	15	55	Male	2	edit	delete
4	New Yves Saint Laurent fragrance for women: Elle	Rtp://tv.rcti.com:5554/channel7	10	45	Female	1	edit	delete
5	New Yves Saint Laurent fragrance for men: L'Homme	Rtp://tv.rcti.com:5554/channel8	15	45	Male	1	edit	delete
6	Watch a Toyota advert and earn 1 credit	Rtp://tv.rcti.com:5554/channel9	10	55	Female	1	edit	delete
7	Watch a Toyota advert and earn 1 credit	Rtp://tv.rcti.com:5554/channel10	15	55	Male	1	edit	delete

Figure 4.6: Adverts look-up table for advertisement database

The IPTV User Profile Information

Users are able to update and modify their user profile information using the *User Profile* tab shown in figure 4.2. This information is then sent in the SDP body of the SIP INVITE message going to the IPTV AS at session setup. Figure 4.7 shows how the information is transported to the Advertisement AS embedded in the IPTV AS. The information is included as optional attributes in the preconditions section of the SIP message and takes the form $a=gender:1$ for a male user and $a=gender:2$ for a female user. The Advertisement AS uses this information to update the profiles database.

An integer is assigned to each preference choice for ease of use at the Advertisement AS. If the preferences allows selection from a drop down list, the first choice corresponds to the integer 0, which is unspecified. The next choice corresponds to 1, and so on. The default choices are all unspecified, meaning all integers are assigned a value of 0 and no level of targeting is possible. For gender, the value 2 corresponds to female, as can be seen when comparing the preference choices in figure 4.2 with the SDP information in figure 4.7. For the check boxes, an unchecked box is default and is assigned a value of 0, while 1 corresponds to a checked box.

```

file  addr  view  terminal  tabs  job
a=country: local none
a=country: remote none
a=des:pos mandatory local sendrecv
a=des:pos mandatory remote sendrecv
a=cl:1
a=gender: 2
a=ad*_3
a=merital_status:1
a=children0:1
a=children1:0
a=children2:0
a=children3:0
a=children4:0
a=children5:0
a=interests0:0
a=interests1:1
a=interests2:1
a=interests3:0
a=interests4:0
a=interests5:0
a=interests6:0
a=interests7:0
a=interests8:0
a=interests9:0
a=pets:0
a=pets1:0
a=pets2:0
a=pets3:0
a=occupation:1
a=income:0
a=vehicle:0

```

Figure 4.7: Sending preferences in SDP contents of SIP INVITE

The IPTV Application Server

The Advertisement AS embedded in the IPTV AS is required to handle the necessary advertisement related functions. These include database look-ups, as described earlier, to select relevant advertisements. The corresponding RTSP address of the media file stored in the Media Server is sent to the UE along with the RTSP address of the requested IPTV media file. The Advertisement AS also hosts a timer. Upon expiry of this timer, the next targeted advertisement in the list is selected and the corresponding RTSP address is sent to the UE during the IPTV session. Advertisements are retrieved from the Media Server by the UE in the same way as IPTV media, after receiving the appropriate RTSP address.

A Typical IPTV Session with Targeted Advertising

For classic IPTV, before any advertisement and charging functionalities were added, the user requests the IPTV service by selecting a channel through the P-CSCF. This can be seen in figure 4.4. The channel selection is of the form *channel1@iptv-as.imsdomain.ims*. As expected, this request is routed through the IMS Core and arrives at the S-CSCF where it is forwarded to the IPTV AS. This decision is made by the S-CSCF based on IFC information which is contained in the IMS user profile and downloaded from the HSS when the user registers with the IMS. The IPTV AS performs a hash table look-up to identify the relevant media file stored in the Media Server, corresponding to the channel

selected by the user. The IPTV AS sends this RTSP address, of the form *rtsp://media-server.imsdomain.ims/channel1*, back to the S-CSCF. When the SIP message containing the RTSP address of the requested media arrives at the UE, the Media Server is contacted directly by the UE requesting the media. The Media Server then streams the requested media file to the UE.

Figure 4.8 shows a signalling diagram of a typical IPTV session supporting advertising and charging functionalities. For the sake of simplicity, only the main entities are shown; OK and ACK messages after INVITE and RE-INVITE messages are not all shown. This IPTV session illustrates the same scenario as described in the previous chapter: a VoD service that uses online charging with event based charging as the charging mechanism. An initial advertisement is streamed to the UE before the IPTV media starts. An intermittent advertisement is scheduled during the media session which causes a SIP RE-INVITE message to be sent to the UE. The user decides to view this advertisement which causes the IPTV media to be paused and resume upon completion of the advertisement. When comparing this signalling diagram to that of the proposed framework introduced in the previous chapter in figure 3.4, only slight changes are observed.

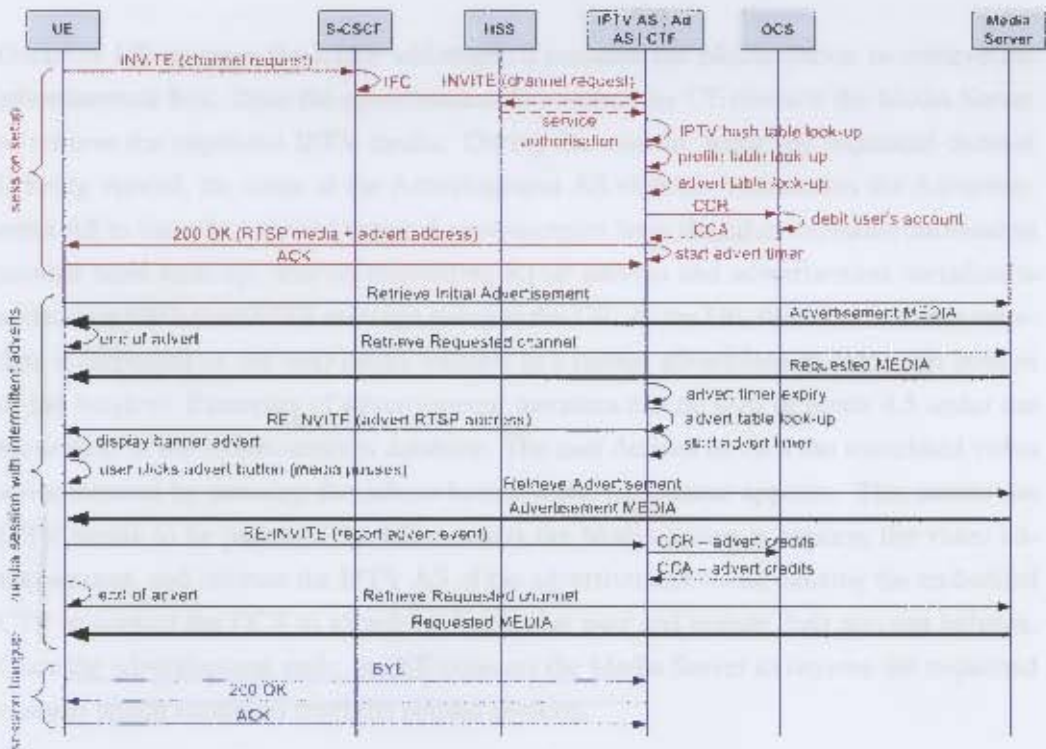


Figure 4.8: Signalling diagram for the modified IPTV session

During session setup, the SIP INVITE message requesting an IPTV channel arrives at the IPTV AS after being routed through the IMS core and an IFC check by the S-CSCF. After authorising the service request by contacting the HSS, the IPTV AS does a hash table look-up to map the requested channel to the corresponding media file in the Media Server. The Advertisement AS processes the SIP message further by looking up the relevant user profile information in the profiles database stored locally. It then scans through the advertisements database and identifies a targeted advertisement based on user profile information that matches the subscriber's specific attributes. Once a targeted advertisement is selected by the Advertisement AS, the corresponding RTSP address, of the form *rtsp://media-server.imsdomain.ims/channel4*, is added to the SIP message going back to the UE, along with the RTSP address of the IPTV media file identified by the IPTV AS. These RTSP addresses are sent back to the UE in the 200 OK message in response to the INVITE.

The CTF embedded in the IPTV AS detects the INVITE message as a chargeable event and contacts the OCS to do a credit check and levy a charge for the requested channel. Once receiving a reply from the OCS indicating that the user has enough credits and that the charge has been levied, the advertisement timer is started.

Once the UE receives the RTSP addresses, it contacts the Media Server to retrieve the advertisement first. Once the advertisement has ended, the UE contacts the Media Server to retrieve the requested IPTV media. During the session, while the requested channel is being viewed, the timer at the Advertisement AS expires. This causes the Advertisement AS to identify a second targeted advertisement from the advertisements database in another table look-up. The corresponding RTSP address and advertisement metadata is added to a SIP RE-INVITE message going to the UE. At the UE, the advertisement metadata is displayed on the VoD media window as a banner advertisement across the bottom of the window. Examples of advertisement metadata can be seen in figure 4.5 under the *name* field of the advertisements database. The user decides to view the associated video advertisement by pressing the *advert* button while the banner appears. This causes the IPTV media to be paused. The UE contacts the Media Server to retrieve the video advertisement, and informs the IPTV AS of the advertisement event, causing the embedded CTF to contact the OCS to award credits to that user and update their account balance. Once the advertisement ends, the UE contacts the Media Server to retrieve the requested channel which continues from the paused position.

