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# User Generated Content for IMS-Based IPTV

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A thesis submitted to the Department of Electrical Engineering,  
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for the degree of Master of Science in Electrical Engineering.

February 2012

## Declaration

I know the meaning of plagiarism and declare that all the work in the document “User Generated Content for an IMS-Based IPTV”, 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.

Denys Vera .....

Date .....

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## Abstract

Web 2.0 services have been on the rise due to improved bandwidth availability. Users can now connect to the internet with a variety of portable devices which are capable of performing multiple tasks. Due to this, services such as Voice over IP (VoIP), presence, social networks, instant messaging (IM) and Internet Protocol television (IPTV) to mention but a few, started to emerge.

IPTV is a system whereby digital television content is delivered over an IP network infrastructure. For past few years, the world-wide IPTV market share has been going up, in the first quarter of 2010 alone it went up by 7.8%. Despite the fact that there is an increase in market share, many service providers are still struggling in terms of profit. Unless there is something to differentiate the offer from the competition, users will ask the question why they need to subscribe. Furthermore, why would they want to pay more money for a duplicate service that uses new technology and an extra set-top box? There has to be a unique selling point (USP), something that represents a compelling emotional reason to sign up for the service

The success of social networks like YouTube, Facebook and all the various blogs shows that there is a personal media revolution and a general need to share content. This contributed to the rise of user-generated content (UGC) on the internet. UGC refers to all the various kinds of media content publicly available that are produced by end-users. Companies offering these services are enjoying increased revenue through advertising. In the United States of America UGC sites generated \$1 billion in advertising revenue in 2007 and it is projected they will earn \$4.3 billion by end of 2011. Based on this projection and the popularity of UGC sites, IPTV broadcasters can enjoy further success by integrating UGC with normal content. IMS (IP Multimedia Subsystem) based IPTV can help them achieve this thereby providing them with the USP. The integration with IPTV will be with a service like YouTube that allows users to upload and share videos of any kind. IP Multimedia Subsystem (IMS) is a set of specifications that describes the Next Generation Networking (NGN) architecture for implementing IP based telephony and multimedia services. It defines a complete architecture and framework that enables the convergence of voice, video, data and mobile network technology over an IP-based infrastructure. The IMS is better than other networks for this because it is access technology independent so anyone with any

device that can access the internet can connect to the IMS network. IMS allows all services to be available irrespective of the users' location and also provides a common platform to reduce time-to-market for rolling out new multimedia services. It provides multimedia services with Quality of Service (QoS) enablement and stores the users' profile information which can be used to provide direct marketing. These benefits made an IMS-based IPTV platform a more favourable implementation. An IMS-based IPTV platform is a service platform architecture which is able to provide IPTV services controlled and handled by IMS core subsystem. This is delivered independently from underlying IP transport networks.

This thesis proposed a framework that will offer user-generated content on an IMS-Based IPTV and the framework will include a personalised advertising system. The system will allow users to upload videos to the server and provide a way for other users to view these videos. This framework should not have a negative effect to the user's Quality of Experience (QoE) of the IPTV service and UGC services. To test the effects on user's QoE an evaluation platform was implemented. This was evaluated by looking at service latency, service features and service quality. The evaluation platform uses the Fraunhofer Fokus Open IMS Core, UCT IMS Client and UCT Advanced IPTV.

To validate the evaluation platform as a suitable testing environment for the proposed framework, proof of concept tests were carried out. After the proof of concept tests were successful, performance tests were then carried out to evaluate the effect of the proposed framework on users' QoE of the IPTV service. The test results showed success of the UGC framework and it did not have negative effects on the user's QoE of the IPTV service. The service latency stayed under the standard expected delay of 5 seconds. Service features meet the expected requirements and these where, easy to use system to upload videos, easy way to discover and select videos to watch because of the easy to use EPG, trick play functions on IPTV media and good service quality.

# Contents

Declaration.....	i
Acknowledgements.....	ii
Abstract.....	iii
Contents .....	v
List of Figures.....	viii
List of Tables .....	ix
Glossary .....	x
1. Introduction.....	1
1.1 Background .....	1
1.1.1 Challenges in adopting UGC services .....	7
1.2 Research Motivation .....	8
1.2.1 Problem definition .....	9
1.2.2 Research Questions.....	9
1.3 Thesis Objectives .....	10
1.4 Scope and Limitations.....	11
1.5 Thesis Outline .....	12
2. Literature Review.....	14
2.1 What is User Generated Content.....	14
2.1.1 User Generated Content on Television.....	15
2.1.2 Advertising on User Generated Content sites.....	20
2.2 Targeted Advertising on IPTV.....	23
2.3 IP Multimedia Subsystem .....	24
2.4 IP Television .....	24
2.4.1 IMS Based IPTV.....	25

2.5	Chapter Summary.....	27
3.	Proposed User Generated Content system for IMS-Based IPTV .....	29
3.1	Design Consideration .....	29
3.1.1	Functional Requirements .....	29
3.1.2	Design Requirements .....	30
3.2	Quality of Experience for IPTV services .....	32
3.2.1	Service Latency.....	35
3.2.2	Service Features .....	35
3.2.3	Service Quality.....	35
3.3	Proposed User Generated Content system for IMS-Based IPTV Architecture .....	36
3.3.2	User-generated content creation .....	39
3.3.3	UGC Content Watching.....	39
3.4	Chapter Discussion.....	40
4.	Architecture and Implementation of an Evaluation Framework.....	41
4.1	Evaluation Objectives .....	41
4.2	Evaluation Requirements .....	42
4.3	Limitations of the Evaluation Framework .....	43
4.4	Architecture of the Evaluation Platform .....	44
4.4.1	Software Used for the test-bed.....	45
4.4.2	Hardware used for the test-bed .....	47
4.5	Operation of the Evaluation Platform .....	47
4.5.1	Creating User Generated Content .....	47
4.5.2	Watching User Generated Content .....	49
4.6	Chapter Discussion.....	51
5.	Evaluation Results and Analysis.....	52

5.1	Verification of the Evaluation Platform .....	52
5.1.1	Scenario 1: Alice .....	53
5.1.2	Scenario 2: Bob .....	55
5.1.3	Scenario 3: Jane .....	56
5.2	Evaluation of the Proposed Framework .....	57
5.2.1	Service Latency .....	58
5.2.2	Service Features .....	61
5.2.3	Service Quality .....	64
5.2.4	Scalability of the evaluation platform .....	65
5.3	Chapter Discussion .....	65
6.	Conclusions and Recommendations .....	67
6.1	Conclusions .....	67
6.2	Recommendations and Future work .....	68
A.	IMS and IMS-Based IPTV Architectures .....	70
	IMS Architecture .....	70
	IMS-Based IPTV Architecture .....	73
A.	Details of machines used in the test-bed .....	77
B.	Accompanying CD-ROM .....	82
	Bibliography .....	83

## List of Figures

Figure 1.1: Challenges in UGC Adoption [55].....	8
Figure 2.1: Stages of the Bunes Fernsehen service [25].....	16
Figure 2.2: Living@room software components. [16] .....	18
Figure 2.3:ETSI TISPAN IMS-based IPTV Architecture [4] .....	27
Figure 3.1 QoE dimension [21] .....	34
Figure 3.2: Proposed User Generated Content System for IMS-Based IPTV .....	36
Figure 4.1: User Video Upload.....	43
Figure 4.2: Modified UCT IMS test-bed with UGC Service.....	45
Figure 4.3 UCT IMS Client .....	46
Figure 4.4: UGC Creation.....	48
Figure 4.5: User Generated Content EPG.....	49
Figure 4.6: Signalling diagram for UGC watching procedure.....	50
Figure 5.1: Information of Alice public video .....	54
Figure 5.2: Information of Alice private video .....	54
Figure 5.3: UGC Database.....	55
Figure 5.4: EPG showing the new video from Alice .....	56
Figure 5.5: EPG showing the private videos for Jane.....	57
Figure 5.6: Setup latency results for the three scenarios .....	60
Figure 5.7: EPG with available Videos.....	62
Figure 5.8: Upload dialog .....	63
Figure 5.9: Triple play functions .....	63
Figure A.1: IMS Architecture [35] .....	71

## List of Tables

Table 2.1: Summary of the drawbacks of the available systems .....	20
Table 3.1: Features of the different systems .....	31
Table 3.2: Performance targets for audio and video applications [23] .....	33
Table 5.1: Timing measurements for typical VoD functionalities. [45].....	58
Table 5.2: Average latency results.....	60
Table A.1: Interfaces and protocol for communication between IMS entities .....	71
Table A.2: IMS based IPTV functional entities and protocols used on reference points [1] .....	73

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## Glossary

3GPP	3rd Generation Partnership Project
AFHV	America's Funniest Home Videos
AS	Application Server
BC	Broadcasting
CATV	Cable Televisions
CDMA	Code division multiple access
CGM	Consumer Generated Media
CoD	Content on Demand
CPM	Cost per Mille
CSCF	Call Session Control Function
DVB	Digital Video Broadcasting
DVR	Digital Video Recorder
EDGE	Enhanced Data for Global Evolution
EPG	Electronic program guides
ETSI	European Telecommunications Standards Institute
FTP	File Transfer Protocol
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HSS	Home Subscriber Server
I-CSCF	Interrogating Call Session Control Function
ID	Identification
IETF	Internet Engineering Task Force
IM	Instant Messenger
IMPU	IP Multimedia Public Identity

IMS	IP Multimedia Subsystem
IPTV	Internet Protocol Television
IPTV-GSI	Internet Protocol Television Global Standards Initiative
IPv6	Internet Protocol version 6
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
LTE	Long Time Evolution
MCF	Media Control Function
MDF	Media Delivery Function
NASS	Network Attachment Subsystem
NGN	Next Generated Networks
P2P	Peer-2-Peer
PC	Personal Computer
P-CSCF	Proxy- Call Session Control Function
PVR	Personal Video Recorder
QoE	Quality of Experience
QoS	Quality of Service
RACS	Resource Admission and Control Subsystem
RTP	Real-Time Protocol
RTSP	Real Time Streaming Protocol
SCF	Service Control Function
S-CSCF	Serving Call Session Control Function
SDF	Service Discovery Functions
SDOs	Standards Developing Organizations
SDP	Service Delivery Platform
SIP	Session Initiation Protocol
SSF	Service Selection Functions

STB	Set to Box
TCF	Transport Control Function
TISPAN	Telecommunications and Internet converged Services and Protocols for Advanced Networking
TV	Television
UCT	University of Cape Town
UE	User Equipment
UGC	User Generated Content
UMTS	Universal Mobile Telecommunications System
UPSF	User Profile Section Function
URL	Universal Resource Locator
USP	Unique Selling Point
VLC	VideoLAN Client
VoD	Video on Demand
VoIP	Voice over Internet Protocol
WiMAX	Worldwide Interoperability for Microwave Access

# Chapter 1

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## 1. Introduction

### 1.1 Background

Many telecommunications service providers worldwide are moving towards triple play offerings by combining voice, video and high speed data services. Voice and high speed data services are already a solid building block of service providers' portfolio. In contrast, video represents a brand new element to be introduced into the traditional telecommunications services portfolio offered to mass markets. Majority of service providers are using IP-based technology to support such video services, commonly known as IPTV (Internet Protocol Television) services.

Internet Protocol television (IPTV) is a system whereby digital television content is delivered over an IP network infrastructure instead of being delivered through traditional radio frequency broadcast, satellite signal or cable television (CATV) formats. It is important to differentiate between IPTV and Internet TV [27]. IPTV is a video service supplied by a telecom service provider that owns the network infrastructure and controls content ingestion and distribution over the broadband network for reliable delivery to the consumer, generally using an IP set top box. This is essentially a private network controlled by the service provider. Internet TV, which is rapidly emerging in parallel, consists of content sourced from anywhere on the Internet that can be streamed and/or downloaded by the user, generally on a PC [22] [27]. Secondly IPTV has a high quality maintained throughout the network whereas Internet TV quality of video is driven by the speed of internet connection i.e. best effort. Furthermore IPTV is a subscription service while Internet TV is typically free or charged per video.

The period between the first quarter of 2009 to the first quarter of 2010 saw a global growth of 46% in IPTV subscriptions, equating to 11.4 million new IPTV subscribers. In the first quarter of 2010 alone the world-wide IPTV market grew by 7.8% leading to an overall 36.3 million IPTV subscribers as of March 31st 2010. IPTV penetration is around 7.7% of total broadband lines; a significant penetration, given the established position of cable, Digital Terrestrial Television and satellite alternatives in many mature markets [34].

Cisco launched the industry's first wireless IPTV service with AT&T which is available across the entire AT&T U-verse TV footprint. This will allow consumers to view high quality video service throughout the home without the need for cables and wires [50]. This shows how Telco's are extending business into IPTV and giving themselves a unique advantage of offering consumers new freedom to watch TV wherever they want in the home.

Even though IPTV adoption is on the rise, according to the article "Understanding User Generated Content" [32], some of these service providers are running at a loss or are just breaking even. Meaning research needs to be done to find ways to increase revenue for the IPTV service providers. There are a number of ways this can be achieved. Firstly by adding an extra service to the IPTV services already being offered, providing the service provider a unique selling point (USP) giving them an advantage over other service providers. The extra service should be one that has the potential to attract more users to the service. This will result in higher revenues for the service providers. A second addition would be advertising. Service providers and network operators have been provisioning advertising of third party products and services to generate additional revenue. This is due to the proven ability of marketing to provide better than average returns and substantially increase cash flow [11].

Technology has allowed almost anyone to be a content creator because of the prevalence of high quality cameras in mobile phones. Mobile phones have the capability to capture live breaking news as it happens and this can be shared with people around the world. This led to an increase in user-generated content (UGC) over the Internet also known as consumer-generated media (CGM), UGC refers to the various kinds of media content publicly available that are produced by end-users. The success of social networks like YouTube, Facebook and all the various blogs shows that there is a personal media revolution and a general need to share content [29]. This indicates that these services will have high chances of success, looking at the adoption rate of the technology. Gone are the days when power rested in the hands of a few content creators and media distributors, when markets controlled the communication and path between advertisement and the consumer. Today's model is collaborative, collective, customised and shared. We now live in a world in which the end-user is the creator, consumer and distributor of content [37]. Hundreds of millions of videos a day are uploaded and viewed on YouTube with approximately ten hours of video uploaded to YouTube every minute [30]. Users of UGC sites show a high degree of involvement as noted by the frequent visitations and long viewing sessions

of the content on these sites. This provides better chances to communicate key messages from adverts as these high volumes of viewers attract advertisers.