The UE ends the session by sending a BYE message to the IPTV AS, followed by the expected three-way handshake.

4.6 Chapter Discussion

After discussing the evaluation requirements, objectives and limitations of the test-bed used to evaluate the proposed framework, it can be seen that the evaluation platform satisfies the requirements. It contains all the required entities, satisfying the architectural requirements, i.e., IMS control elements, an IPTV AS with an embedded CTF and Advertisement AS, an HSS for IMS user profiles, IPTV user profiles stored in the Advertisement AS, UE with an IMS client, a Media Server and charging elements. The test-bed conforms to 3GPP and ETSI TISPAN standards. Since the architectural requirements have been met, the test-bed is able to accurately evaluate the proposed framework and provide meaningful results. A GUI is implemented on the IMS client for ease of use of the IPTV, advertisement and charging service features and to update and modify IPTV user profile information. In this way, the user may choose the level of targeting they wish to receive. Banner advertisements were implemented during a media session to ensure minimal disruption. Trick play functions were disabled during video advertisements to ensure the advertisement credit system is not abused.

The following chapter details the proof of concept tests performed to validate the test-bed as an adequate evaluation environment, after which, user's QoE will be tested using three parameters: service latency, service features and service quality. The next chapter details these tests and the results obtained.

A detailed scenario is described in Appendix B. A demonstration video for that scenario can be found on the accompanying CD-ROM in Appendix D, along with all the source code used to setup the evaluation platform.

Chapter 5

The Evaluation Platform

An accurate evaluation of the effectiveness of a personalised advertising platform for IMS-based IPTV can only be performed in a real world implementation by telcos and advertisers. However, based on success elements identified and analysed in Chapter 2, the framework is expected to increase revenue for telcos and boost the effectiveness of marketing campaigns for advertisers.

This chapter details the evaluation verification of the test-bed presented in the previous chapter. Verification is performed by way of proof of concept tests to verify the evaluation platform as a suitable testing environment by running typical IPTV sessions for two different scenarios and comparing the outcome to what is expected from the theoretical framework. Evaluation is performed by conducting QoE tests to analyse the effect of the proposed personalised advertising framework on the users' QoE of the IPTV service. The parameters used to evaluate QoE are service latency, service features and service quality. Classic IPTV, before any advertising and charging functionalities were added, is used as a reference scenario in these tests.

5.1 Verification of the Evaluation Platform

Proof of concept tests validate the evaluation platform as an accurate testing environment for the proposed framework. This ensures further results are meaningful. Proof of concept tests are performed for two scenarios, each with expected outcomes. The observed results are then compared to the expected results, which are based on the theoretical framework. If the actual outcome corresponds to what is expected for both scenarios, the evaluation platform may be considered a suitable and accurate testing environment to evaluate the proposed framework.

In scenario 1, a user, *Bob*, requests a VoD channel. The advertisements database in the Advertisement AS has no relevant advertisements listed for Bob who is a male, aged 45. When Bob requests a VoD channel, he should experience the IPTV service as normal, with no advertisements streamed to him and no banner advertisements pushed to his UE. Furthermore, he should perceive no latencies over and above the expected VoD access delay.

In scenario 2, a user, *Alice*, requests the same VoD channel. However, in this case, the Advertisement AS has two relevant advertisements listed for Alice who is a female, aged 32. When Alice requests the VoD channel, she should see the first targeted advertisement listed in the advertisements database in her VoD window. Once that video advertisement has ended, her requested media should begin. While she is watching the VoD media, a banner should appear on her screen after a timeout period, which was set to 60 seconds for testing purposes. She chooses to ignore this banner, which should disappear after a timeout, which was set to 30 seconds. 60 seconds later, a second banner should appear. Alice decides to watch this advertisement and earn credits by pressing the advert button while the banner appears. The corresponding video advertisement should then be streamed to her VoD window. Upon completion of the advertisement, her requested VoD channel should commence in the same VoD window. Her credit balance should be updated in the profiles database on the Advertisement AS. If Alice clicks the advert button while no banner is present on her screen, this should have no effect on the IPTV service. The banner should take up a maximum of 10% of the VoD window to be considered as unobtrusive and non disruptive. Furthermore, the IPTV trick play functions should be disabled during video advertisements to ensure advertisements cannot be skipped or fast-forwarded after earning credits for choosing to view them. The corresponding profiles and advertisements databases for these scenarios can be found in Appendix B, in figures B.1 and B.2 respectively.

Depending on the telco's or advertiser's preferences and requirements, many aspects of the proposed framework may be customised. For example, the advertisement metadata to be displayed as banner advertisements; the credit value for each advertisement, which may be set to any integer, including zero; the frequency of a banner advertisement by changing the timer at the Advertisement AS; and the duration of a banner advertisement by changing the timeout period at the UE. For testing purposes, the timeout values were set to 60 seconds and 30 seconds respectively for ease of evaluation.

Scenario 1: Bob

Figure 5.1 shows the signalling flow which took place for Bob's scenario. Only the main entities are shown for simplicity. Bob requests a VoD channel using his UE. When this SIP INVITE message arrives at the S-CSCF, an IFC check is done to determine which AS to forward the request to. The IPTV AS authorises Bob's service request upon receiving the SIP INVITE message. This is done by contacting the HSS and checking Bob's IMS user profile information. Once authorised, the IPTV AS performs a hash table look-up to map the channel requested by Bob to the relevant media file stored in the Media Server. The embedded Advertisement AS then looks up Bob's profile information in the profiles database stored on the Advertisement AS. It retrieves his gender and age, determining he is a male, aged 45. The Advertisement AS then scans through the advertisements database looking for advertisements to match Bob's attributes. No relevant advertisements are found. The embedded CTF contacts the OCS for a credit check and to debit Bob's account for the requested VoD service. The RTSP address of the identified VoD media file is added to the SIP 200 OK message going to the UE in response to the INVITE message. The advertisement timer is started. Since only one RTSP address is delivered to Bob's UE, it contacts the Media Server to retrieve the requested media upon receiving the SIP 200 OK message. The advertisement timer is started. Since only one RTSP address is delivered to Bob's UE, it contacts the Media Server to retrieve the requested media upon receiving the SIP 200 OK message.

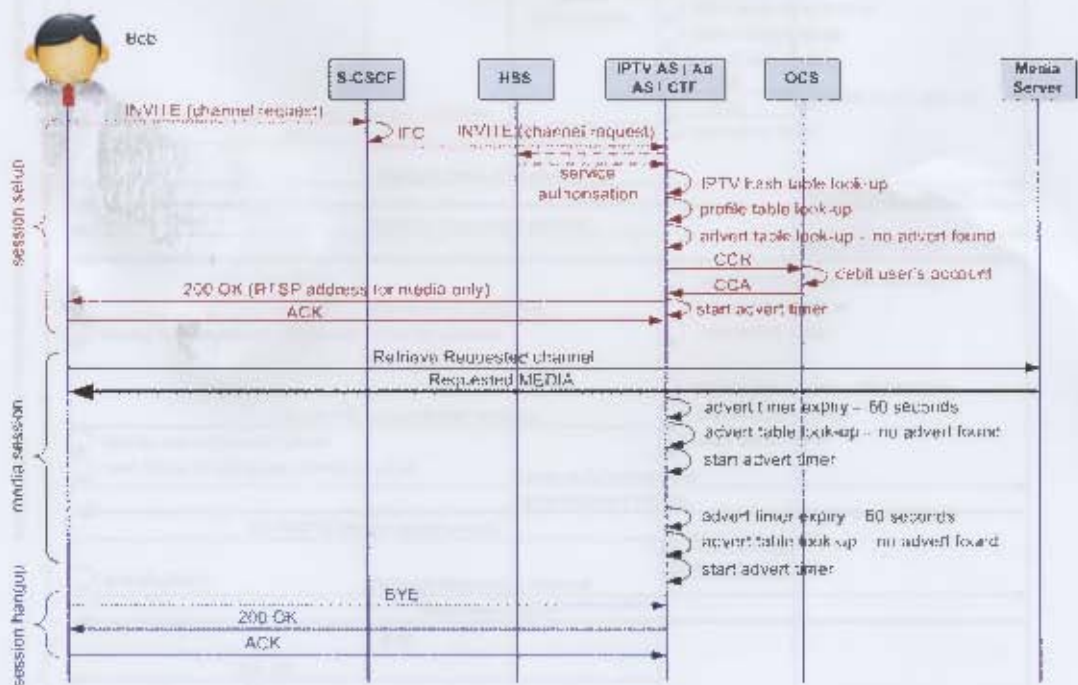


Figure 5.1: Signalling diagram for scenario 1 - Bob

During Bob's VoD session, the advertisement timer expires, causing the Advertisement AS to scan through the advertisements database, looking for a relevant advertisement. Again, no appropriate advertisements are found and the advertisement timer is started again. This will continue throughout the duration of the VoD session.

The Advertisement AS timer expiry and database look-ups that take place during the VoD session are not perceived by Bob due to the layered architecture of NGN networks. Since no relevant advertisements are identified, no RE-INVITE messages are sent to the UE during the session and no banner advertisements are displayed.

Scenario 2: Alice

Figure 5.2 shows the signalling flow which took place for Alice's scenario. Again, only the main entities are shown for simplicity. The 200 OK responses to SIP RE-INVITE messages and their corresponding ACK messages are not shown here.

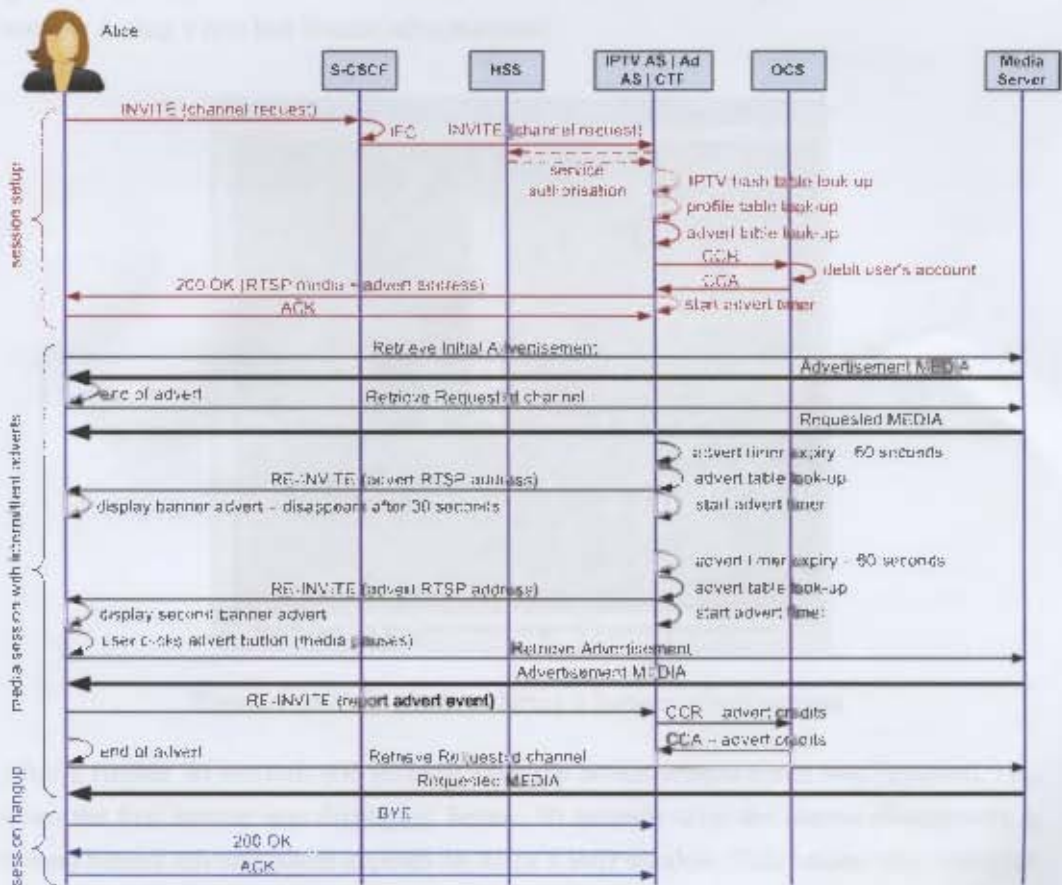


Figure 5.2: Signalling diagram for scenario 2 - Alice

Once the IPTV AS has authorised the channel request from Alice's UE, it maps the requested channel to the corresponding RTSP address of the media file stored in the Media Server. The embedded Advertisement AS looks up Alice's IPTV user profile information in the profiles database which is stored locally. It then scans through the advertisements database, looking for any advertisements relevant to a female, aged 32. Upon identifying the first advertisement, the corresponding RTSP address is retrieved. The embedded CTF performs the necessary online and event based charging functions before the RTSP addresses for the requested media and the identified advertisement are added to the SIP 200 OK message going back to Alice's UE. At the UE, the advertisement is retrieved from the Media Server first, followed by the requested media once the end of the advertisement is reached.

After Alice has been viewing her requested channel for 60 seconds, a banner appears across the bottom of her VoD window, prompting her to click the advert button. This banner stretches across two lines and occupies 10% of the VoD window. She decides to ignore the prompt and the banner disappears after 30 seconds. Figure 5.3 shows the VoD window during a two line banner advertisement.

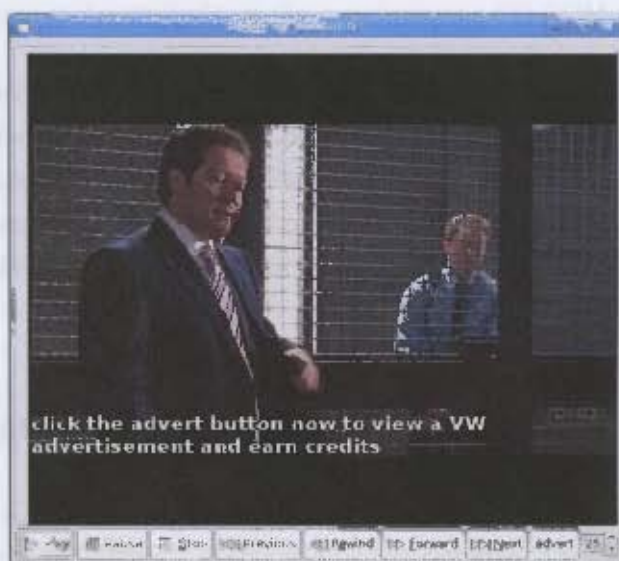


Figure 5.3: VoD window during a banner advertisement

After a further 30 seconds (60 seconds after the advertisement timer was restarted, i.e., when the first banner was displayed, hence, 30 seconds after the banner disappears), a second banner advertisement appears on Alice's VoD window. This banner only occupies one line and therefore takes up 5% of the window. Alice decides to view the associated video advertisement by pressing the advert button while the banner appears on the win-

dow. This causes her VoD media to be paused and the requested advertisement starts playing in the same VoD window. When the advertisement ends, the requested media resumes in the same window. However, the media does not resume from the paused position. Instead, it starts again from the beginning of the VoD media file. This is due to limitations in the VideoLAN Client (VLC) software used on the Media Server.

During the video advertisements, trick play functions were disabled to ensure advertisements could not be skipped after choosing to view them. After viewing the video advertisement, Alice's credit balance was updated in the profiles database on the Advertisement AS. If the advert button is pressed during the VoD session while no banner appears on the screen, no effect on the session is observed.

The text length in the *name* field of the advertisements database is limited to allow for a maximum of two lines of text on the VoD window, i.e., 10% occupation. This is also in accordance with the ITU-T QoE recommendations for metadata [27], suggesting a small metadata size, relative to the network bandwidth.

Alice's scenario is detailed further in Appendix B and a demonstration video for this session can be found in Appendix D, on the accompanying CD-ROM.

The outcome observed for both scenarios corresponds to what is expected based on the theoretical framework. As a result, the proof of concept tests may be considered successful and as such, the evaluation platform may be considered a suitable and accurate testing environment for the proposed framework. The next section details the QoE tests performed to analyse the effect of the personalised advertising framework on the user's QoE of the IPTV service.

5.2 Evaluation of the Proposed Framework

User experience (QoE) is determined by a number of factors, both objective and subjective [27], as seen in figure 4.1. Objective factors fall under QoS and are made up of service factors, transport factors and application factors. Transport factors are beyond the scope of this thesis. Thus, service latency is used to measure QoE objectively, as it is assumed the network is able to provide the recommended bit rate and PLR, due to its managed SDP and QoS guarantees. Subjective factors are human components such as user emotions, billing and user experience. These are measured by looking at service features and service quality, and comparing them to those offered in similar services. These parameters measure QoE from the end user's perspective.

5.2.1 Service Latency

To measure service latency, session setup delay for a VoD session was used. This included the delays experienced in the network, at the AS and in the UE. Both Bob and Alice's scenarios were compared to a third reference scenario. In scenario 3, a user, *Charlie*, uses the classic IPTV system, before the proposed framework was added to the IPTV service, i.e., before any advertising and charging functionalities were added to the IPTV AS and UE. Service latencies are expected to be less than 10 seconds for the IPTV service [29][27]. Table 5.1 shows the standard typical latencies expected for the VoD service in particular [31]. The VoD access delay refers to session setup. The latencies for all three scenarios should therefore be less than 5 seconds.

Table 5.1: Typical latencies for VoD functionalities [31]

Function	Elapsed Time (seconds)
UE registration	0.8
IPTV service subscription	1.3
VoD access	< 5
Channel change	0.4

Scenario 3: Charlie

Figure 5.4 shows the signalling flow which took place for Charlie's scenario. For simplicity, only the main entities are shown. Charlie requests a VoD channel from his UE. The service request message is routed through the IMS core. At the S-CSCF, an IFC check is done, based on IMS user profile information downloaded from the HSS at registration. This determines the SIP INVITE should be forwarded to the IPTV AS. The IPTV AS contacts the HSS to authorise the service request upon receiving the INVITE message. It then performs a hash table look-up to map the requested channel to the corresponding media file stored in the Media Server. The RTSP address of this media file is added to the SIP 200 OK message going back to Charlie's UE in response to the SIP INVITE message. The UE uses this RTSP address to retrieve the requested media directly from the Media Server.