User-generated content draws users to companies that offer it; this can be used by the IPTV service providers to draw in users by offering UGC as one of the IPTV services. The increase in users will help boost revenue. The service providers can offer a service which allows users to upload personal videos through their set top box or TV sets to be watched by other users on the network. The extra service will allow the user to consume both professionally made content and content created by the community. An interactive TV service like this is referred to as social TV. Social TV is a general term for technology that supports communication and interaction in the context of watching TV, or related to TV content. It can be seen as the application of social networking in the domain of TV. Specifically, social TV allows users to share their TV experiences with others by providing a variety of ways for users to interact. For example, social TV may combine VoIP, Instant Messaging (IM), Presence, and video conferencing etc. with TV [5].

Social TV is a very active area of research and development that is also generating new services as TV operators are looking for ways to increase revenue. AmigoTV [12], CollaboraTV [13] and BuddyTV [5] are some of the examples that have integrated UGC with TV. But these technologies do not include sharing of video files that will be stored on a network that allows users to access and consume them. These platforms provide a system in which users can share comments on content and provide ratings but it does not allow the users to upload video files.

The idea of UGC on TV has been around for some time now but it has been implemented in different ways. In 1990, America's Funniest Home Videos (AFHV) debuted, bringing homemade content into American living rooms. The show is a competition in which the audience will vote for the video they consider the funniest. AFHV is the one of the longest running primetime series on ABC networks in the United States and has set a precedent not only for reality-based programming, but also for UGC on the Internet [14]. With the proven success of AFHV on television, creating a system with YouTube like features for users to experience shared content on TV could be a good business model. Allowing the users to upload and share their homemade content through their TVs in their living rooms.

FameTV on Sky is the world's first broadcast channel featuring wholly user-generated content and is available to more than eight million viewers in the U.K. and Ireland. On their system the only way you can upload videos is through their website but there needs to be a systems which will make it easy for users to do it without leaving the couch and upload on the set top box.

Netflix, Inc. is an American provider of on-demand internet streaming video in the United States and Canada. In April 2011 Netflix announced 23.6 million subscribers [48]. Diffusion's new study apparently found out that 32% of Netflix users plan to cut down on or cut out entirely their cable plans as a result of the availability of streaming content, up from 16% in 2010 [49]. This study shows that traditional TV services are facing competition from streaming services. Hence offering consumers IPTV that will provide on-demand streaming video can help them stay relevant in the ever changing market. IPTV will have an added advantage of having live TV, especially sports, in which streaming services like Netflix doesn't have. Diffusion's study [49] also showed which application in North American that used the most downstream bandwidth on fixed access networks at peak periods and it showed Netflix as number one with 29.7%. This shows that on demand streaming is very popular with consumers so offering it can be a success. The study also revealed that YouTube is the number 3 application with 11.04%, thus providing a service that will include VoD and UGC can be a success. Integrating IPTV services with a service like YouTube that allows users to upload and share their private videos can be the USP that can help IPTV service providers to stay relevant.

Furthermore, UGC has the potential to facilitate in addressing issues and problems faced within communities. UGC provides a good platform for local politics and lobbying: it is proving to be a very effective way to raise awareness, foster discussions and impact the decision-making processes within the community all of which contribute to engaging more and more customers in the project. In addition, UGC can be used as an effective business tool, especially for subject matter experts, providing local and niche businesses with a unique platform to address highly relevant micro-audiences in a cost-effective way [25].

The second way of improve revenue as mentioned is through advertising. The success of UGC sites with users resulted in advertisers investing in it because they want to advertise where there is a large audience. In the United States of America in 2006, UGC sites attracted 69 million users

and in 2007 it generated \$1 billion in advertising revenue. By the end of 2011, UGC sites were projected to attract 101 million users in the U.S and make \$4.3 billion in ad revenue [37]. Cost per Mille (CPM) ad costs across the UGC segment range from the low single digits to \$25 or more depending on placement, content area and depth of the library, with monthly avails totalling \$7 billion [45]. YouTube Generated an Estimated \$213 Million (Net) in Pre Roll Advertising in 2010 [44]. Based on these projections, IPTV broadcasters can enjoy further success by integrating UGC with normal content that comes from professional content producers as advertising on UGC sites has been tried and tested.

Users of IPTV services can offer personal information like gender, age and preference to the service providers. This information can be used to provide direct marketing. Direct marketing re-evaluates old advertising models by showing that it is not just about delivering the advertisements efficiently over a network that matters, but rather, the emphasis should be on delivering the right advertisement to the right consumer at the right time. This helps 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 [11].

Social networking and UGC sites have provided high value advertising inventory and audience segments needed to capture more of the market share and targeted audience reach that advertisers demand, for example Microsoft's investment in Facebook, Google's acquisition of YouTube and News Corps' acquisition of MySpace [37].

UGC has become popular and successful for a number of reasons some of which include; firstly, internet is easily accessible regardless of what device one is using, as long as it can handle the internet protocol, one can consume or contribute to the UGC on the internet. The access technology does not matter when accessing the internet. Secondly, the location of the user is also not important to contribute as they can do so anywhere. Thirdly, UGC sites change a lot with time as new features are added to the service for them to stay relevant and deliver what the end-user requires. All these are some requirements that are needed for UGC service to be successful. It is important for the network to be able to meet these requirements for it to be offered as an IPTV service. Hence IP Multimedia Subsystem (IMS) is the best network to use

because it meets these requirements and with its other properties, it can bring more to the UGC service.

IMS is a Next Generation Network (NGN) control framework which is designed to provide reliable communication services and multimedia applications to subscribers. It does this by providing the control functionality required to run managed Service Delivery Platforms (SDPs) over NGN networks [11]. IMS defines a complete architecture and framework that enables the convergence of voice, video, data and mobile network technology over an IP-based infrastructure. It fills the gap between the two most successful communication paradigms, cellular and Internet technology [47]. IMS was initially defined by the 3rd Generation Partnership Project (3GPP). This is a collaboration agreement among a number of telecommunications standards bodies as part of their standardisation work for supporting GSM networks and radio technology evolution. The IMS is better than other networks in that it is access technology independent so anyone with any device that can access the internet can connect to the IMS network, meeting the first requirement stated above. The IMS allows all services to be available irrespective of the users' location meeting the second requirement. Moreover it provides a common platform to reduce time-to-market for rolling out new multimedia services, third requirement. Furthermore, it provides multimedia services with Quality of Service (QoS) enablement [47]. In addition, the IMS stores the users' profile information which can be used to provide direct marketing. These benefits made an IMS-based IPTV platform a more favourable implementation.

To provide a USP for its IPTV offerings, Telekom Austria created Buntes Fernsehen which offered standard broadcast channels, VoD, and also programs and channels featuring content created locally. The system was deployed in a small community of 8 000 inhabitants. The feedback was that people were interested in community channels and programs but not interested in the "standard" approach of a local website. They wanted something they could watch, contribute to and interact with via their TV sets, not just their PCs. The pilot was so success that Telekom Austria believes user-generated content will be a key factor in the success of tomorrow's applications [25].

The availability of bandwidth has made streaming services like Netflix become popular and companies like Facebook and YouTube are getting into the business of streaming movies. As shown in [49], this could be the reason why people are moving away from TV because they can now watch TV series and movies anytime they want. As these services get better, TV operators are losing subscribers hence moving to IPTV is a good business move. With IPTV, they can offer both live TV and streaming services with Video on Demand (VOD) and have an advantage over the streaming services.

### **1.1.1 Challenges in adopting UGC services**

As Telcos enhance their service offerings by leveraging Social Networking and UGC services, they will have to address some key challenges:

#### **Network Bandwidth Constraints**

With the increasing popularity of Social Networking and UGC websites and mobilization of these services to provide customers with an ‘on-the-go’ experience, Telcos must address challenges related to bandwidth availability for the customers. They have addressed issues related to downstream bandwidth in the past. With these new services attracting more users to upload heavy files in the form of photos and videos, Telcos will have to focus on upstream bandwidth. Sharing of rich media across online communities, on demand user-generated video and music streaming create a burden on the available bandwidth especially when Telcos are allocating bandwidth for their IPTV and VoIP offerings. According to the Wall Street Journal and the United States Internet Industry Association, “the 100 million videos streamed each day through YouTube consume as much bandwidth as the entire Internet in 2000”[54].

#### **Potential Legal Issues**

Integration of User-Generated Content with Telco’s online portals and mobile devices enables users to upload and post content from several new access points. While hosting these new services can increase the revenue for Telcos, their vulnerability to host of legal issues also increases. Telcos have to take necessary steps to manage the potential risks and prevent liabilities arising out of legal issues as such [54]:

- Copyright and intellectual property infringement
- Defamatory, racial and sexual rhetoric

- Obscene and pornographic content that may be available to minors

More of the challenges are summarised in Figure 1.1

Issue	Why is it a challenge?
User-interface	Difficulty in discovering content; Difficulty in accessing content; Difficulty in navigating content; Difficulty in utilising multiple applications simultaneously; Difficulty in creating content; Difficulty in uploading content
Industry Structure	Operator dominance of value chain perceived by start-up service providers as restricting industry growth and limiting opportunities
Network Speed and Capacity	Latency issues with 2.5G and 3G; excessive uptake of some mobile entertainment services could place a strain on network capacity
Service Pricing	Pricing UGC content at too high a level may alienate the user base. Conversely, by setting prices too low, providers may fail to extract maximum value from their products
Cost of data services	Retail price per MB much higher than in fixed space, pricing structure often unclear to consumers
Handset capacity and battery life	Concerns remain over impact of multiple active applications on battery life; significant capacity needed to store/upload/download media files
Privacy	Possible (criminal) misuse of information
Differentiation	Start-ups in particular will need USPs to gain a critical mass of users
Customer Retention	In a competitive market, service providers will need to ensure of high quality of service to maintain customer acquisition/retention levels
Regulation	Providers must ensure compliance with copyright, age-verification and data mining regulation

Source: Juniper Research

Figure 1.1: Challenges in UGC Adoption [55]

## 1.2 Research Motivation

This thesis proposes and investigates a framework which is able to deliver user-generated content services as one of the IPTV services. This will use IMS as the control platform and uses

direct marketing to effectively deliver advertisements to consumers. This section describes the motivation behind the research work.

### **1.2.1 Problem definition**

Offering an IPTV service is one possible approach for Telco. However, there is a need to have something to differentiate the offer from the competition, users will question why they need to subscribe. After all, they already receive national broadcast channels and may in some instances subscribe to cable TV or satellite services. There has to be a unique selling point (USP), something that represents a compelling emotional reason for people to sign up for the service [25]. With this in mind, IPTV providers have looked into ways to provide the services in a more competitive and attractive way. Social TV is one of the ways the service providers are trying to set apart their offerings and provide the USP for the end-user. A number of different implementations of Social TV are available [5][12][13][14][16][25], each with its unique attributes. All these variations have the potential to attract consumers but they lack a clear way in which the service provider can generate revenue out of it. Furthermore, most of these solutions will require redesigning the network for them to work, an extra cost to the service providers. This extra cost is one of the reasons why an IMS solution is better given that IMS is standardised. Moreover, the fact that IMS is a common platform, time-to-market for rolling out new multimedia services is significantly reduced.

Quality of Experience (QoE) is defined as the overall performance of a system from the point of view of the users. It is a measure of the end-to-end performance levels from the perspective of how well the system meets the user needs [22]. Given the stiff competition surrounding the IPTV, the QoE of the users has become very important in keeping them satisfied and using the service. To keep the end-user satisfied the system has to meet and exceed quality levels currently offered by the traditional TV operators, IPTV service providers and UGC services. QoE

### **1.2.2 Research Questions**

This thesis aims to overcome the above mentioned problems of IPTV service providers not making profit, TV operators losing users to streaming services and incentivise IMS-based IPTV roll out. In particular, it will answer the following research questions:

- Can adding UGC services which also have an advertising system as an extra service to IPTV be a feasible business model that can increase revenue and subscribers for Telcos?
- Can this also act as an incentive for others to invest in IMS-based IPTV?
- IPTV is usually offered on subscription hence users have an expected QoE which can be measured using service latency, service features and service quality. So how would the adding of UGC services to IPTV service affect user's QoE of the IPTV service?

### 1.3 Thesis Objectives

The objective of this thesis is to propose and investigate a framework for IMS-based IPTV that include UGC services that have an advertising system. Furthermore, it aims to investigate and analyse the effect of the services to both the Telco's and users. For the Telco's, this means how feasible is it to offer such a service and how it will increase their revenue. For the users it refers to the effect on QoE of the IPTV service? To analyse the framework by testing different scenarios that highlights the requirements of the system, an evaluation platform should be used. Therefore, the objectives of this thesis are as follows:

- To Propose an IMS-based IPTV framework that supports UGC service as one of its services. The framework will also include an advertising system that uses direct marketing to provide targeted marketing for the purpose of trying to increase the number of users and increase revenue for the service providers
- To analyse how UGC services can bring in revenue by investigating related works.
- To analyse the effect of the UGC services on the user's QoE through the use of evaluation platform. The user's QoE will be measured using *service latency*, *service features* and *service quality*. Service latency refers to IPTV session setup delay. Service features refers to the features expected by the user looking at other UGC services online, these include the ability to upload videos, ability to watch videos uploaded by other users and the ease of use of these features. Service quality refers to the quality of the adverts and their length as compared to other UGC services and also if the electronic programme guide (EPG) meets the EPG requirements.

- To analyse scalability on the evaluation platform which looks at the amount of live streams and upload session that can be handled in the setup of the evaluation platform. This will provide a better understanding of how a proper media server has to function and to show the limitations of the evaluation platform.

To evaluate success or failure of the proposed platform, the metrics considered are *revenue and quality of experience (QoE)*. Revenue is evaluated by investigating related works on how UGC sites like YouTube make money from adverts. The user's QoE is measured using an evaluation platform.

## 1.4 Scope and Limitations

There are a number of IPTV architectures provided by the different Standard Development Organizations (SDOs), but this thesis will only look at the IMS-Based IPTV architecture standardised by ETSI TISPAN. This is because it has the most comprehensive set of specifications making it the most widely accepted [11][28].

UGC refers to a variety of content that is produced by the user but this thesis will only be investigating videos submitted by the users. The integration of UGC with IPTV services will only be of videos provided by the users. Advertising on UGC sites is done in a number ways which include pre-roll, overlay, dedicated channels and branding wrappers, to mention but a few. But in this thesis pre-roll was used which refers to when a short video advert would run before the selected video itself.