For this scenario, session setup delay is expected to be shorter than that of Bob and Alice's case, since there are no CTF and Advertisement AS processes taking place on the SIP INVITE message arriving at the IPTV AS.

Each scenario was run a total of 20 times, and the session setup delay was recorded for each instance. Figure 5.5 plots these latencies for each scenario, arranged in ascending order. The latencies obtained for scenario 1 (Bob) are shown in blue, scenario 2 (Alice) are shown in purple and scenario 3 (Charlie), using classic IPTV, are shown in yellow. The y axis depicts delay in milliseconds.

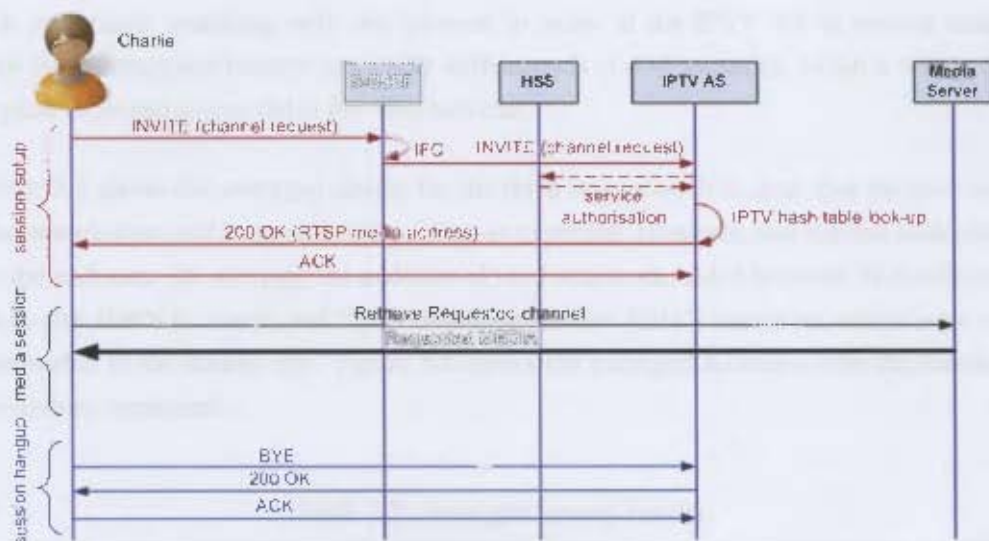


Figure 5.4: Signalling diagram for scenario 3 - Charlie

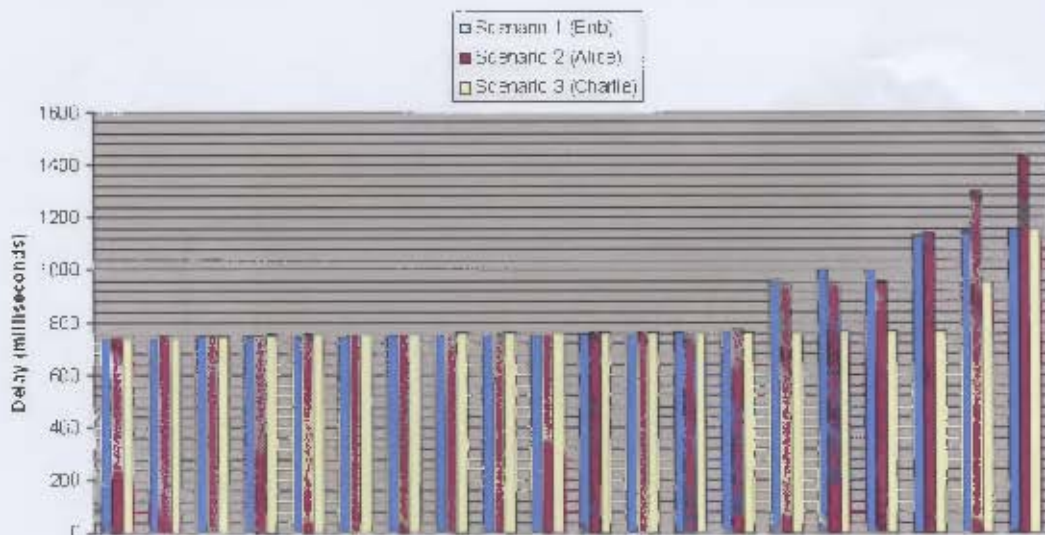


Figure 5.5: Session setup latency results for three scenarios

A group of closely clustered results with occasional, larger outliers is observed. The outliers are caused by activity on the network and at the AS and UE. They are noticeably larger for scenarios 1 and 2 due to the further processing required at the IPTV AS and UE at session setup, as well as the extra overhead on the SIP messages passing through the network, though this is not major and only due to optional attributes. For the classic IPTV system, smaller outliers are observed since advertising and charging processes are not performed, requiring only one process to occur at the IPTV AS at session setup. The largest recorded latency was 1,434 milliseconds (1.434 seconds), which is within the typical expected access delay for VoD services.

Table 5.2 shows the averaged results for the three scenarios. It is clear that the proposed framework does add to session setup delay, as expected. However, this was not noticeable to the end user. On average, the addition of the framework added between 58.6 milliseconds (for Bob's scenario) and 75.85 milliseconds (for Alice's scenario), which were not noticeable to the human eye. Figure 5.6 shows the averaged latencies with the standard deviations measured.

Table 5.2: Averaged latency results

	User	Description	Average latency	Std Dev.
scenario 1	Bob	no relevant advertisements in Media Server	849.35 milliseconds	153.94
scenario 2	Alice	two relevant advertisements in Media Server	865.60 mill seconds	201.84
scenario 3	Charlie	classic IPTV	790.75 milliseconds	97.31

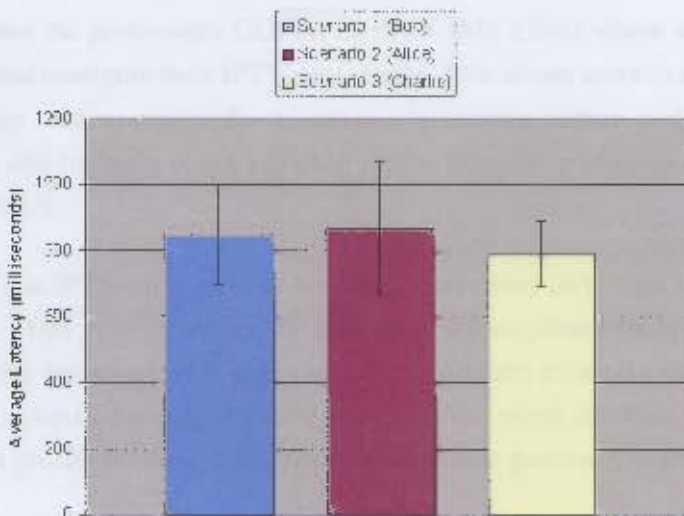


Figure 5.6: Averaged latencies with standard deviations

The results obtained in this chapter do not consider the issue of scalability, as it is beyond the scope of this thesis. However, service latency is bound to increase with the number of parallel sessions, since the server will be required to deal with requests from more users simultaneously. Mathematical modelling could be used to evaluate the framework for a larger number of users, i.e., queueing theory could be applied to the results obtained to estimate the performance under the consideration of scalability.

5.2.2 Service Features

User expectations determine the expected service features for IMS-based IPTV. This service is comparable to live television and PVR services. As a result, similar features are expected to boost user QoE. Since IPTV requires user subscriptions, users would expect service features over and above those offered by live television. PVR services also require a subscription fee, suggesting IPTV service features should be, at least, on par with those offered by PVR services. A GUI is required, offering ease of use of services such as IMS registration and IPTV service selection. Figure 5.7 shows the user GUI for the UCT IMS Client [45]. A user is able to easily register with the IMS and request a VoD channel from the drop down menus at the top of the client interface. The demonstration video in Appendix D illustrates these features more clearly.

Trick play functions are key features in PVR services, setting them apart from live TV. As such, IPTV services are expected to offer the same functionality. Figure 5.8 shows a screenshot of the VoD window, indicating the trick play buttons available to the user.

Figure 4.2 shows the preferences GUI on the UCT IMS Client where a user is able to easily change and configure their IPTV user profile. This allows users to choose the level of targeting they wish to receive for advertising by sharing certain profile information. Users are also able to easily select a pricing profile from the preferences menu. This is shown in figure 5.9.

It can be seen that IPTV services offer service features over and above those offered by live television. This is expected by the user since subscription fees apply and service billing affects the perceived QoE. Users are able to perform trick play functions on VoD media, easily configure their IPTV user profile from the client interface, and choose between different pricing profiles. These features contribute positively to user QoE.