The proposed framework will include a personalised advertising platform which was proposed in the thesis "Delivering Personalised Advertising in IMS-Based IPTV through Direct Marketing" [11] as the advertising system that is used by the UGC service. The evaluation platform which is then used to evaluate the UGC services will not include the personalised advertising platform as it is not the focus of this thesis. All the details of the platform are available in the thesis mention above. The selection of the adverts to play will be done by using the category of the video. This system of using the categories of the video will be useful when the user hasn't provided their personal information that is used by the personalised advertising system to provide the relevant advert.

One of the biggest criticisms of UGC is copyright infringement; this is why UGC sites are researching ways to filter the videos uploaded by users. YouTube for example, has video length limitations to stop users from uploading a pirated movie for example. The proposed framework does not provide any way to filter the videos uploaded as this is out of the scope of this thesis. Nonetheless the system will allow the service provider to remove any content uploaded so they can remove it if there is any complaint about the content.

## 1.5 Thesis Outline

The structure of this thesis is as follows:

- Chapter 2 defines what User Generated Content (UGC) is and gives a brief history of UGC. It then looks at the work that has been done in the area of UGC on television, giving a brief description of each technology that was proposed and looking at the shortfalls of these systems. The chapter goes on to look at how advertising is done on UGC sites defining the roles of the three stakeholders, which are *advertisers*, *media owners*, and *users*. Information on how successful advertising on UGC sites is also given in terms of the growth in revenue seen for the past few years.
- Chapter 3 will give the design considerations for the system that will solve the shortfalls of the systems presented in chapter 2. It will then give the different requirements for each of the stakeholders involved. The chapter will also discuss the QoE for IPTV services and give more details of the metrics that are used to measure QoE using an evaluation platform. The proposed architecture will be presented in this chapter. It will use standard NGN and IMS entities, interface and protocols as defined by the 3GPP and ETSI TISPAN which is according to the requirements outlined in beginning of the chapter. The chapter also gives details and use of each of the components that make up the proposed architecture.
- Chapter 4 details the design and implementation of the evaluation platform for the proposed framework. The chapter will discuss the evaluation requirements, objectives and limitations of the test-bed used to evaluate the proposed framework, making sure that it satisfies the requirements. Complying with all the requirements makes the test-bed able to accurately evaluate the proposed framework and provide meaningful results. The

chapter then concludes by giving an operation of the evaluation platform taking a look at the two procedures for UGC. The two procedures that are provided in this chapter are *creating procedure* and *watching procedure*. It gives in detail the signalling for these procedures.

- Chapter 5 details the evaluation verification of the test-bed presented in chapter 4. Proof of concept test was used to verify the evaluation platform as a suitable testing environment by running IPTV sessions for two different scenarios and comparing the outcome to what is expected from the theoretical framework. These two scenarios will present the two procedures for UGC. These are *creating procedure* and *watching procedure* introduced in chapter 4. The evaluation is performed by running QoE tests which will be done by running different scenarios that will analyse how the UGC service will affect the users' QoE of the IPTV services. The parameters that are used to evaluate QoE are service latency, service features and service quality. Scalability of the media server on the evaluation platform will also be investigated. A classic IPTV VoD service will be used as a reference scenario in these tests.
- Chapter 6 draws conclusions and also answers the research questions from the evaluation of the architecture. It will also provide recommendations on possible extensions of the work presented in the thesis.

# Chapter 2

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## 2. Literature Review

This Chapter defines user-generated content (UGC), while providing a brief history of UGC. It then looks at the work that been done in the area of UGC in combination with television, giving a brief description of each technology that was proposed and looking at the faults of these systems. The chapter then goes on to look at how advertising is done on UGC sites defining the roles of the three stakeholders, namely *advertisers*, *media owners*, and *users*. Information on how successful advertising on UGC sites is also given in terms of the growth in revenue seen over the past few years. The chapter will also discuss targeted advertising on IPTV. Lastly the chapter gives brief introductions of IMS and the ETSI TISPAN IPTV-IMS architecture used as the reference architecture for this thesis.

### 2.1 What is User Generated Content

User-generated content also known as Consumer generated media encompasses opinions, experiences, advice and commentary about products, brands, companies and services-usually informed by personal experience that exist in consumer-created postings on Internet discussion boards, forums, Usenet newsgroups and blogs. UGC can include text, images, photos, videos, podcasts and other forms of media [20]. UGC has been around in one form or another since the earliest days of the Internet itself. But in the past few years, thanks to the growing availability of high-speed Internet access and search technology, it has become one of the dominant forms of global media [37]. UGC is omnipresent in e-commerce today, and its rapid growth has created some of the most successful digital brands, such as YouTube and Wikipedia. In the United States, 63 million people read at least one blog a month, and 24 million visit YouTube. A recent industry research report also reveals that consumption of UGC has reached levels comparable with traditional media, such as commercial radio and regional newspapers in the United Kingdom [20].

## History of UGC

UGC has been a staple of the peer-to-peer experience since the dawn of the digital age. The earliest forms arrived in 1980 with Usenet, a global discussion network that allowed users to share comments and experiences of a given topic. Early versions of Prodigy, a computer network launched in 1988, also facilitated user discussions and comments, as did the early versions of America Online (AOL). The late 1990s saw the rise of “ratings sites” which allowed users to rate subjects based on any number of criteria, from physical appearance (ratemyface.com and hotornot.com) to professional competence (ratemyprofessors.com). Another early form of UGC are forums; areas within content websites that allow readers to communicate with each other around topics related to the content. Even in this era dominated by social media sites, forums continue to be robust controlled areas of user content [37].

### 2.1.1 User Generated Content on Television

#### 2.1.1.1 *Buntes Fernsehen (Colourful TV)*

Telekom Austria [25] invests approximately 62 million USD per year in R&D aimed at migrating voice and data multimedia networks to next generation platforms. They wanted to create an interactive IPTV that relies heavily on UGC which will offer the opportunity to involve end users emotions in the service offered, driving a level of involvement and loyalty that rivals the success of the free online video sharing service like YouTube. So they created Buntes Fernsehen (Colorful TV) which offered standard channels and pay-per-view, Hollywood movies but also programs and channels featuring content created locally. The pilot project was launched in a small community which has 8000 inhabitants. It was clear that people were interested in community channels and programs but not interested in the “standard” approach of a local website. They wanted something they could watch, contribute to and interact with via their TV sets, not just their personal computers (PCs). The main objective of the project was to test the wide range of possibilities offered by broadband technology, as well as to investigate the types of technology and content that will attract and retain users in the future. Figure 2.1 on the next page shows the stages of interaction among all participants in the Buntes Fernsehen service. The pilot was a success for them that they came to a conclusion that UGC is will be a key factor in the success of tomorrow’s applications. In addition to becoming a unique selling point (USP) for

Telcos that possess the infrastructure to offer such interactive services, it will also represent a significant differentiator from other providers and will drive usage of broadband-based multimedia platforms.

The drawback of this system was that, when the pilot was deployed it was free of charge. This meant that there was no modelling on how best to monetize the system. The system lacked a charging mechanism

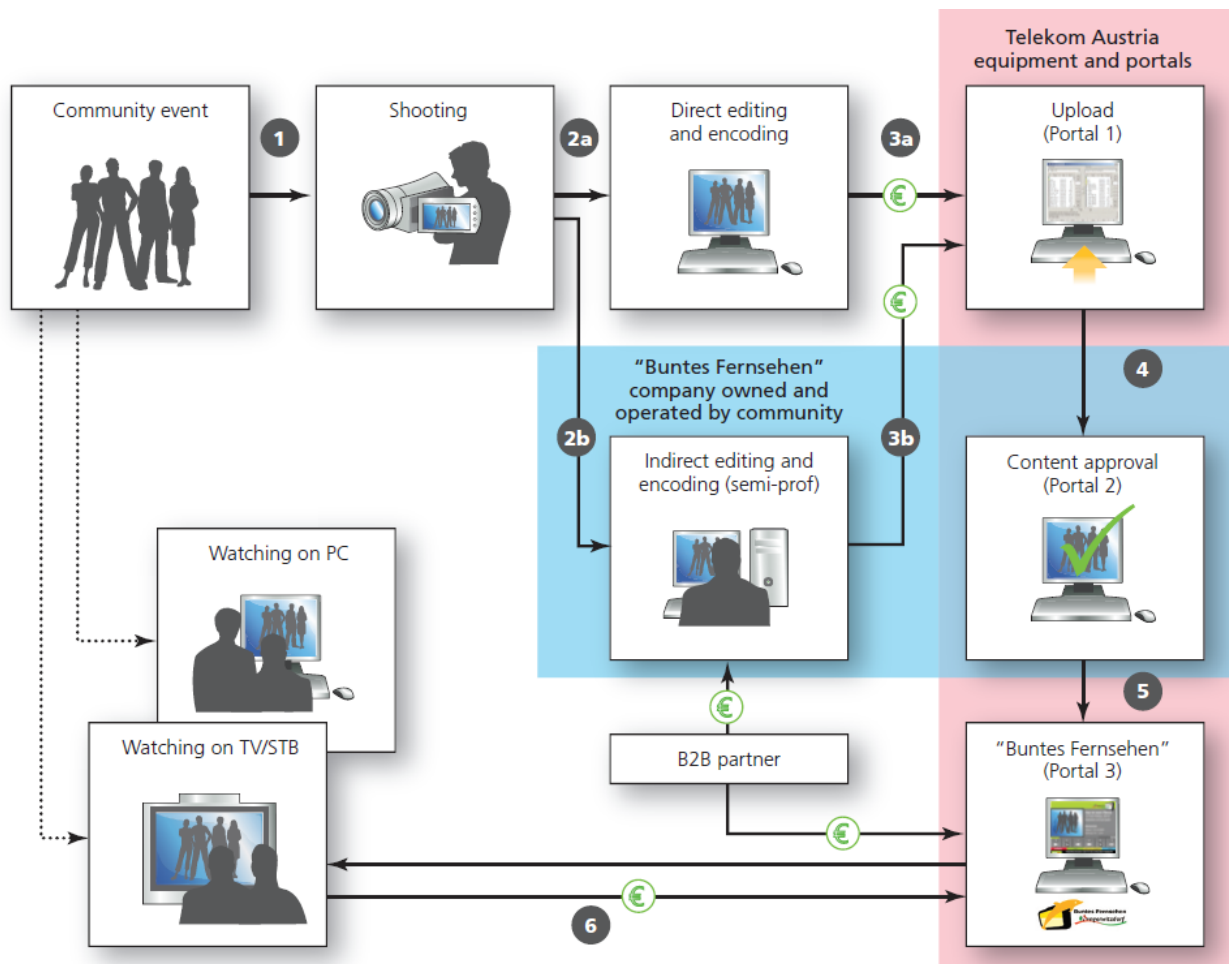


Figure 2.1: Stages of the BUNTES FERNSEHEN service [25]

### 2.1.1.2 TV Blog

E. Mantzari et al [15] introduced TV Blog and explained it in terms of three scenarios. The first two address the concept of blogging in its original form i.e. simple text posts. Blog TV

offers a simple interactive opportunity, by allowing users to access informational material about a preselected theme (based on user profiling) in a push mode, where users either simply decide to respond to it and add their personal opinion or relevant material in a text form, and / or find other individuals interested in the same topic and learn about a particular community – with the chance to enlarge their social contacts. The third scenario was added as a hypothetical example where the UGC is not only limited to simple text but also includes videos and links. The users would then upload videos on the blog and other users download the content to their recorders to watch.

The drawbacks of this system are that, the only way the user can view a video is by downloading the content so that it is locally available on their system meaning the user has to wait for the video to download before they can watch it. Furthermore, this system requires the user to have storage on their side to be able to enjoy the content. Blogs are usually limited to a specific topic which means users can't really upload any videos they want.

### *2.1.1.3 Living@room*

G. Andrea et al [16] proposed a system called Living@room shown on the next page Figure 2.2 which enables the remote enjoyment of multimedia content (photo, video, documents, etc.) simulating a face-to-face interaction. Their system created an environment in which one user can share content with other users. One person starts up a session online by selecting the people they want to share the content with. Then they have to select which content to stream from their local resources (file, CD, DVD etc.). The user would be able to see video streams from the other users so that they can chat while watching the content. The system allows the other users to pause and play the live stream which works like a shared remote control.

The problem of this system is that it requires the users to communicate first before the session starts. Once the streaming sessions is over and the user who had initiated the session is gone, the other users can't access the content. Also, the system only allows one person to share per session meaning if the others want to share their content they have to exit the session and start their own. A lot of computing power is required for streaming; because of this the client has to be sophisticated requiring a streaming unit and a controller to handle it all.

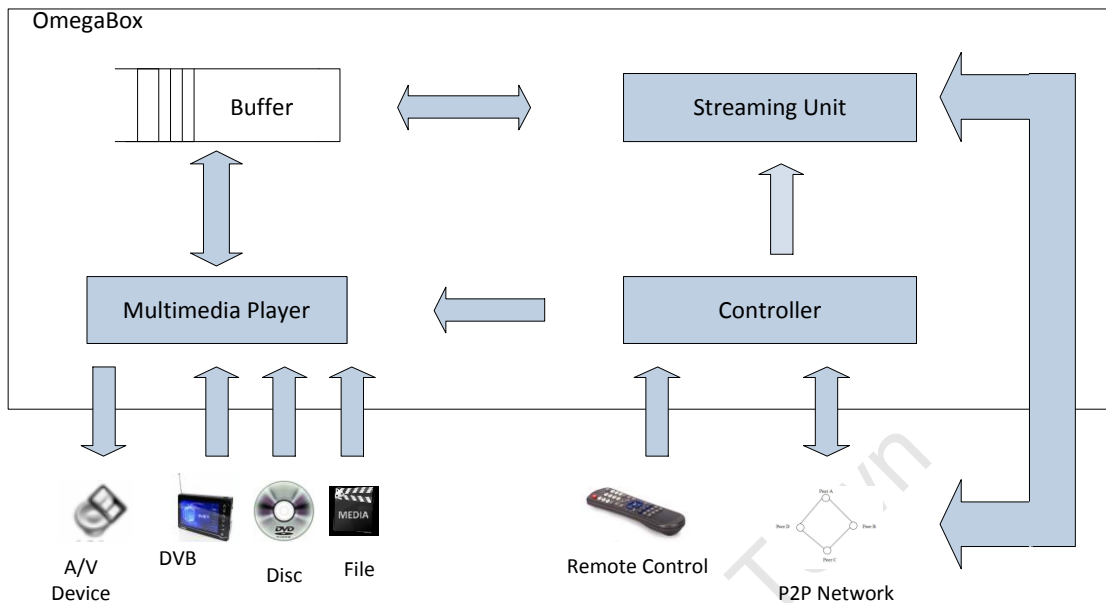


Figure 2.2: Living@room software components, [16]

#### 2.1.1.4 Tribler

J.A. Pouwelse et al [17] created Tribler, introduced it as a novel social-based Peer-to-Peer (P2P) system that exploits social phenomena by maintaining social networks and using these in content discovery, content recommendation, and collaborative downloading. J. Fokker et al [18] then used this for their Peer-to-Peer Television (P2P-TV) which they also called Tribler. This allows users to be connected in a network where they can view other users' content which they can watch through downloading, live streaming and VoD. The Tribler graphical user interface was based on two fundamental elements, the content and the users. The user interface gives access to all discovered content and users in the network, but also provides the means to browse personalized content with the distributed recommendation engine and the advanced social network each user creates implicitly and explicitly.

The drawbacks of this system are that, the service provider has no control of the system, meaning they can't make money out of it. There is also the problem of some content not being available when the user is offline since it's not server based.

### *2.1.1.5 Social TV*

Social TV is a general term for technology that supports communication and social interaction in either the context of watching TV or related to TV content. Social TV systems can for example include integrated voice communication, text chat, presence and context awareness, TV recommendations, ratings, or video-conferencing with the TV content by using ancillary devices or directly on the screen. MIT Technology Review on Social TV in 2010 named Social TV as one of the top 10 most emerging technologies [40] and in 2011, David Rowan, the Editor of the Wired magazine named Social TV at number three of the six in his peek into 2011 and what trends to expect to get traction [41].

L. Coppens et al, C. Harrison et al, E. Boerjes and H. Zhang et al [12, 13, 19, 5] proposed AmigoTV, CollaboraTV, ConneCTV, TV Buddy and Social electronic programme guide (EPG) respectively for Social TV services. The solutions are similar with slight differences/variations, AmigoTV shares messages and information among users using SIP protocol. CollaboraTV and ConneCTV provide user generated recommendations; ConneCTV goes an extra mile by allowing other users to download the recommended video from the user's digital video recorder (DVR). TV Buddy allows users to share text, photos, videos through instant messaging and Social EPG retrieves and shows the shared resources from the user's friends.

All these services have one weakness; they depend on the person providing content to be online when the user is offline the content is also offline. Moreover, most of these services work only for users who are your friends (people in your buddylist), meaning that the content consumed is limited and if the user does not have a lot of friends the service is not as enjoyable.
















### *2.1.1.6 Super 5 Media*

Super 5 Media [43] is a South African company that was formed in May 2009 after Telkom SA sold 75% of its stake in Telkom Media. The company is supposed to offer digital media to South Africa which includes IPTV. According to their website they will be offering User and Community Generated Content as part of their IPTV services. Content such as video clips, pictures, audio clips and information boards can be uploaded to an environment and shared within a community. No more details are provided to show how this will work so that a comparison can be made with the system being proposed in this thesis; furthermore the service

has not gone live.

Table below shows a summary of the problems all of the above mentioned systems.

**Table 2.1: Summary of the drawbacks of the available systems**

Problems	Colorful TV [25]	TV [15]	Blog	Living@room [16]	Triber [18]	Connect TV [19]
Lacks a way to generate revenue for the service provider						
Prior communication is needed between users before content can be watched						
Allows downloading only to watch content this means users have to wait for the video before they can watch						
Service provider do not control the system						
Requires storage on the user side						
Content goes offline when the user is offline						
Limited use to friends only						

### 2.1.2 Advertising on User Generated Content sites

Traditionally, marketers have been able to buy time or space on fixed media in a controlled context. They knew where their advertisement would appear, what it would look like, and perhaps most importantly, in what context it would be seen. In other words, they could be

guaranteed their message wasn't being delivered in a hostile or inappropriate environment. Today, such guarantees are harder to make, and that lack of control can be a source of great anxiety for marketers. But it also represents an unrivalled opportunity. Advertising in UGC requires marketers to alter their approach. Instead of broadcasting one-way messages to their audiences, advertisers are compelled to engage in a conversation. Doing so carries risks, but failure to do so carries even bigger risks [37].

S. Krishnamurthy and W. Dou [20] examined the inter-relationships among the major stakeholders in the UGC advertising environment, which are *advertisers*, *media owners*, and *users*:

### **Advertisers**

Advertisers can advertise in two ways in the UGC environment: they can provide professionally created advertising alongside content created by UGC users, or they could ask users of the UGC environment to create advertisements for the firm's brand.

### **Media Owners**

The role of the UGC media owner (i.e., the Web site that hosts the UGC) is less visible than that of owners of traditional media. Although the UGC advertiser still pays the UGC media owner advertising revenue (sometimes even lending a sense of legitimacy if the advertiser is a famous brand), the UGC media owner may have little to do (except serving as a platform) when the advertiser seeks advertising created by UGC users.

### **Users**

The roles of advertising users are more prominent and sometimes more complex than those in other media advertising. Users are not just passive consumers of media content instead they represent the lifeblood of UGC, and their behaviours may shape the advertising policies espoused by UGC media. Thus, the UGC advertiser must place the UGC users at the core of its UGC advertising strategy planning, because these users count not only as creators of their advertising but also as integral parts of the UGC media.

According to an AccuStream industry report [44], UGC video sites, networks, channels and brands like YouTube, Break.com, Metacafe, Dailymotion, MySpace and Veoh, among others generated more than 230 billion domestic US views in 2010, a 146.9% year-to-year increase.

Advertisers spent some \$426 million in pre-roll ad spend across the UGC segment [45].

Cost per Mille (CPM) ad costs across the UGC segment range from the low single digits to \$25 or more depending on placement, content area and depth of the library, with monthly avails totalling \$7 billion [45]. YouTube Generated an Estimated \$213 Million (Net) in Pre Roll Advertising in 2010 [44].

ComScore's study of consumers' receptivity to advertising in different media format [51]. Pointed out an adverts' effectiveness is based, in part, on the medium that carries it and how much trust the consumer has on the medium. The study revealed that the demographic segments of 18-34 year olds are much more comfortable with UGC sites, with 41% responding that they are receptive to advertising on these sites. For them what this meant was, online advertisers have some opportunities right now to connect with consumers on UGC sites. Additionally, the greater receptivity among younger age groups to advertising on UGC sites suggests that the future is bright for advertising in this medium.

#### *2.1.2.1 Trends in UGC Advertising*

There are ways for brands to leverage the UGC platform: by placing commercial messaging in and around the content or becoming a part of the content itself [37]. The following are a few of the most popular on UGC sites.

#### **“Pre-roll” and “Overlay” Video Ads**

“Pre-roll” ads, this is when a short video advert would run before the selected video itself. “Overlay”, are ads that pop up 15 seconds into a video and only cover the bottom 1/5 of the screen, and disappear after a few seconds if the user doesn't click on them. But if the user does click, the video will pause and advert will play. The video will resume once the ad has ended.

#### **Custom Communities**

Custom communities provide a hub for brands to entertain and engage users through interesting content, unique assets, games, polls, quizzes or contests. Off-site advertising drives consumers to these communities where they can participate and pass along content they find interesting or valuable [37].

#### **Dedicated Channels**

This is another version of custom communities. An advertiser creates their own community on

a content-sharing site like YouTube. Consumers can visit these sites and engage in all manner of branded activity.

### **Brand Profile Page**

Advertisers can create a profile page on social networking site for its product. The page can be used to provide materials and information of the product, such as demonstration videos and graphics that other users can use to decorate their own pages.

### **Branding Wrappers**

One way to get noticed on a UGC site is a branding wrapper or “skin.” These wrappers transform a social network’s landing page into a 360-degree branding experience, complete with wallpaper, photos, video, music, and links. A user logging onto MySpace, for example, would find the home page fully dedicated to a single brand or product, and could easily engage with that marketer even before entering her password [37].

## **2.2 Targeted Advertising on IPTV**

Facing high start-up costs and limited initial subscriber revenues from IPTV deployments, Telcos must find other applications for generating revenue to fund continued deployment. A proven money-maker is local advertising, which earned U.S. cable operators \$5 billion in 2007. Local advertisements are developed for specific geographies and demographics and are typically used by small businesses to target consumers in their region. While cable operators are planning to increase their share of revenues from the advertising market with targeted advertising, Telcos can take a step ahead and capture additional advertising revenues by making the advertisements highly targeted and increasing the effectiveness and return on investment (ROI) of their advertisements [26].

Globally, Internet-based advertising is growing rapidly at a 22% annual growth rate. The growth has come from value shifting of advertising dollars from traditional broadcast advertising to targeted advertising offered by the Internet. Targeted advertising represents a significant emerging opportunity for Telcos worldwide that can drive their IPTV revenue growth and profitability [26].

The systems provided for targeted advertising in [26, 52, 53] all use the location of the consumer to determine which advertisement will be played. This means that the geographic

location will have its own set of adverts that apply to them, a local store for example that is only available in one location. These systems don't really provide any personal tweaking for each individual user to tailor make which kind of advert the consumer prefers to get.

The system proposed in [11] provides more personalisation as the consumer specifies more personal information like gender, age, etc. so that the system can provide a more relevant advert. Since the adverts are targeted, users are less likely to skip the adverts. Furthermore, the system awards credits as an incentive for users to view the advertisements.

### **2.3 IP Multimedia Subsystem**

The IP Multimedia Subsystem (IMS) is an IP multimedia and telephony core network that is defined by the 3rd Generation Partnership Project (3GPP) and 3rd Generation Partnership Project 2 (3GPP2) standards and organizations based on Internet Engineering Task Force (IETF) Internet protocols. IMS is access independent as it supports IP to IP session over wire line IP, Wi-Fi, WiMAX, CDMA, packet data along with GSM/EDGE/UMTS and other packet data applications [35].

The IMS architecture has been designed to enable operators to provide a wide range of real-time, packet-based services and to track their use in a way that allows both traditional time-based charging as well as packet and service-based charging. It has become increasingly popular both with wireline and wireless service providers as it is designed to increase carrier revenues, deliver integrated multimedia services, and create an open, standards-based network [36]. The full architecture of the IMS and its entities are provided in Appendix A.

### **2.4 IP Television**

IPTV services can be divided into three types of services, broadcasting services (BC): live TV broadcasted over network, content on demand (CoD): unicast services provided on subscriber demand and personal video recorder services (PVR): services that allow recording, pause or time shift capabilities for live content. IPTV has evolved over the years and there are at least three noticeable different stages of evolution:

- Non-Next Generation Network (NGN) based IPTV solutions; this is the most common solution on the market currently.

- NGN based IPTV architecture. This approach uses a dedicated IPTV subsystem within NGN to provide all necessary IPTV required functionalities, hence why they are referred to as Dedicated IPTV Systems. It enables interaction and interworking over specified reference points between IPTV applications and NGN components. These components include transport control elements for resource admission and control subsystem (RACS) or the TISPAN network attachment subsystem (NASS) [33]. 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 such, dedicated IPTV systems are generally used as standalone services [11].
- IMS based IPTV architecture. The IMS is used for IPTV registration, Service Discovery and IPTV session control. By supporting IPTV services with IMS functionality enables more IPTV features including integrated user registration and authentication, user subscription management, interaction with existing NGN service enablers for example presence, roam and nomadic support, QoS and bearing support, unified charging and billing. It also has these advantages, support for mobility, service personalization and media adaption as well as providing converged applications integrated voice, data video and mobile services [33]. For these reasons, IMS based IPTV architecture was used in this thesis.

#### 2.4.1 IMS Based IPTV

Different Standard Development Organizations (SDOs), such as Open IPTV Forum [38], International Telecommunication Union-Telecommunication Internet Protocol Television Global Standards Initiative (ITU-T IPTV-GSI) [39] and European Telecommunications Standards Institute (ETSI) Telecoms and Internet Converged Services and Protocols for Advanced Networking (TISPAN) [1] all work on guidelines, frameworks and standards addressing the harmonisation of global standards for NGN IPTV. The IMS based IPTV architecture standardised by ETSI TISPAN has the most comprehensive set of specifications making it the most widely accepted. The standards are developed in co-operation with other SDOs such as ITU-T IPTV Focus Group, ATIS IPTV Interoperability Forum and DVB interoperability between IPTV systems developed by different vendors and deployed by different networks. For

this reason, the ETSI TISPAN IMS-based IPTV was chosen as the reference IMS-IPTV architecture for this thesis. The overall functional architecture for IPTV services is shown in Figure 2.3 shows the five main sections which are; User Equipment, Application and IPTV service Functions, Core IMS, Media Delivery Distribution and storage and Transport Layer. Each of the sections is briefly described below.

### **User Equipment (UE)**

The UE is responsible for IPTV control and media signals as well as displaying of the corresponding information to the user. This is where the user selects programs, content and services descriptions.

### **IMS Core**

This provides functionality for authentication, authorization, and signalling for the setup of the service provisioning and content delivery. The IMS Core routes signalling messages to the appropriate application server or triggers the application based on the settings maintained in the database of users profiles.

### **Application and IPTV service Functions**

This includes all the functions that are needed to control the IPTV services which are; Service Discovery Function (SDF), Service Selection Functions (SSF), Service Control Function (SCF) and User Profile Section Function (UPSF). The SDF and SSF provide information necessary to the UE to select IPTV services. SCF is a SIP Application Server (AS) which is responsible for authorization during session setup and modification. The UPSF holds the IMS user profile and possibly IPTV specific profile data. More details of these functions are provided in Appendix A.

### **Media Delivery, Distribution and Storage**

This is made out of the IPTV Media Control Function (MCF) and the Media Delivery Function (MDF). These functions are in charge of controlling and delivering the media flows to the UE. More details of each of these functions are provided in Appendix A.

### **Transport Functions**

The Transport Control Functions (TCF) enable policy control, resource reservation and admission control, as well as IP address provisioning, networking level user authentication and access network configuration, as defined in TISPAN. The Transport Processing Functions (TPF) represents the IP core and access network transmission links.