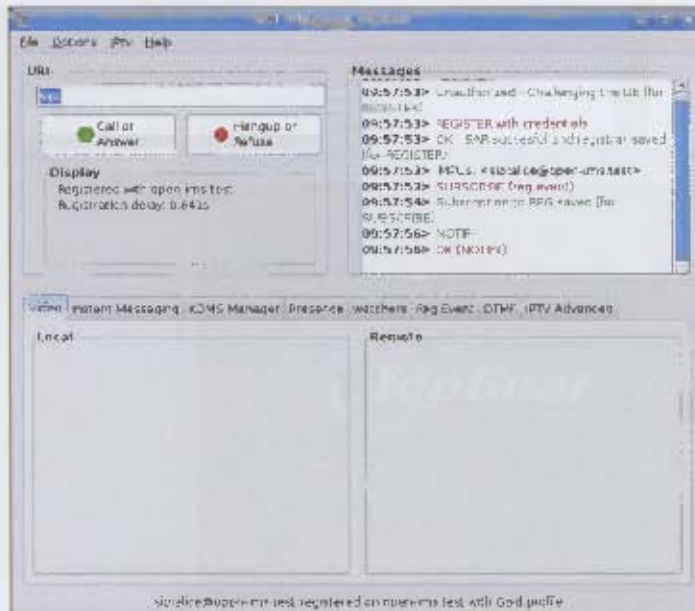


Figure 5.7: User GUI of the UCT IMS Client

5.2.3 Service Quality

Service quality further contributes to user's QoE. User expectations are determined by the quality of similar services, such as live TV and PVR. These services both offer high quality media. As a result, the expectations for IPTV services are no different. Figure 5.3 shows a screenshot, indicating the level of media quality. The media files stored in the Media Server are AVI format, which conforms to the Microsoft Windows Resource Interchange File Format (RIFF) specification [34]. Aspects relating to media compression and media codecs are beyond the scope of this thesis. However, video quality perceived by the user was comparable to that of live TV and PVR services. It is assumed that since IMS-based IPTV is offered over a managed SDP, the QoS required to stream the video at full quality is guaranteed. This ensures a high QoE.

Since inserting advertisements increases bandwidth usage on the network, it was decided to ensure advertisements are kept relatively short and are of lower quality than the VoD media files. On average, the advertisement file sizes were kept to 10 MB, in MPEG format. Typically, a full length feature film (in AVI format) is roughly 1.4 GB. The advertisement framework is able to minimise bandwidth wastage by only delivering targeted advertisements to users. Further, it should ensure advertisements use a maximum of 10% of the network bandwidth during a VoD session. This is to ensure efficient usage of the available network bandwidth. Advertisement media traffic would not be paid for by user subscriptions; telcos would be expected to absorb the costs of delivering advertisement

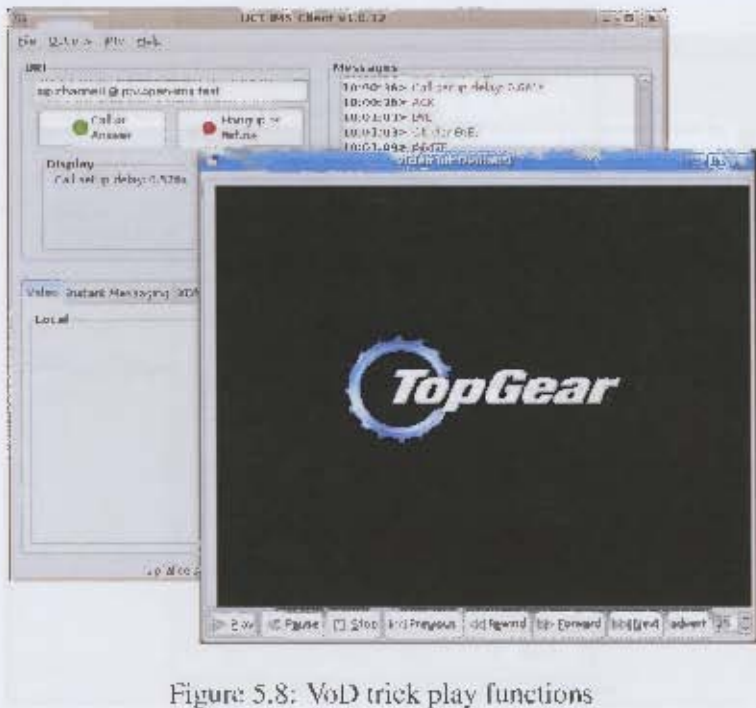


Figure 5.8: VoD trick play functions

media streams to users. This means that, on average, a maximum of 12 advertisements should be delivered to a user when watching a feature film. The advertisement timer could be set accordingly to ensure an advertisement is delivered every 15 minutes. A longer timer may be set for a lower percentage of bandwidth usage. A 10% bandwidth usage would correspond to a case in which the user decides to view all the advertisements pushed to the UE during the session. Since telcos are able to set the duration of the advertisement timer, they have control over the amount of bandwidth used for advertising. Hence, telcos can control how efficiently the available network bandwidth is used. A trade-off will occur between revenue earned from marketers for delivering more advertisements, versus bandwidth used for delivering advertisements which is not paid for by the user.

There are several issues that need to be considered when using this approach. The primary concern is:
 As mentioned in Chapter 4, QoE recommendations also exist for metadata [27]. There are: high availability to be ensured when transmitting the metadata over the network; the size of the transported data is sufficiently small, relative to such factors as the number of total services, the number of contents, and network bandwidth; and the service provider should ensure that the metadata tagged to a particular content are correct. Since the proposed framework is based on IMS-based IPTV, sufficient QoS is guaranteed when transmitting metadata over the network. The size of the metadata is limited to 80 characters to ensure no more than 10% of the screen is occupied by the banner advertisements.

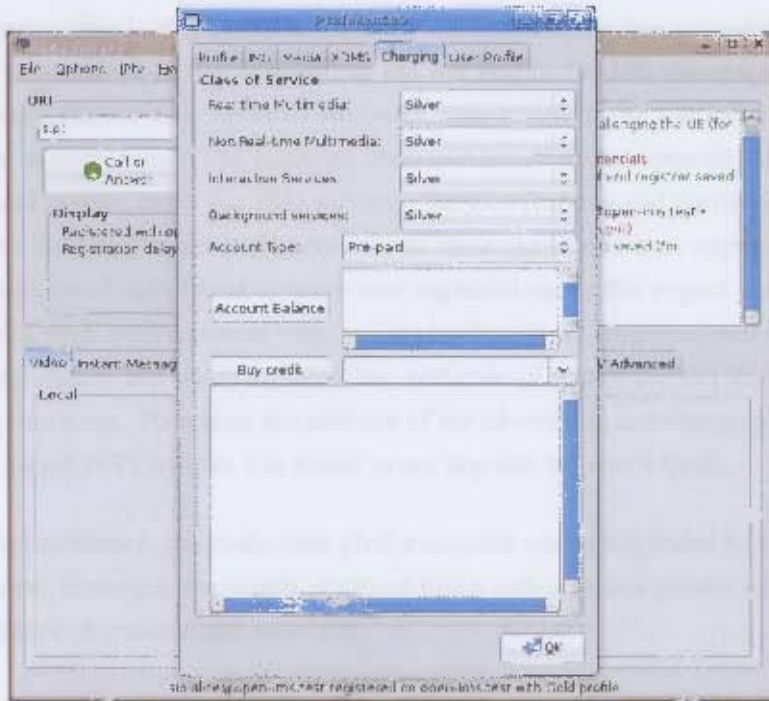


Figure 5.9: Charging preferences

This corresponds to a small data size relative to the network bandwidth used for streaming VoD media files. Lastly, the advertisements database is managed manually, ensuring the correct metadata is assigned to each advertisement.

5.3 Chapter Discussion

This chapter presented the verification and evaluation techniques used on the evaluation platform presented in the previous chapter.

Proof of concept tests were carried out using two scenarios. The observed outcomes for each scenario corresponded to what was expected based on the theoretical framework. These tests validated the evaluation platform as an accurate testing environment to evaluate the proposed framework.

Evaluation of the framework was performed by looking at three parameters to measure the effect of the proposed framework on the user's QoE of the IPTV service: service latency, service features and service quality. Service latency tests compared session setup delay for the above mentioned scenarios to a third scenario, representing the reference, using classic IPTV. The tests showed the framework added slightly to session setup delay due to the

additional processing load required at the IPTV AS and UE. Session setup delay included the delays experienced in the network, at the AS and in the UE. No major signalling overhead was added as only optional attributes were added to the SIP INVITE message at the UE at session setup. The latencies observed for all three scenarios fell within the recommended service delay for VoD services. Service features and service quality were compared to that of TV and PVR services, as these determine user expectations. The proposed framework was found to meet user expectations in this regard due to its high quality media, high entertainment value, trick play functions, graphical user interface for profile configuration and charging selection, and ease of use of the IPTV, charging and advertising functions. Therefore, the addition of the advertising and charging frameworks to the IMS-based IPTV system was found to not degrade the user's QoE.

Due to time limitations, the evaluation platform could not be expanded to include more user attributes. However, the results obtained using only age and gender were adequate for testing proof of concept and user QoE.

Chapter 6

Conclusions and Recommendations

This thesis proposed and evaluated a personalised advertising framework for IMS-based IPTV, to provide an advertisement-subsidised IPTV service to subscribers. It integrates advertising and charging functionalities with ETSI TISPAN's IMS-based IPTV. It uses IPTV user profile information to select and deliver targeted advertisements to an end user during a VoD session, and uses IMS charging to reward users for viewing those advertisements.

It investigated current consumer and market trends to propose a business model for IMS-based IPTV, implementing an advertisement-subsidised IPTV service.