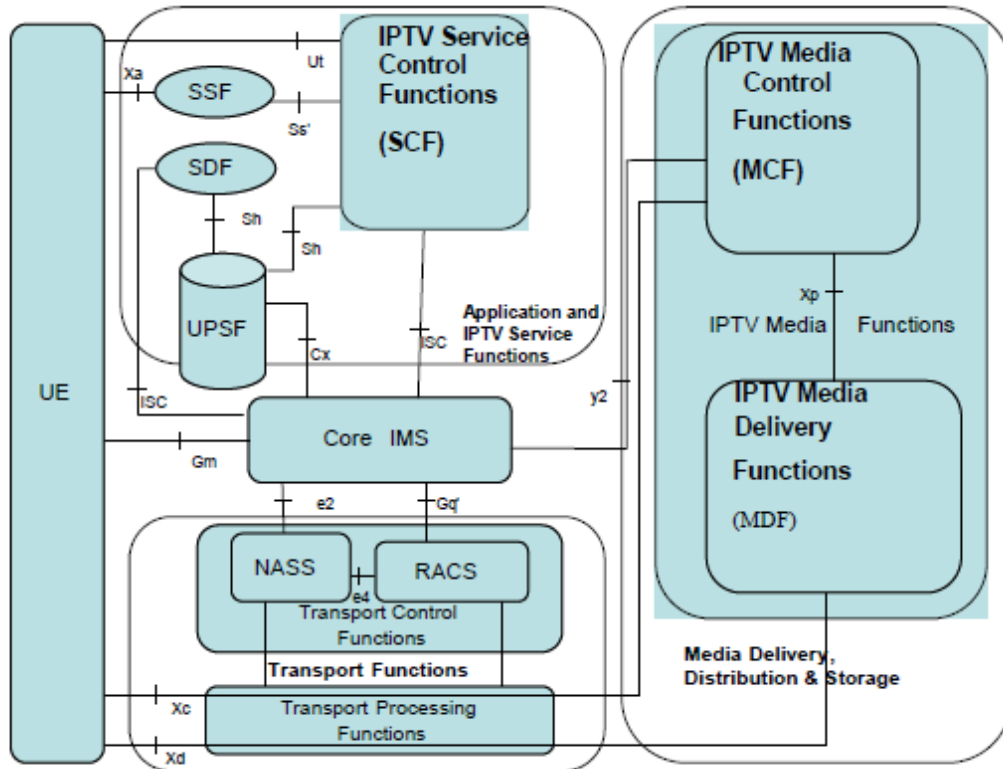


Figure 2.3:ETSI TISPAN IMS-based IPTV Architecture [4]

## 2.5 Chapter Summary

This chapter discussed a number of different solutions for implementing UGC on television and identified the drawbacks of each of them. E. Mantzari et al [15] system has the following drawbacks; the need for a local storage to download videos before the user can watch it, leading to the user having to wait for the video to finish downloading before they can watch the video. Also blogs are usually limited to a specific topic which means users can't really upload any videos they want.

G. Andrea et al [16] system has the problem that it requires the users to communicate first before the session starts since its P2P streaming with no server. Also once the user who initiated the session goes offline the other users can't access the content anymore. The system also requires a sophisticated client that will be able to handle a streaming unit and a controller unit to compute the required processing required for the system.

L. Coppens et al, C. Harrison et al, E. Boerjes, H. Zhang et al and J.A. Pouwelse et al [12, 13, 19, 5 and 17] have different systems but all of them share the same weakness; they depend on

the person providing content to be online, when the user is offline the content is also offline. Also most of these services work only for users who are your friends (people in your buddylist), meaning that the content consumed is limited. If the user doesn't have a lot of friends the service is not as enjoyable. Also all these systems do not clearly provide a way in which the service provider can increase their revenue.

Chapter 3 will show how the proposed architecture will address these drawbacks. This chapter also went on to provide some of the different ways with which advertising is done on UGC sites as well as discussing targeted advertising on IPTV. The chapter then introduced the IMS and ETSI TISPAN IMS-based IPTV architecture. It is this architecture that will be used as reference architecture for the proposed architecture in Chapter 3.

University of Cape Town

# Chapter 3

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## **3. Proposed User Generated Content system for IMS-Based IPTV**

This Chapter begins by stating design considerations which are divided into functional requirements and design requirements of the proposed system. The chapter then explains how these issues will be resolved by the proposed architecture. The chapter will then look at the different requirements for each of the stakeholders who include the users, advertisers and IPTV service provider. It will then discuss Quality of Experience for IPTV and give more details of the metrics that are going to be used to evaluate the proposed system. Lastly, the chapter will present the proposed detailed user-generated content system for IMS-based IPTV to address the research questions presented in Chapter 1 and resolve the issues identified in Chapter 2.

### **3.1 Design Consideration**

In Chapter 2 drawbacks of existing systems were highlighted and those were used in the design consideration.

#### **3.1.1 Functional Requirements**

One problem that affected most of the systems is that they do not have a server to store the uploaded content. This meant that content was streamed and in some cases downloaded from one user to another in a peer-to-peer manner. The problem with that is, when the source of the content goes offline so does the content. The proposed system will solve this problem by allowing the users to upload to a central server and from the server the other users can stream the content. Streaming also solves the issues of the user requiring storage on their side. Streaming saves the users' time because they do not have to wait for the video to download before they can enjoy it. For seamless streaming, the buffer size at the client side has to meet the requirements and enough bandwidth has to be available. Details of the buffer size required and the amount of bandwidth was out of the scope of this thesis because IPTV is a video service supplied by a telecom service provider that owns the network infrastructure and controls content ingestion and

distribution over the broadband network for reliable delivery to the consumer. This is essentially a private network controlled by the service provider [27]. Hence the buffer size requirements and network speed requirements for seamless streaming is always guaranteed. Having the content on the server eliminates the need of prior communication between the users before they can watch the content uploaded not like in some of the systems. The server will also make it possible for the user to watch the content whenever they get to their TV and at any time.

As noted in Chapter 2, most of these systems are private which limits the user to videos from their friends only. The system introduced in this chapter will have both options to share the content with a selected few or with everyone on the network making it a better social service.

















The system introduced in [15] TV Blog, has an additional issue that blogs are usually limited to a specific topic which means users cannot upload any videos they want. The system proposed in this chapter handles this better because users can upload any video they like in different categories. Living@room [16] requires a sophisticated client to handle all the computing that is needed for the streaming. But in this system a simple IMS client will be able to access the content because most of the work is done on the server side.

All the systems discussed in Chapter 2 do not show how the IPTV service provider can generate revenue. The proposed system provides a way in which the service provider can generate revenue by having a personalised advertising system which will play adverts before playing the required video. As shown in Chapter 2, pre-roll video ads bring in revenue to UGC sites and this can work in the same way for IPTV service providers. Table 3.1 shows the feature sets of the different systems and the proposed one summarizing the functional features.

### **3.1.2 Design Requirements**

For the proposed user-generated content system for IMS-Based IPTV to be a success it has to satisfy the requirements for all the parties who are going to use the system. In terms of UGC service there are two parties to be considered, the user and the media owner (the IPTV service provider) and for advertising on UGC there are three stakeholders as discussed in chapter 2, the user, the media owner and the advertisers. Highlighted below is how the system will address the requirements of the different stakeholders.

Table 3.1: Features of the different systems

Features	Colourful TV [25]	TV Blog [15]	Living@room [16]	Tribler [18]	Proposed System
Server Storage					
Streaming capability					
Publically shared content					
Instant watching with no communication between users					
Way to generate revenue					

### Users

Users play a very important role in the success or failure of the system. For this reason the following requirements have to be satisfied by the system:

- It should provide a good QoE for the IPTV services.
- It should be easy to use and all features should be visible to the user.
- The system should allow the users to upload their videos and have the option for their content to be viewed by people in their buddy list or by everyone on the network.
- It should allow the user to provide metadata for the video.
- It should allow the user to select and watch content shared by other users.

### Advertisers

As noted in chapter 2, advertisers can advertise in one of two ways in a UGC environment. They can provide professionally created advertising alongside content created by UGC users, or they could ask users of the UGC environment to create advertisements for the firm's brand. Thus the requirements specific to the advertisers are:

- The system should be able to play pre-roll ads.

- It should use targeted advertising system to determine which advert to be played
- Content should be stored in categories with each category having its own set of adverts associated to it. This will be useful when there is not enough information about the user for the targeted advertising to work.

### **IPTV service provider (media owner)**

The service provider controls and manages the system; hence it should have these requirements:

- The ability to delete any uploaded content if it infringes on any copyrighted material.
- The ability to determine which category content is stored and be able to move it around if necessary.

## **3.2 Quality of Experience for IPTV services**

As service providers roll out IPTV services, they face various challenges. Their top priority is to deliver a superior experience to their customers. IPTV services must meet and exceed quality levels currently offered by traditional TV players such as satellite or cable providers. Providing such service quality levels is even more complex when delivering video using a multiservice IP platform where multiple services share the same resources. Metrics such as network delay, jitter, packet loss and throughput are used to indicate IPTV service performance. Quality of Service (QoS) practice is focused on such network aspects [22]. Nevertheless such parameters represent the network performance parameters, they may affect user experience. The Quality of Experience (QoE) is not represented by these metrics.

The G.1010 recommendation [23] 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. Since there is no conversational element, IPTV applications which include streaming audio and video are not sensitive to jitter and can tolerate large delay. This means that the delay requirement is less stringent than for conversational services such as voice and video calling [11]. In Table 3.2 the audio and video applications performance targets are shown. It shows that a service like IPTV which offers 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 of less than

1%. But since IMS-based IPTV is offered over a managed SDP, we assume the target bit rate and PLR are guaranteed. The other factors affecting QoE at the transport layer which include buffering techniques, media coding and QoS classes required to offer these guarantees are beyond the scope of this thesis. Therefore the thesis is only concerned with parameters that are perceived by the user, i.e. service delay. Service delay refers to the time that elapses between when a user requests a function/feature to when the user can use or see the function/feature.

**Table 3.2: Performance targets for audio and video applications [23]**

Medium	Application	Degree of symmetry	Typical data rate	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	Lipsynch: < 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 the overall performance of a system from the point of view of the users. It is a measure of the end-to-end performance levels from the user perspective and an indicator of how well this system meets the users' needs. The distinction between QoS and QoE is that QoE is performance measured at application level from the user perspective while QoS is performance measured at packet level from network perspective. Figure 3.1 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. 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. To measure these parameters, available features and service quality may be compared to those offered in similar services for example, TV services, PVR services and other systems that offer UGC services [11].

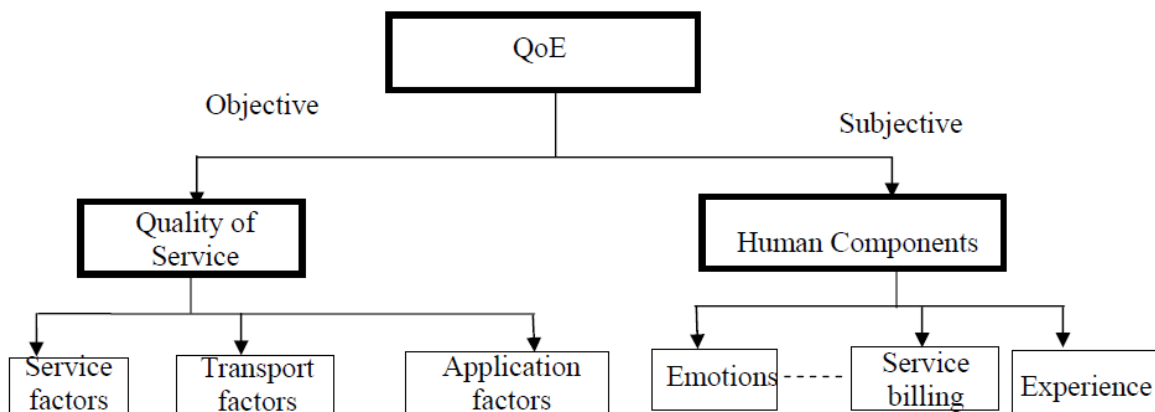


Figure 3.1 QoE dimension [21]

Recommendation G.1080 [21] defines user requirements for QoE for IPTV services. These requirements are from the user's perspective and are diagnostic 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. Therefore, recommendation G.1080 [21] 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 [11]. 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 Channel zapping time (channel switching time) are also recommended in ITU-T G.1080 [21]. Channel zapping has strong relationship with end user experience of service quality. Generally, it is primarily determined by the time required to have a proper frame at the STB to start decode processing for the new channel. Channel zapping requests can occur when there is a metadata request in the electronic program guide (EPG). In addition the ITU-T G.1080 also gave the requirements for EPG which include: user-friendliness (the EPG user interface is recommended to be designed for ease of use.) and response time to display EPG page (The response time – the interval of time elapsed between the moment the EPG button of the remote control is pushed and the moment the EPG page is displayed – is recommended to be sufficiently short).

From this section it can be noted that QoE can be measured using three metrics which are *service latency*, *service features* and *service quality*.

### **3.2.1 Service Latency**

Service latency refers to IPTV session setup delay. These delays are the delays in the terminal, network and servers. Session setup delay for one of the IPTV services for example, VoD service will be compared to the service latency of the UGC service. The delays of the two services should not be significantly different.

### **3.2.2 Service Features**

Service features refer to the features expected by the user and the ease of use of these features. The features are compared with competing services like live TV, PVR, streaming services and other systems that offer UGC services. These features include; upload of user videos with the ability to provide metadata for the videos the ability for user to specify who can watch their uploaded videos; select and streaming of shared videos; trick play functions to pause, fast forward and rewind the media (users don't have these functions when the pre-roll advert is playing).

### **3.2.3 Service Quality**

Service quality checks if the EPG meets the requirements specified in the ITU-T G.1080[21]. This will also look at the pre-roll advertisements quality. The videos uploaded by the user may

differ from user to user but the quality of the adverts should always be high. The pre-roll advertisement should be 30 seconds or less.

### 3.3 Proposed User Generated Content system for IMS-Based IPTV Architecture

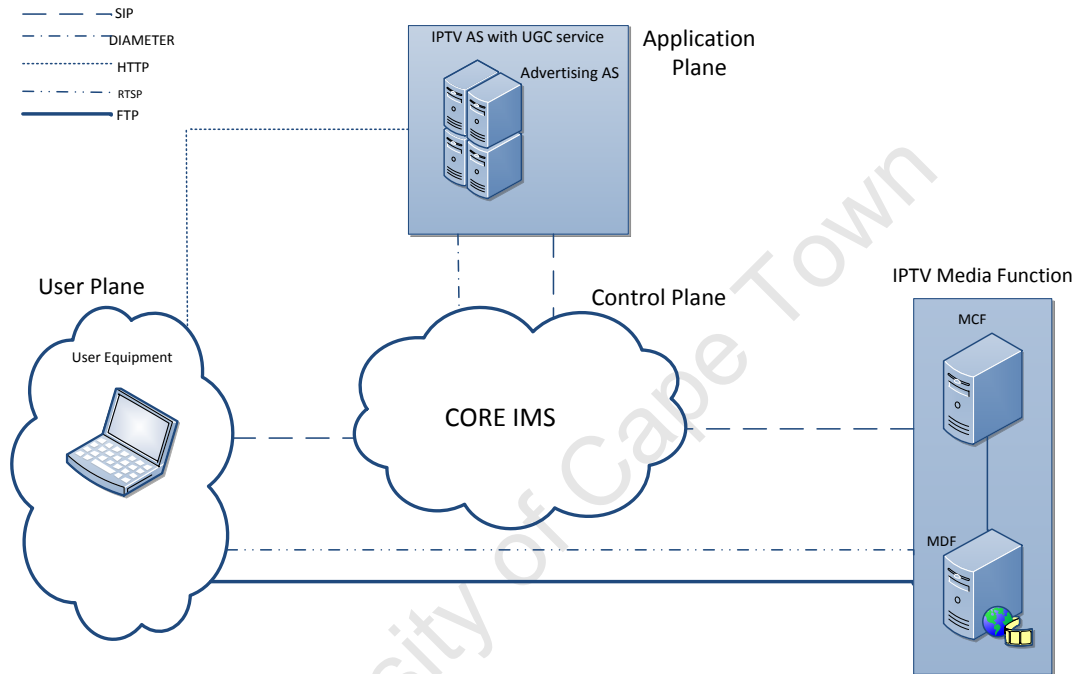


Figure 3.2: Proposed User Generated Content System for IMS-Based IPTV

Figure 3.2 above illustrates the architecture of the proposed UGC system for IMS-Based IPTV and how it works with IMS IPTV. The architecture conforms to the ETSI TISPAN IMS-Based IPTV architecture [4] by using standard IMS and NGN functional components, interface and protocols. There are 4 main protocols which are used in the proposed architecture and these are SIP, Diameter, HTTP, RTSP and FTP. A brief description of each is given below.

**Session Initiation Protocol (SIP)** is an IETF-defined signalling protocol widely used for controlling communication sessions such as voice and video calls over Internet Protocol (IP). The protocol can be used for creating, modifying and terminating two-party (unicast) or multiparty (multicast) sessions. Sessions may consist of one or several media streams.

**Diameter** is an authentication, authorization and accounting protocol for computer networks, and an alternative to Remote Authentication Dial In User Service (RADIUS).

**Hypertext Transfer Protocol (HTTP)** is an application protocol for distributed, collaborative, hypermedia information systems. HTTP is the foundation of data communication for the World Wide Web.

**Real Time Streaming Protocol (RTSP)** is a network control protocol designed for use in entertainment and communications systems to control streaming media servers. The protocol is used for establishing and controlling media sessions between end points. Clients of media servers issue VCR-like commands, such as *play* and *pause*, to facilitate real-time control of playback of media files from the server.

**File Transfer Protocol (FTP)** is a standard network protocol used to transfer files from one host to another host over a TCP-based network.

The architecture comprises of four planes which are *the Control plane, Application plane, User plane* and *Media plane*.

#### **3.3.1.1 Control Plane**

This includes the Core IMS which is required to process SIP signalling and to manage the IPTV sessions. As mentioned in Chapter 2 the core consists of three CSCFs which are the P-CSCF, I-CSCF and S-CSCF. The P-CSCF acts as an inbound/outbound SIP proxy server between the UE and the IMS core and uses a SIP based Gm interface to communicate with UE. The I-CSCF retrieves user location information from the HSS using the Diameter protocol over a Cx interface. It routes the SIP request from the P-CSCF to the appropriate destination, which is usually the S-CSCF. The S-CSCF handles the entire SIP signalling for the core. The S-CSCF also performs session control, facilitating the delivery of the media streams and acts as a SIP register by maintaining a binding between the user's location and SIP address. The communication with the AS is done over a SIP based ISC interface.

#### **3.3.1.2 Application Plane**

This plane has the Application Servers which provides NGN/IMS services to users. The AS

can operate in one of four modes: SIP proxy mode, SIP UA mode, SIP redirect mode or SIP B2BUA mode. In the provided architecture the IPTV AS is operating as SIP proxy server. When the IPTV AS receives a channel request message for the UGC content from the S-CSCF on behalf of the UE, 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 beforehand 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 [11]. If the user does not have an advertising profile the category in which the video is stored in is used to determine the pre-roll advert. The categories allow the AS to identify the relevant advert for the content. The metadata for the identified advert is sent in the SDP body of the SIP INVITE message which is sent back to the S-CSCF. The information is extracted by the MCF which then communicates with the MDF to stream the advert first followed by the requested media.

### *3.3.1.3 User Plane*

This is where the user will access the IMS services. In this case, the user will be able to request the IPTV services which include UGC. It uses a SIP based Gm interface to the P-CSCF to request an IPTV's services, a HTTPS based Xa interface to the IPTV AS for service discovery and service selection, and a RTP based Xd interface to the MDF for media delivery directly to the terminal.

### *3.3.1.4 Media Functions*

This is where all the IPTV media and video adverts are stored and controlled. There are two media functions for an IPTV service: MCF and MDF. The MCF receives channel requests for the S-CSCF via a SIP y2 interface and controls media delivery through the MDF via an RTSP based Xp interface. The MCF maps the IPTV channel request to the appropriate media file which is stored in the MDF. The media stream is then delivered to the UE via an RTP based Xd interface. Uploading of content from the UE to the MDF will be done via FTP.

The UGC service is added to the IPTV services meaning the proposed architecture will have three services (Broadcast services, VoD services and UGC services). UGC services include two procedures the first one being the **creation of the user-generated content**: this type of procedure allows a user to declare and upload his/her own content to the network. The second procedure is the **watching of user-generated content**: this type of procedure allows a user to select and watch user-generated content.

### 3.3.2 User-generated content creation

The UGC creation process comprises three major steps:

#### **Step 1: Declaration and Publication of user-generated content by UE**

- The UE sends a user-generated content creation request to the IPTV AS and receives a content ID for the UGC from the IPTV AS. The request also includes a description of the User Generated Content (name, category, textual description, special group users).

#### **Step 2: Creation of user-generated content**

- The UE initiates a session with the IPTV AS and MF in order to create the user-generated content for uploading the content to MF. The MF provides the IPTV AS with the location at which the UGC becomes available. The transfer of the file from the UE to the MF will be done using FTP and the content will be stored in a category which is determined by the category provided by the user in step 1.

#### **Step 3: Publication of user-generated content information**

- The IPTV AS establishes the relationship between UGC content ID, UGC description, and the MF. This information is then stored into a MySQL database and this database information is then used to populate the UGC Electronic Programme Guide (EPG).

### 3.3.3 UGC Content Watching

The UGC watching procedure comprises two major steps:

#### **Step 1 Selection of UGC**

- The user will select the content from an EPG. The EPG will have the name of the content and textual description. This information is from the MySQL database which is updated

every time new content is added in step 3 of the creation of UGC.

### **Step 2 Watching of UGC**

- When the user selects the content, a SIP INVITE message is sent which requests the channel for the UGC content.
- The INVITE is then forwarded to the IPTV AS by the Core IMS.
- The embedded Advertising AS runs the categorising algorithm using the IPTV user profile information.
- Then performs a hash table lookup to select the targeted advertisement for user category
- The RSTP addresses of the requested media and advertisement are forwarded to UE which then requests the media from the Media Function
- The Media Function will stream the advertisement first and after it finishes it streams the selected content.

## **3.4 Chapter Discussion**

This chapter discussed various shortfalls of the other systems that were presented in chapter 2 and shows how these shortfalls are resolved by the proposed system. It then proposed the different requirements for each of the stakeholders involved. The chapter discussed the QoE for IPTV and explained the metrics that are used in this thesis to measure QoE. The proposed architecture uses standard NGN and IMS entities, interface and protocols as defined by the 3GPP and ETSI TISPAN which is according to the requirements outlined in beginning of the chapter. It introduced the two procedures for UGC and these are *creating procedure* and *watching procedure*. The chapter also gives details and uses of each of the components that make up the proposed architecture.

# Chapter 4

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## 4. Architecture and Implementation of an Evaluation Framework

Chapter 3 presented the proposed system for UGC on IMS-based IPTV. This Chapter presents the architectural design and implementation of a suitable test-bed for evaluating the proposed system. The chapter discusses the objectives, requirements and limitations of the evaluation framework. The chapter then introduces the evaluation platform used to test the proposed architecture. Finally, the operation of the evaluation platform is discussed.

### 4.1 Evaluation Objectives

Before meaningful test results can be provided by the evaluation platform, a proof of concept test is necessary to test the suitability of the evaluation platform as an adequate environment for the proposed framework. After validating the evaluation platform meaningful tests may be carried out. The objective of the evaluation platform is to test the effect of the system on users' QoE of the IPTV services, focusing on the UGC service.

QoE is defined as a measure of an end-to-end performance levels from the user perspective and an indicator of how well the system meets the user needs. It is also defined by the ITU-T [21] as the overall acceptability of an application or service, as perceived subjectively by the end-user. From these definitions, parameters were chosen to effectively evaluate QoE from the user's perspective. These parameters include: service latency, service features, service quality. Scalability of the evaluation platform was also tested.

*Service latency* refers to IPTV session setup delay. These delays include the delays in the terminal, network and servers. The session setup delay of a normal VoD session will be compared to the session setup delay of the UGC session. The delays of the two services should not be significantly different. From what was discussed in the previous chapter the standard expected delay for a one-way video service like this should be less than 10 seconds.

*Service features* refer to the features expected by the user and the ease of use. These include the uploading of user videos with the ability to provide metadata for the videos; the ability for the user to specify who can watch their uploaded videos; the ability to select and stream of shared videos; trick play functions to pause, fast forward and rewind the media (users don't have these functions when the pre-roll advert is playing).

*Service quality* checks if the EPG meets the requirements specified in the ITU-T G.1080[21]. This will also look at the pre-roll advertisements quality. The videos uploaded by the user may differ from user to user but the quality of the adverts should always be high. The pre-roll advertisement should be 30 seconds or less.

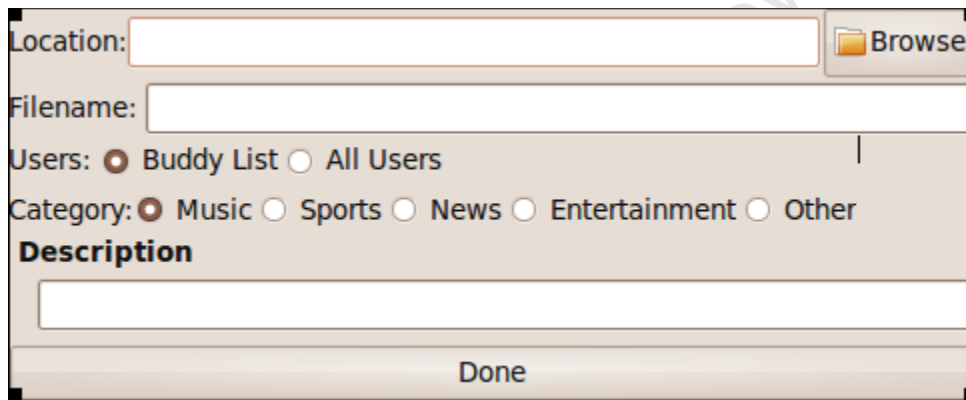
*Scalability* will test the proposed system if it is scalable looking at the amount of video streams and upload session that can be handled in the setup of the evaluation platform. This is important in order to provide a better understanding of how a proper media server has to function and to show the limitations of the evaluation platform.

## **4.2 Evaluation Requirements**

In order to satisfy the objectives of the evaluation framework suitable test-bed architecture should be designed. The framework should be integrated with IMS-based IPTV to ensure high quality service delivery over a managed platform. Implementing of the requirements outlined in chapter 3 should be done in accordance to the standards provided by the 3GPP for the IMS Core and ETSI TISPAN for the IMS-Based IPTV. The entities to be implemented to test the proposed framework are: UE with a suitable IMS client, IMS control elements (CSCFs), IPTV Application Server with a UGC service, Media Server to store UGC media and video advertisements. The proposed architecture included the personalised advertising server but in the evaluation architecture it is not included. This is because that is not the main purpose of this thesis. But this thesis will add an option that was not included in the personalised advertising system proposed in [11]. This option is what to do when the user does not provide the information needed to select the advert. The server will then use the category of the video to determine the advert that will be played. This will be the option that will be used to test the system in this thesis since the other one was well documented when it was proposed. Since the media at the server will be in

categories, it will be easy to associate an advertisement to a certain category. Figure 4.2 shows the architecture of the evaluation platform which implements these entities.

As outlined in the previous chapter the system should be easy to use. The IMS client should have a Graphic User Interface (GUI) for ease of use of the service features. These features include the user being able to upload a video and provide metadata (name, category, textual description, special group users) for the video, select a video to watch from an EPG and achieve trick play functions. Figure 4.1 shows the GUI that will popup when a user wants to upload a video and this will allow the user to provide all the needed information about the video. The IMS client should conform to ETSI TISPAN IMS Based IPTV standards.



The screenshot shows a user interface for uploading a video. It features a 'Location:' field with a 'Browse' button, a 'Filename:' field, 'Users:' radio buttons for 'Buddy List' (selected) and 'All Users', 'Category:' radio buttons for 'Music' (selected), 'Sports', 'News', 'Entertainment', and 'Other', a 'Description' text area, and a 'Done' button at the bottom.

Figure 4.1: User Video Upload

The uploaded videos need to be stored in categories so that each category has its own set of advertisements linked to it. Both the metadata of the uploaded videos from the users and of the advert are to be stored in MySQL databases. The UGC video database contains a list of the videos stored in the Media Server. The database will contain the user's IMS public user identity (IMPU) for the user who uploaded it, the filename, permissions, category and the description of each video. The advertisements database contains a list of the advertisements stored in the Media Server, their name and the category in which they belong.

### 4.3 Limitations of the Evaluation Framework

To provide more accurate results on the effectiveness of the proposed framework on the user's QoE for the IPTV service, a test-bed was chosen. Although hardware test-beds are limited

in size due to associated costs and limitations of the hardware required to construct the test-bed it was selected over simulation. This was because QoE can be perceived more accurately in a practical test-bed environment. Furthermore, simulations do not put into consideration all the real world factors such as server processing delays and other hardware factors which are important when testing QoE as they add to service latency. QoE is mainly from the users' perspective hence their experiences with service features and service quality would have to be tested. To test these two factors, a practical test-bed is required as both hardware and software play a role in determining these outcomes. On the other hand, simulations are able to simulate large numbers of users which is not possible in a test-bed environment. However, for the purpose of this thesis, it is more important to achieve accurate QoE measurements for service latency, service features and service quality.

As mentioned in section 4.2, the evaluation platform does not include the personalised advertising framework. Since the functionality of the system was well tested when it was proposed in [11] there was no need to repeat the same tests. In this thesis, the condition that was tested when the user did not provide the service provider with information needed for targeted advertising. In this situation the category of the video was used to determine the adverts.