6.1 Conclusions

The proposed personalised advertising framework considers paradigm shifts in marketing and consumer behaviour which are taking place due to three factors: evolving technologies, increasingly empowered consumers and more self-reliant advertisers. It delivers targeted advertising in a VoD system, enabling marketers to deliver effective advertising by reaching the right consumers and offering a solution to PVR and DVR advertisement skipping. Since advertisements are targeted, users are less likely to skip them, or simply "tune in, but turn off". Further, it offers an incentive to users for viewing advertisements by awarding credits. The control lies with the consumer, since they are able to choose what user profile information to share and hence, the level of targeting they will receive. In these ways, advertising is adapted to suit the paradigm shifts in marketing and consumer behaviour.

NGNs are able to offer lucrative, value-added multimedia applications and communication services to subscribers due to the highly managed and tightly controlled SDPs and

control functionalities added by the IMS. These result in QoS and QoE guarantees, which are beneficial to the user. However, they also translate to large CAPEX and OPEX, resulting in telcos charging high subscription fees. Furthermore, telcos are experiencing a decline in ARPU and no killer application has been identified for NGN services. Large subscription costs mean NGN services are unlikely to be adopted on a wide scale. As such, a new revenue stream needs to be identified to shoulder the large costs required to roll out NGN services. Advertising is proven to boost revenue for service providers and has been adopted in a number of business models to shoulder the costs of offering services to subscribers over managed SDPs. This results in subsidised service costs for users. Offering personalised advertising is a way to further boost revenue, since marketers would be able to deliver targeted advertising campaigns. Since NGNs are all-IP networks, advertising can be targeted, interactive and flexible. Furthermore, telcos could make higher profits from advertisers since they are able to measure the effectiveness of their advertising campaigns and pay only for the actual impact made on consumers. As such, personalised advertising is determined to be a feasible business model to encourage the roll out of IMS-based IPTV and subsidise service costs for subscribers.

An evaluation platform was used to test the effect of the proposed framework on the user's QoE of the IPTV service. This was done by testing three parameters: service latency, service features and service quality. Service latency tested the objective component of QoE, while service features and service quality tested the subjective component. It was found that additional processing functions, required at the IPTV AS and UE, added to service latency. However, the service delays were below those recommended for VoD services. Service features and service quality were compared to those offered in live TV and PVR services. They were found to meet user expectations due to the functions available to the user, their ease of use, and the high quality VoD media. It is therefore concluded that the addition of an advertising framework does not negatively affect user's QoE of the IPTV service.

6.2 Recommendations for Future Work

As a convenient point of departure from this thesis, a number of recommendations are made for future work.

The proposed framework could be enhanced by adding a recommendation system to make use of the same IPTV user profile information to recommend IPTV content that the user may be interested in, based on shared profile information. Metadata could be used to

categorise the IPTV media stored in the Media Server. The wireless dimension could be added to the proposed advertising model by testing the performance over a wireless access network such as WiMAX or WiFi. These recommendations will further enhance the user experience.

The aspect of automatic metadata creation was not considered in this thesis. It could be applied to the proposed framework to make the system fully automated and self-sustaining. Removing the human element of manual metadata creation would make the system more scalable and less prone to errors in metadata assignment.

Scalability issues are beyond the scope of this thesis and, as such, were not considered. However, service latency is bound to increase with the number of parallel sessions, since the server will be required to deal with requests from more users simultaneously. As such, it is worth considering for future work, to evaluate service latency versus the number of users. To evaluate the framework for a larger number of users and consider scalability of the proposed framework, mathematical modelling could be used. Queueing theory could be applied to the results obtained in this thesis to estimate the performance of the system for a larger number of users. Such a mathematical model would be able to estimate the probability of service latency being higher than the recommended value of 5 seconds (5000 milliseconds), given the network utilisation and processing capabilities of the servers and user terminal.

Appendix A

IMS IPTV Functional Entities, Reference Points and Protocols

Figure A.1 shows the functional entities and reference points of the ETSI TISPAN IMS-based IPTV system. The full specification can be found at [17].

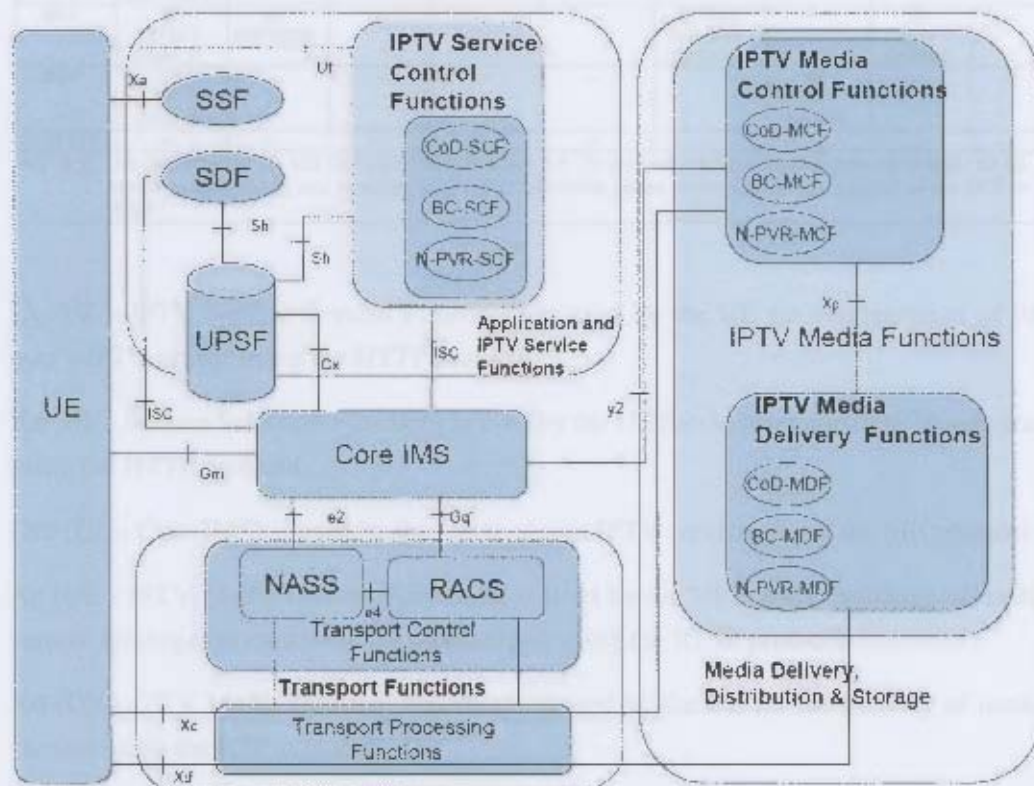


Figure A.1: ETSI TISPAN functional IMS-based IPTV architecture [17]

Table A.1 shows the names of the interfaces identified in figure A.1 and the signalling protocols associated with those interfaces. Ten interfaces are relevant to this thesis: Ut, Xa, Gm, Xc, Xd, ISC, Cx, Sh, y2 and Xp. For the full specification, refer to [18].

Table A.1: Interfaces and protocols for communication between IMS IPTV entities [18]

FE/ Ref.point (protocol)	UE	IMS core	UPSF	SDF	SSF	SCF	MCF	MDF	ECF/ EFF
UE	—	Gm (SIP/SDP)	—	via Core IMS (SIP/SDP)	Xa (HTTP, DVBSTP, FLUTE)	Ut (HTTP), via Core IMS (SIP/SDP)	Xc (RTSP) (Note 1)	Xd (UDP/RT) (Note 1)	Dj, Di IGMP/ MLD
IMS core	Gm (SIP/SDP)	—	Cx (Diameter)	—	—	ISC (SIP/SDP)	y2 (SIP/SDP)	—	—
UPSF	—	Cx (Diameter)	—	Sh (Diameter)	—	Sh (Diameter)	—	—	—
SDF	via Core IMS (SIP/SDP)	—	Sh (Diameter)	—	—	—	—	—	—
SSF	Xa (HTTP, DVBSTP, FLUTE)	—	—	—	—	—	—	—	—
SCF	Ut (HTTP), via Core IMS (SIP/SDP)	ISC (SIP/SDP)	Sh (Diameter)	—	—	—	via Core IMS & y2 (SIP/SDP)	—	—
MCF	Xc (RTSP) (Note 1)	y2 (SIP/SDP)	—	—	—	via Core IMS & y2 (SIP/SDP)	—	Xp (not defined)	—
MDF	Xd (UDP/RTP) (Note 1)	—	—	—	—	—	Xp (not defined)	—	—
ECF/ EFF	—	—	—	—	—	—	—	—	—

NOTE 1: As described in TS 182 027 [2] clauses 6.4 and 6.5, Xc and Xd are logical reference points that can be decomposed into Dj and possibly Di, Ds or Iz reference points depending on the location of the MCF or MDF.

Ut (UE - IPTV Service Control Functions) is used by the UE for configuration of the user's IPTV profile using the HTTP protocol.

Xa (UE - Service Selection Function) is used by the UE for the selection of IPTV services using the HTTP protocol.

Gm (UE - Core IMS) is used by the UE to access IPTV services using the SIP protocol.

Xc (UE - IPTV Media Control Functions) is used by the UE for the exchange of media control messages to control IPTV media flows using the RTSP protocol.

Xd (UE - IPTV Media Delivery Functions) is used by the UE for the delivery of media content using the RTP protocol.