#### **4.4 Architecture of the Evaluation Platform**

The University of Cape Town (UCT) IMS test-bed was used to evaluate the framework and was taken through some modification to meet the requirements. The standard entities, interfaces and protocols defined by the 3GPP and ETSI TISPAN were kept. Figure 4.2 shows the architecture of the test-bed. This is architectural design and implementation of proposed system in chapter 3 on the UCT IMS test-bed. The UCT IMS test-bed was modified so that it can test the functional features presented in chapter 3.

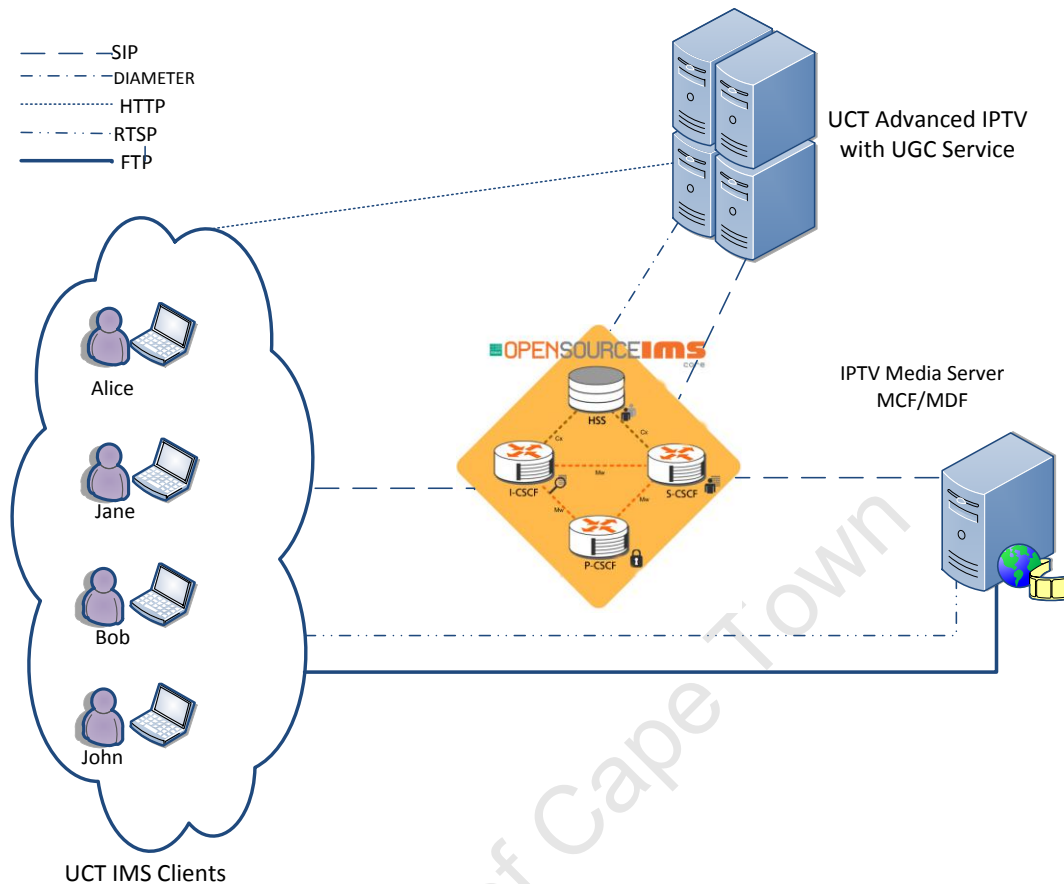


Figure 4.2: Modified UCT IMS test-bed with UGC Service

#### 4.4.1 Software Used for the test-bed

The UCT IMS Client [8] is used to provide the user with the required client functionality for IPTV services. These include IMS registration, IPTV service selection, viewing IPTV media and allowing trick play functions. The UCT IMS Client was modified to allow users to access the UGC service. Figure 4.3 shows the UCT IMS Client modified to allow the user the ability to select UGC service by clicking the UGC Listing in the IPTV advanced tab. Figure 4.5 shows the EPG for UGC and Figure 4.1 shows the GUI for the user to upload videos and provide metadata.

FOKUS Open IMS Core [7] is used to provide all the necessary functionalities of the control plane in an NGN network. The FOKUS Core consists of the HSS, P-CSCF, I-CSCF and S-CSCF. The functions of these entities are discussed in detail in chapter 2.

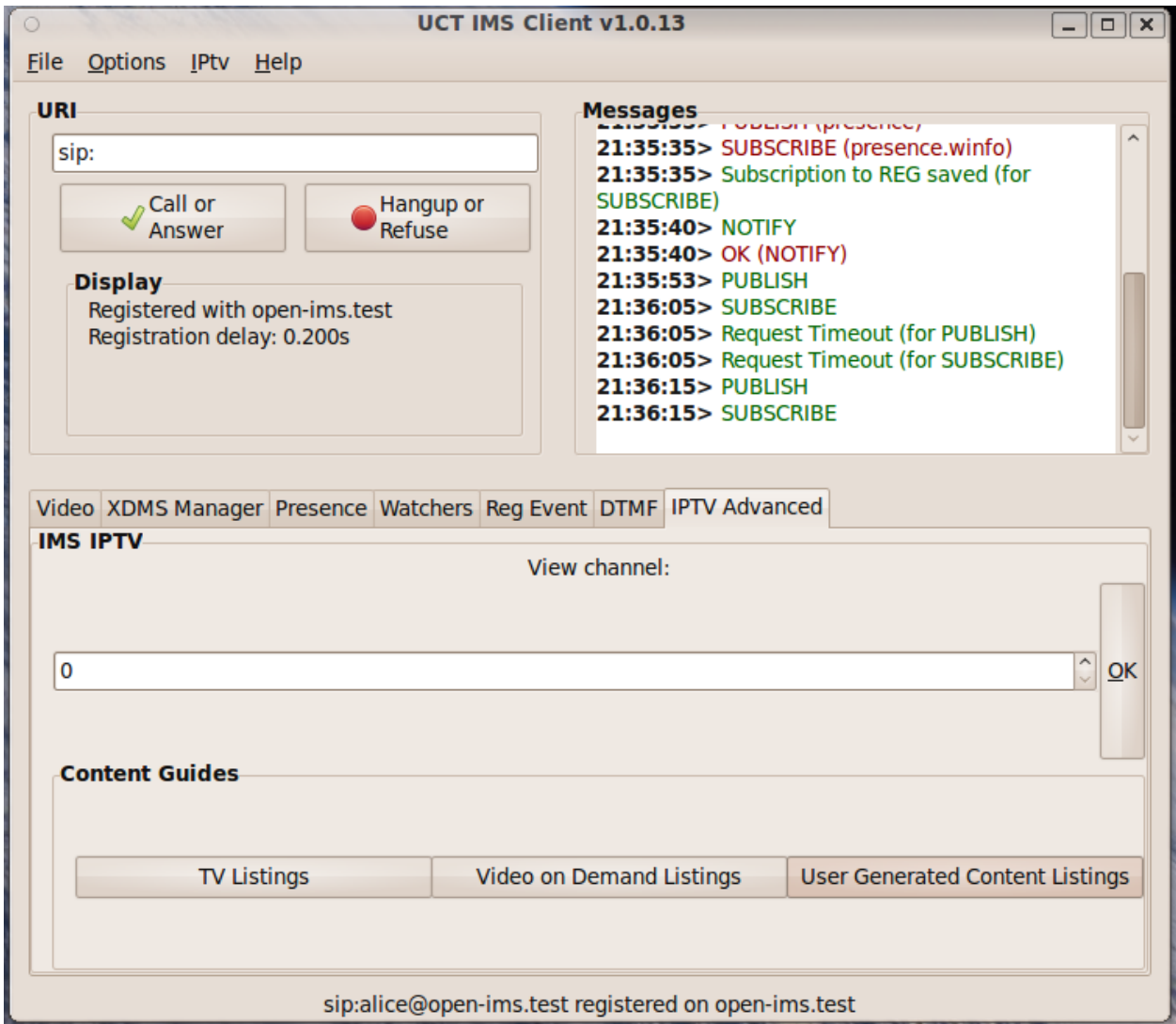


Figure 4.3 UCT IMS Client

The UCT Advanced IPTV system [9] is used to provide the required IPTV AS functionalities. This AS is modified to offer UGC services. These modifications include the ability for the server to service one of the two procedures that occur during UGC services which can either be creation procedure or watching procedure. It was also modified so that it would be able to determine which advert would be played according to the category of the requested video. The AS still offered VoD and live TV services. IPTV AS hosts the advertisement database. 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. The UCT advanced 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. VLC streaming server was used.

The Media Server is implemented as a hybrid of the two modules MDF and MCF. 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 [11].

#### **4.4.2 Hardware used for the test-bed**

The test-bed architecture is shown in Figure 4.2. It consists of four machines connected via a 100Mbit/s Ethernet connection. One machine runs all the client terminals all of which run the modified UCT IMS Client software to support the features called for in this thesis. The second machine runs the S-CSCF and HSS of the Open IMS core and the third machine runs the other two i.e. I-CSCF and the P-CSCF. The last machine was used to run modified IPTV AS with the UGC services software and the hybrid MCF/MDF software. The details of each machine used can be found in Appendix B.

### **4.5 Operation of the Evaluation Platform**

There are two procedures that the user can do when operating the system which can, either creating content or consuming/watching content. The first operation that is going to be discussed is the creation of user-generated content.

#### **4.5.1 Creating User Generated Content**

Figure 4.5 shows the Electronic Programme Guide (EPG) that will appear when the user selects the UGC listings on the UCT IMS client shown in figure 4.3. More details of the EPG

will be given in the following chapter. What is important for this operation is the upload button on the bottom. Upon clicking this button, Figure4.1 will appear asking the user to first browse for the video they wish to upload by clicking the browse button. After that the user will enter the name of the video, specify who has the permission to watch this video by selecting all users which refers to the video being public or buddy list which will make the video private and only the people in their buddy list can view it. The user will then specify the category in which the video belongs and lastly the description of the video. Clicking the done button will send an UGC creation request to the IPTV AS through the IMS Core. The request will also contain the information about the video. After receiving this request, the IPTV AS will store the video information into the UGC video database. The IPTV AS will send an acknowledgement and the content will be transferred from the UE to the MF using FTP. The location on the Media Server is also stored in the database. Figure 4.4 depicts the steps that occur during UGC creation