ISC (Core IMS - Service Discovery Function) is used to provide service attachment information and for discovering personalised IPTV services using the SIP protocol.

Cx (Core IMS - UPSF) is used to obtain user profile information during session setup and modification using the Diameter protocol.

Sh (UPSF - IPTV Service Control Functions) is used for authorisation during session setup and modification using the Diameter protocol.

y2 (Core IMS - IPTV Media Control Functions) is used by the IPTV AS to indirectly control the MCF through the S-CSCF using the SIP protocol.

Xp (IPTV Media Control Functions - IPTV Media Delivery Functions) is used by the MCF to control the MDF using the RTSP protocol.

Appendix B

Example Scenario

This scenario is based on scenarios 1 and 2 which were introduced in Chapter 5, i.e., Bob and Alice's scenarios. Figures B.1 and B.2 show the profiles and advertisements databases respectively. Gender 2 indicates a female user and 1 indicates male, as can be seen in figure B.1. A gender value of 0 means unspecified, or relevant to both male and female users, as can be seen in figure B.2. The advertisements database has two listed advertisements: a Swatch and a Nivea advertisement. The Nivea advertisement is worth 1 credit. It can be seen that both advertisements are relevant to Alice, but neither are relevant to Bob.

No.	IMPU	Names	Age	Gender	Credits	Update	Remove
1	alice	Alice Clarkson	32	2	40	edit	delete
2	bob	Bob Marley	45	1	4	edit	delete

Figure B.1: Profiles look up table for advertisement database

No.	Advert Name	RTSP URL	Min Age	Max Age	Gender	Credits	Update	Remove
1	Click the advert button now to watch a Swatch advertisement	rtsp://tv.open-ims.test:5554/channel2	10	40	0	0	edit	delete
2	Watch a Nivea advert now and earn 1 credit	rtsp://tv.open-ims.test:5554/channel3	20	50	2	1	edit	delete

Figure B.2: Adverts look up table for advertisement database

Subsequent advertisements are selected throughout the duration of the media session, working down the advertisements database. Once the end of the table is reached, the selection will begin again from the first targeted advertisement in the list.

A demonstration video for this scenario can be found in Appendix D. It shows the profiles database for two listed users: Alice, who is a 32 year old female; and Bob, who is a 45 year old male. Alice has 45 advertisement credits and Bob has 4. It also shows the IPTV user profile configuration.

Alice registers with the IMS and requests channel 1 using the UCT IMS Client. She sees the Swatch advert. It can be seen that trick play functions are disabled when Alice tries to skip this advertisement. It also shows how the user profile information is sent in the SIP INVITE message. After the Swatch advertisement ends, the requested media starts in the same VoD window, which is an episode of Top Gear. A while later, a banner appears across the bottom of the window, using two lines of text, occupying 10% of the window. This banner corresponds to the Swatch advertisement since it is the first listed advertisement in the database which is relevant to Alice. She decides to ignore the banner and it disappears after 10 seconds. A few minutes later, a second banner appears, corresponding to the Nivea advertisement. This banner takes up only one line of text, occupying 5% of the VoD window. Alice decides to view this advertisement and earn 1 credit. She presses the *advert* button, causing the advertisement to be shown in the same VoD window.

Alice then de-registers. Bob registers and requests the same channel. The requested media starts immediately and no advertisement is seen by Bob before the episode of Top Gear starts.

The profiles database is shown. Alice now has a credit balance of 46 and Bob still has 4 credits.

Figures B.3 - B.6 illustrate the use of the profiles and advertisements database. Figure B.3 shows how a new user profile may be added, while B.4 shows how a user profile may be edited.

Figure B.5 shows how a new advertisement may be added to the list of advertisements, while figure B.6 shows how a listed advertisement may be edited.

Add new user profile

IMPU:

Names:

Domain:

Age:

Gender: Female Male Unspecified

Figure B.3: Adding a user profile

Details for Alice Clarkson

IMPU:

Names:

Age:

Gender:

Credits:

Figure B.4: Editing a user profile

Add new Advertisement

Advert Name:

RTSP URL:

Min Age:

Max Age:

Gender: Female Male Unspecified

Credits:

Figure B.5: Adding an advertisement

Details for rtsp://tv.uct.ims:5554/channel4

Advert Name:

RTSP URL:

Min Age:

Max Age:

Gender:

Credits:

Figure B.6: Editing an advertisement

Appendix C

Test Bed Hardware and Software

This appendix details the implementation software and hardware which was used to ensure reproducibility of the results obtained and presented in this thesis.

C.1 Software

UCT IMS Client [45]

The UCT IMS Client was used to provide the necessary client functionalities for the IPTV service. System requirements and installation instructions may be found at: <http://uctimsclient.berlios.de/>. The client was modified to supply advertising functionalities to the user. The source code may be found on the accompanying CD-ROM in Appendix D.

UCT Advanced IPTV [44]

The UCT Advanced IPTV was used to provide the IPTV service to the end user. Installation and configuration instructions may be found at: http://uctimsclient.berlios.de/uctiptv_advanced_howto.html. This system was modified to add advertising functionalities. The source code may be found on the accompanying CD-ROM in Appendix D.

UCT IPTV Charging [44]

The UCT IPTV Charging system was used to provide the necessary charging functions to allow for online and offline charging. The Fokus C Diameter Peer (CDP) is used to implement the Diameter based Rf and Ro interfaces. Installation instructions may be found at: <http://uctimsclient.berlios.de/uctimscharging.html>. The charging system was modified to record advertisement credits. The source code may be found on the accompanying CD-ROM in Appendix D.

Fraunhofer Fokus Open IMS Core [47]

The Fraunhofer Fokus Open IMS Core was used to provide the IMS core elements and a lightweight HSS. Details of the operation of the Open IMS Core, as well as download, installation and configuration instructions may be found at: <http://www.openimscore.org/>.

Media Server

The Media Server is implemented as a third party RTSP server. It uses VLC software and is only compatible with AVI and MPEG file formats. Installation and configuration instructions may be found at: http://uctimsclient.berlios.de/uctiptv_howto.html. The configuration file may be found on the accompanying CD-ROM in Appendix D. However, the media files are not included.

C.2 Hardware

The following commands were used to obtain the CPU information, memory information, OS distribution and kernel information for each machine used on the testbed:

- `head /proc/cpuinfo`
- `head /proc/meminfo`
- `lsb_release -a`
- `uname -a`

I-CSCF and S-CSCF

```
processor : 0
vendor_id : GenuineIntel
cpu family : 6
model : 15
model name : Intel(R) Pentium(R) Dual CPU E2160 @ 1.80GHz
stepping : 13
cpu MHz : 1203.000
cache size : 1024 KB
physical id : 0
```

siblings : 2

MemTotal: 1027004 kB

MemFree: 418328 kB

Buffers: 37564 kB

Cached: 250180 kB

SwapCached: 0 kB

Active: 278268 kB

Inactive: 184876 kB

HighTotal: 122624 kB

HighFree: 232 kB

LowTotal: 904380 kB

Distributor ID: Ubuntu

Description: Ubuntu 8.04.1

Release: 8.04

Codename: hardy

Linux ims-testbed 2.6.24-19-generic #1 SMP Wed Jun 18 14:43:41 UTC 2008 i686 GNU/Linux

P-CSCF

processor : 0

vendor_id : GenuineIntel

cpu family : 6

model : 15

model name : Intel(R) Pentium(R) Dual CPU E2160 @ 1.80GHz

stepping : 13

cpu MHz : 1203.000

cache size : 1024 KB

physical id : 0

siblings : 1

MemTotal: 1027052 kB

MemFree: 403348 kB

Buffers: 52332 kB
Cached: 250732 kB
SwapCached: 0 kB
Active: 293096 kB
Inactive: 187004 kB
HighTotal: 122624 kB
HighFree: 252 kB
LowTotal: 904428 kB

Distributor ID: Ubuntu
Description: Ubuntu 8.04.1
Release: 8.04
Codename: hardy

Linux pcscf 2.6.24-19-generic #1 SMP Wed Jun 18 14:43:41 UTC 2008 i686 GNU/Linux

HSS, CDF, OCS, IPTV AS

processor : 0
vendor_id : GenuineIntel
cpu family : 15
model : 2
model name : Intel(R) Pentium(R) 4 CPU 3.00GHz
stepping : 9
cpu MHz : 2992.816
cache size : 512 KB
physical id : 0
siblings : 2

MemTotal: 1018296 kB
MemFree: 28736 kB
Buffers: 566308 kB
Cached: 229036 kB
SwapCached: 0 kB
Active: 258996 kB

Inactive: 677968 kB
HighTotal: 113852 kB
HighFree: 208 kB
LowTotal: 904444 kB

Distributor ID: Ubuntu
Description: Ubuntu 8.04.1
Release: 8.04
Codename: hardy

Linux hss 2.6.24-19-generic #1 SMP Wed Jun 18 14:43:41 UTC 2008 i686 GNU/Linux

Client Terminals (Alice, Bob and Charlie)

processor : 0
vendor_id : GenuineIntel
cpu family : 6
model : 15
model name : Intel(R) Pentium(R) Dual CPU E2160 @ 1.80GHz
stepping : 13
cpu MHz : 1203.000
cache size : 1024 KB
physical id : 0
siblings : 2

MemTotal: 1026996 kB
MemFree: 410440 kB
Buffers: 14460 kB
Cached: 294108 kB
SwapCached: 0 kB
Active: 230992 kB
Inactive: 240120 kB
HighTotal: 122624 kB
HighFree: 236 kB
LowTotal: 904372 kB

Distributor ID: Ubuntu

Description: Ubuntu 8.04.3 LTS

Release: 8.04

Codename: hardy

Linux wilson-pc-1 2.6.24-26-generic #1 SMP Tue Dec 1 18:37:31 UTC 2009 i686 GNU/Linux

Appendix D

Accompanying CD-ROM

The CD-ROM included with this thesis contains the following files and information:

- *Example Scenario* - A demonstration video of the example scenario described in Appendix B can be found in the directory labelled "*Example Scenario*".
- *Publications* - Copies of papers which have been accepted to conferences, written or co-written by the author of this thesis, can be found in the directory labelled "*Publications*".
- *Research Literature* - Electronic versions of the research papers and other literature used during the course of this research can be found in the directory labelled "*Research Literature*". A text file containing a list of the URLs for online references is also included.
- *Results* - The results obtained during the performance tests carried out for this thesis can be found in the directory labelled "*Results*". This includes provisional, final and averaged results.
- *Software* - All the source code which was written and modified for the purpose of implementation of this project can be found in the directory labelled "*Software*".
- *Thesis* - An electronic version of this thesis document can be found in the directory labelled "*Thesis*".

- [11] S. J. Campbell. "alcatel-lucent launches new iptv advertising platform," [online]. available: <http://jobs.tmcnet.com/topics/broadband-comm/articles/41488-alcatel-lucent-launches-new-iptv-advertising-platform.htm>. Accessed: June 2009.
- [12] P. Christian. "iptv advertising measurements - making more money from advertising," [online]. available: [http://www.iptvmagazine.com/2007\[underscore\]01/iptv magazine\[underscore\]2007\[underscore\]01\[underscore\]iptv\[underscore\]advertising.html](http://www.iptvmagazine.com/2007[underscore]01/iptv magazine[underscore]2007[underscore]01[underscore]iptv[underscore]advertising.html). *IP Television Magazine*, January 2007.
- [13] D. Cotriss. "iptv advertising comes to life," [online]. available: <http://www.dailyiptv.com/news/iptv-advertising-rises-031207/>. Accessed: June 2009.
- [14] S. Dredge. "analysis: Blyk hitting right notes with ad-funded mvno, but faces challenges," [online]. available: [http://www.techdigest.tv/2007/09/analysis\[underscore\]blyk\[underscore\]h.html](http://www.techdigest.tv/2007/09/analysis[underscore]blyk[underscore]h.html). Accessed: June 2009.
- [15] ebay.co.uk. <http://www.ebay.co.uk/>. Accessed: April 2009.
- [16] ETSI. Ngn functional architecture release 1. *ES 282 001 V1.1.1, TISPAN*, December 2005.
- [17] ETSI. Iptv architecture: Iptv functions supported by the ims subsystem. *TS 182 027 V2.4.1, TISPAN*, July 2009.
- [18] ETSI. Ims-based iptv stage 3 specification. *TS 183 063, TISPAN*, June 2008.
- [19] K. Fitchard. "argela develops ad-subsidized voip platform," [online]. available: [http://nxtcommnews.com/ims/news/argela\[underscore\]subsidized\[underscore\]voip \[underscore\]062507/](http://nxtcommnews.com/ims/news/argela[underscore]subsidized[underscore]voip [underscore]062507/). Accessed: June 2009.
- [20] Google. "google adsense - about adsense" <https://www.google.com/adsense/support/bin/topic.py?hl=en&topic=13488>. Accessed: April 2009.
- [21] Google. "gtalk - about google talk" <http://www.google.com/talk/about.html>. Accessed: October 2009.
- [22] L. Harte. *IPTV Business Opportunities: How to Make Money in the Emerging IP Television Industry*. Althos Books, 2008.
- [23] L. Harte. "addressable tv advertising," [online]. available: [http://www.iptvmagazine.com/iptv\[underscore\]magazine\[underscore\]featured\[underscore\]article.html](http://www.iptvmagazine.com/iptv[underscore]magazine[underscore]featured[underscore]article.html). *IP Television Magazine*, November 2009.

- [24] S. Higginbotham. "germans get cheaper cell phone service in exchange for ads," [online]. available: <http://gigaom.com/2009/06/29/germans-get-cheaper-cell-phone-service-in-exchange-for-ads/>. Accessed: June 2009.
- [25] Y. Hu. Iptv market and standards update. In *the 5th International FOKUS IMS Workshop*, Berlin, Germany. November 2009.
- [26] IAB. "iptv and the advertiser," [online]. available: http://www.iabuk.net/en/1/iptv_andtheadvertiser.html. Accessed: June 2009.
- [27] ITU-T. Quality of experience requirements for iptv services. *G.1080, SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS: Multimedia quality of service and performance, Generic and user-related aspects*, December 2008.
- [28] ITU-T. Qos and qoe. *QoS and QoE standards overview*, March 2008.
- [29] ITU-T. End-user multimedia qos categories. *G.1010, SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS: Quality of service and performance*, November 2001.
- [30] C. Longbottom. "iptv - the new age of web ads," [online]. available: <http://www.it-director.com/content.php?cid=8474>. Accessed: June 2009.
- [31] I. Mas, V. Berggren, R. Jana, J. Murray, and C. W. Rice. Ims-tv: An ims-based architecture for interactive, personalized iptv. *IEEE Communications Magazine*, vol. 52:pp 156–163, November 2008.
- [32] Microsoft. "about webtv and msn tv" <http://www.about-the-web.com/shtml/webtv.shtml>. Accessed: June 2009.
- [33] Microsoft. "microsoft advertising - adcenter" <https://adcenter.microsoft.com/>. Accessed: April 2009.
- [34] Microsoft. "overview of multimedia specifications," [online]. available: [http://www.tactilemedia.com/info/mci\[underscore\]control\[underscore\]info.html](http://www.tactilemedia.com/info/mci[underscore]control[underscore]info.html). Accessed: December 2009.
- [35] E. Mikoczy, D. Sivchenko, B. Xu, and J. I. Moreno. Iptv services over ims: Architecture and standardization. *IEEE Communications Magazine*, vol. 46:pp 128–135, May 2008.

- [36] A. Nicklas and J. P. Reining. Online gaming - business model and technical challenges. In *the 5th International FOKUS IMS Workshop*, Berlin, Germany. November 2009.
- [37] W. Oosthuysen. Plenary presentation. In *the Southern Africa Telecommunication Networks and Applications Conference (SATNAC)*, Mbabane, Swaziland. September 2009.
- [38] S. Sahai. "interactive television advertising," [online]. available: <http://www.ipvtv-magazine.com/2009/02/ipvtv-magazine/2009/02/interactive-tv-advertising.html>. *IP Television Magazine*, February 2009.
- [39] K. Scherf and H. Wang. Reaching the unreachable consumer: Advertising in the digital age. *Parks Associates*, 2005.
- [40] Skype. "skype - call costs and rates" <http://www.skype.com/intl/en/prices/callrates/allratestab>. Accessed: October 2009.
- [41] Skype. "skype - get connected" <http://www.skype.com/intl/en/getconnected/>. Accessed: October 2009.
- [42] TRUSTe. "behavioral targeting: Not that bad?! truste survey shows decline in concern for behavioral targeting," [online]. available: <http://www.truste.com/about/truste/press-room/news/truste-behavioral-targeting-survey.html>. Accessed: June 2009.
- [43] A. Turk. New media services google. In *the 5th International FOKUS IMS Workshop*, Berlin, Germany. November 2009.
- [44] D. Waiting, R. Good, R. Spiers, and N. Ventura. Open source development tools for ims research. In *the 4th International Conference on testbeds and Research Infrastructures for the Development of Networks and Communities (Tridentcom)*, Innsbruck, Austria. March 2008.
- [45] D. Waiting, R. Good, R. Spiers, and N. Ventura. The uct ims client. In *the 1st Open IMS Testbeds Workshop, co located with Tridentcom*, Washington D.C., USA. November 2009.
- [46] T. Walsh. Next generation advertising: a quantified shift to the network edge. *Openet Transactional Intelligence*, 2008.

- [47] P. Weik, D. Vingarzan, and T. Magedanz. *The FOKUS Open IMS Core - A Global Reference Implementation, from The IMS Handbook: Concepts, Technologies and Services*. pp. 113 - 132, November 2008.
- [48] P. R. Wilson, V. G. Oziyani, and N. Ventura. Monetizing ims-based iptv through personalized advertising. In *the International Conference on Ultra Modern Telecommunications (ICUMT)*, St. Petersburg, Russia. October 2009.
- [49] P. R. Wilson and N. Ventura. A direct marketing platform for ims-based iptv. In *the Southern Africa Telecommunication Networks and Applications Conference (SATNAC)*, Mbabane, Swaziland. September 2009.
- [50] Yahoo! "yahoo! search marketing - international search engine marketing" <http://searchmarketing.yahoo.com/international.php>. Accessed: April 2009.
- [51] YouTube. <http://www.youtube.com>. Accessed: October 2009.