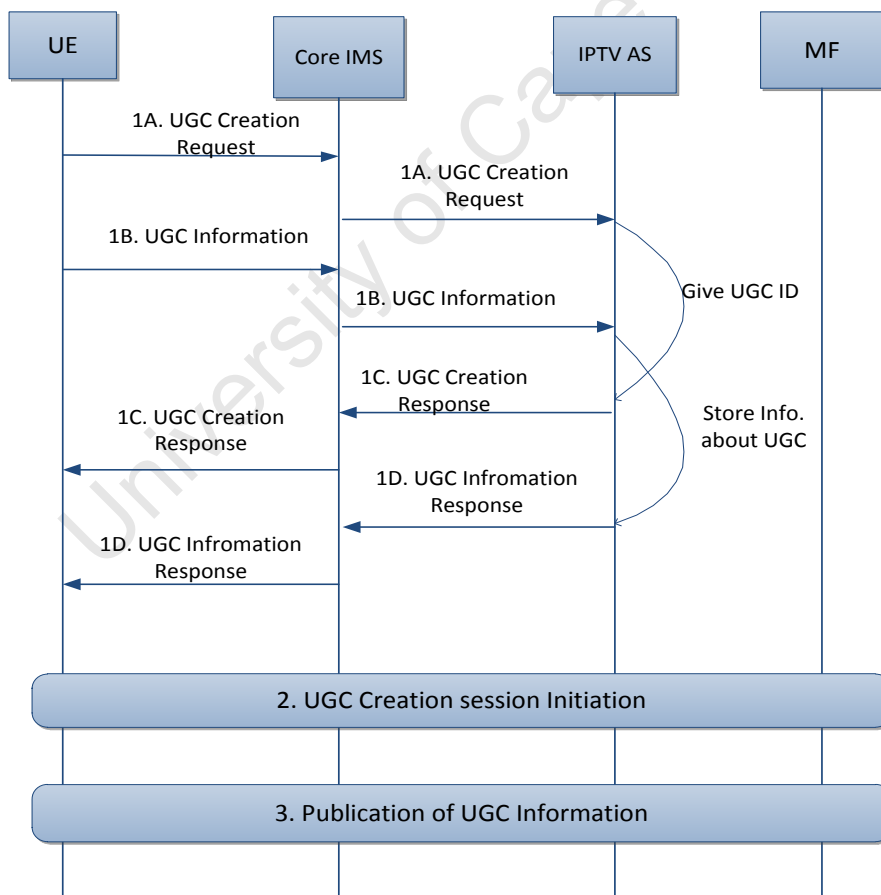


Figure 4.4: UGC Creation

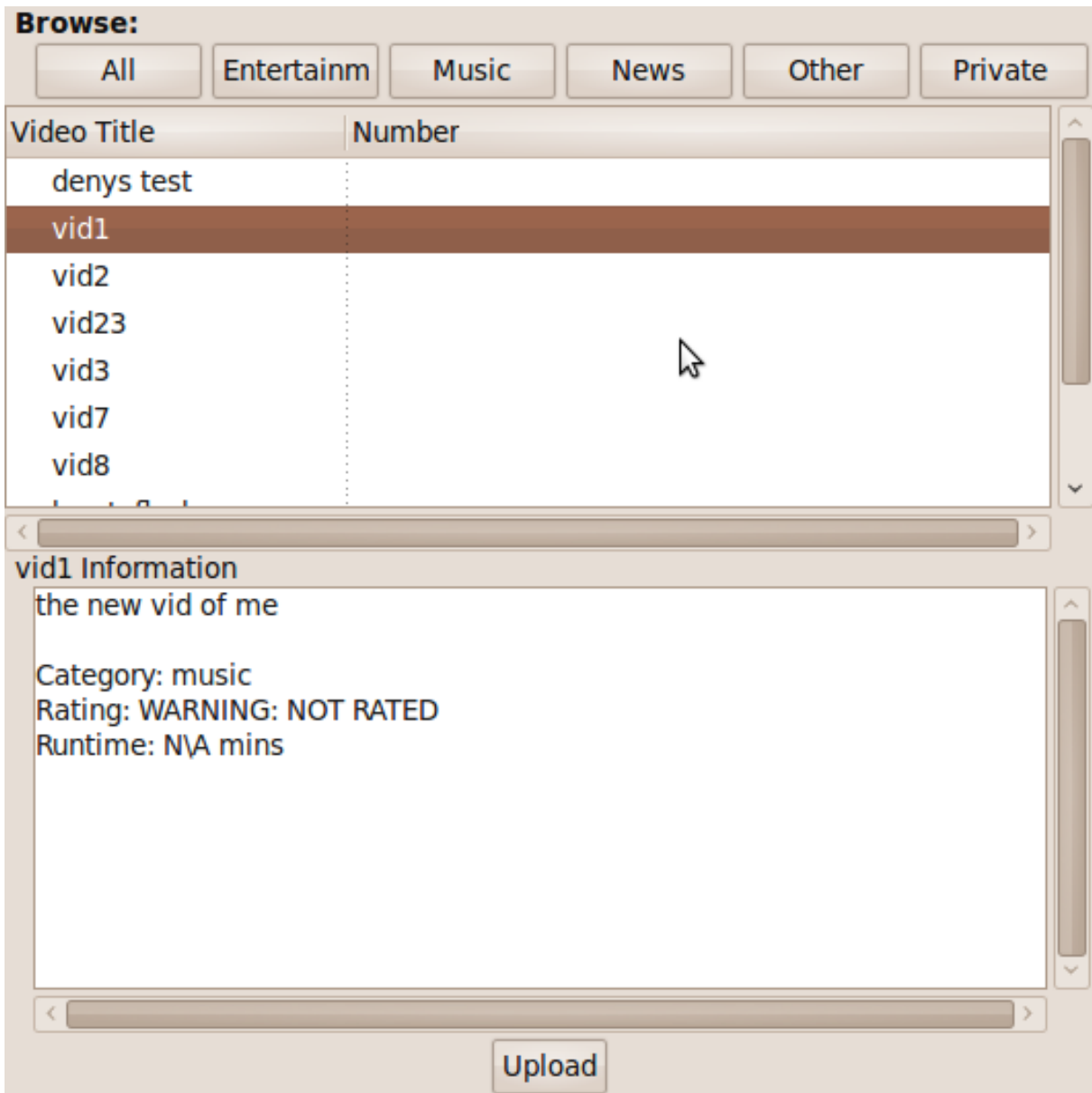


Figure 4.5: User Generated Content EPG

## 4.5.2 Watching User Generated Content

The user selects a video to watch from the EPG and the video selection is of the form NameOfVid@iptv-as.imsdomain.ims.As expected, this request is routed through the IMS Core to the IPTV AS. The IPTV AS performs a hash table look-up to identify the relevant media file stored in the Media Server, corresponding to the selected video. The IPTV AS will also check the category that the video belong to so that it can determine which advert is more suitable to the content. Once a relevant advertisement is selected by the IPTV AS, the corresponding RTSP

address of the form `rtsp://media-server.imsdomain.ims/advert` is added to the SIP message going back to the UE. The SIP message will also contain the RTSP address of the IPTV media file of the form `rtsp://mediaserver.imsdomain.ims/NameOfVid`, identified by the IPTV AS. These RTSP addresses are sent back to the UE in the 200 OK message in response to the INVITE. 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 UGC media. The UE ends the session by sending a BYE message to the IPTV AS, followed by the three-way handshake. Figure 4.6 shows a signalling diagram for the UGC watching procedure.

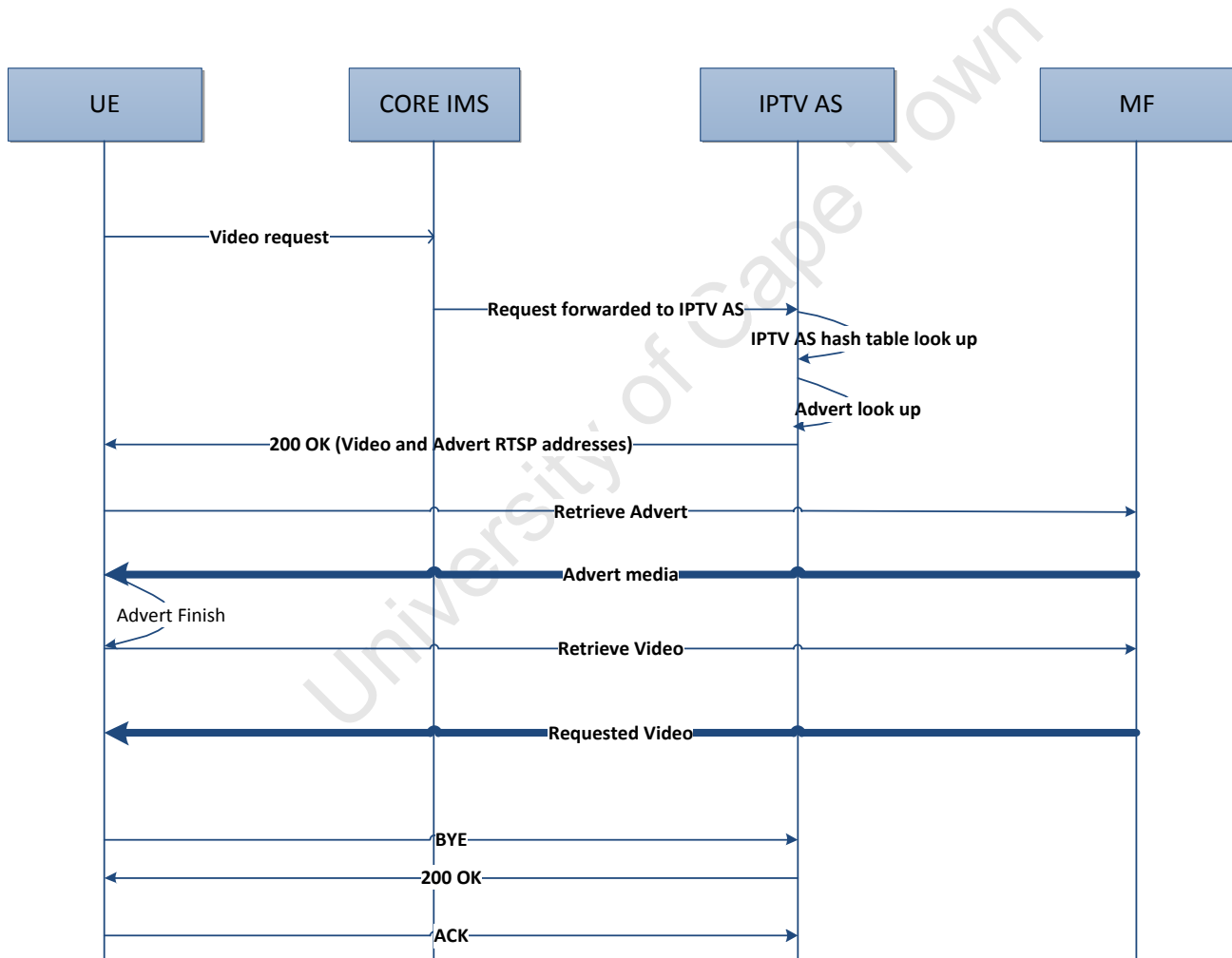


Figure 4.6: Signalling diagram for UGC watching procedure

## 4.6 Chapter Discussion

The chapter starts off with discussing the evaluation requirements, objectives and limitations of the test-bed used to evaluate the proposed framework, making sure that it satisfies the requirements started in chapter 3. The architecture contains all the required entities and these are an IMS control element, which is the FOKUS IMS Core, User Equipment, which is the PC running the modified UCT IMS Client , an Application Server, which is the modified UCT Advanced IPTV and a Media Server. Complying with all the requirements makes the test-bed able to accurately evaluate the proposed framework and provide meaningful results. The chapter then concludes by giving an operation of the evaluation platform. The operational of UGC services include two procedures which are *creation procedure* and *watching procedure*. Creating procedure refers to when the user creates the UGC content by uploading it to the server and providing all the metadata of the file. Watching procedure refers to user consuming the media that is on the server which includes the watching of a pre-roll advert before the requested media.

# Chapter 5

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## 5. Evaluation Results and Analysis

This chapter details the evaluation of the test-bed presented in the previous chapter. This was done by performing some proof of concept tests, which were done by running three different scenarios and comparing the outcome to what is expected from the theoretical framework. The scenarios were designed to test the functions of the proposed system. After the evaluation platform passed these tests, it was then considered a suitable testing environment. Evaluation is performed by conducting tests to analyse the effect of adding the UGC service to the users' QoE of the IPTV service. The metrics used to evaluate QoE are *service latency*: which refers to the setup delays, *service features*: which refers to how the service meets the users' expectations, *service quality*: which refers to the advert quality and how the EPG abides to the IPTV EPG requirements and *scalability* which refers to how scalable the evaluation platform is.

### 5.1 Verification of the Evaluation Platform

To validate the evaluation platform as an accurate testing environment for the proposed framework proof of concept tests needs to be carried out. This ensures further results obtained from the proposed framework are meaningful. Proof of concept tests are performed for three scenarios, each with expected outcomes. The observed results are then compared to the expected results, which are based on the theoretical framework. Obtaining the expected results in all three scenarios will help to consider if the evaluation platform a suitable and accurate testing environment to evaluate the proposed framework.

In scenario 1, a user, *Alice*, will request for the UGC service. She will upload two videos to the server. One of the videos is a public video while the other is a private video and she will provide the metadata for both files. From the metadata provided by *Alice* for the first video, the video will be in entertainment category. The file will be stored on the server in the entertainment category and will be visible to anyone on the network. *Alice* will also upload the second video

that she took at a party with her friends and only wants people in her buddy list to view this video. She will upload the video as a private video and the video will be stored on the server on her private collection that will be viewed by her friends. The video is also stored in a category specified in the metadata.

In scenario 2, a user, *Bob*, will request for the UGC service by requesting the UGC electronic program guide. The UGC EPG will show all the public videos shared by all the people on the network. He will be able to view the public video that was uploaded by *Alice* when he selects this video an advert in the entertainment category will play first before the desired video is played. Whilst the advert is playing the advert the trick play functions are disabled to ensure advertisements cannot be skipped or fast forwarded. *Bob* is not friends with *Alice* so he would not be able to view the second private video uploaded by *Alice*. When *Bob* request for private videos by selecting the private button on the UGC EPG, the server will look for the private videos he and his friends on his buddy list have uploaded. In this scenario *Bob* does not have friends who have uploaded private videos and he has not uploaded any videos also. So the EPG will display nothing.

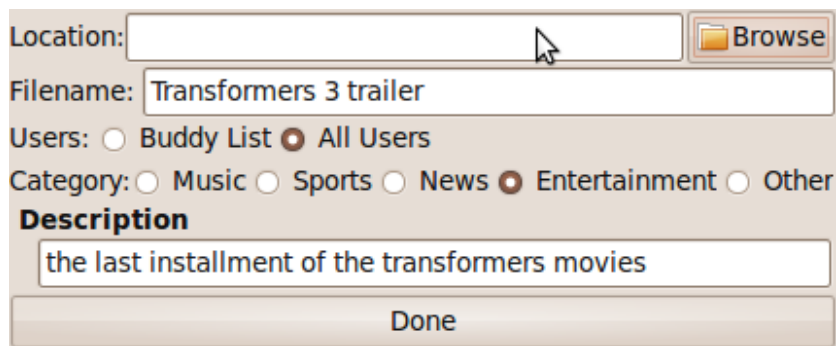
In scenario 3, a user, *Jane*, will also request for UGC service just like *Bob* in scenario 2. *Jane* will be able to view everything that *Bob* was able to view but the only difference is that *Jane* is friends with *Alice* so she will be able to view the private video that *Alice* uploaded. When *Jane* requests for the private videos, the server will check the private collections of all the people in her buddy list and check if they have uploaded some videos. In this case *Alice* has uploaded a video so it will show this video to *Jane*. When *Jane* selects this video an advert will play first which is determined by the category in which *Alice* specified when she uploaded the video. Just like in scenario 2 when the advert is being played the trick play functions are disabled so the user does not skip the advertisement.

The sections below show the three scenarios implemented on the evaluation platform

### 5.1.1 Scenario 1: Alice

Alice sends a request to upload a video using her UE through the UGC EPG by clicking the upload button. Figure 4.3 shows the EPG. When the request is received the server will respond

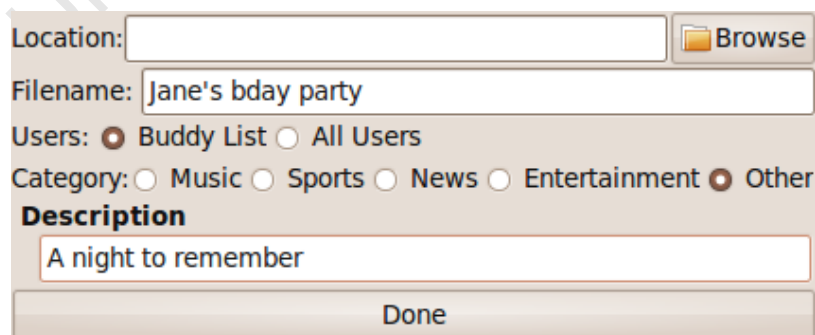
by providing Alice with the upload video GUI and Figure 5.1 shows the GUI with the information about the video provided by Alice. The figure shows the video name together with the description. It also shows that Alice has classified the video as a public video meaning that it can be viewed by everyone on the network. It also shows that the video is in the ‘entertainment’ category. When she presses the done button the file will be copied from her UE using FTP and stored in the entertainment category on the media server. All the provided information of the video is stored into a MySQL database and the IPTV server is updated with URL of the new content.



The screenshot shows a web-based form for uploading a video. It includes a 'Location' field with a 'Browse' button, a 'Filename' field containing 'Transformers 3 trailer', a 'Users' section with radio buttons for 'Buddy List' and 'All Users' (the latter is selected), a 'Category' section with radio buttons for 'Music', 'Sports', 'News', 'Entertainment' (selected), and 'Other', a 'Description' field containing 'the last installment of the transformers movies', and a 'Done' button at the bottom.

Figure 5.1: Information of Alice public video

Figure 5.2 shows the information on the second video, showing that it is a private video meaning that it can only be viewed by her friends. She also provides the category of the video as ‘other’. Like the previous video, all the information of the video is stored in UGC database.



The screenshot shows a web-based form for uploading a video. It includes a 'Location' field with a 'Browse' button, a 'Filename' field containing 'Jane's bday party', a 'Users' section with radio buttons for 'Buddy List' (selected) and 'All Users', a 'Category' section with radio buttons for 'Music', 'Sports', 'News', 'Entertainment', and 'Other' (selected), a 'Description' field containing 'A night to remember', and a 'Done' button at the bottom.

Figure 5.2: Information of Alice private video

Figure 5.3 shows the UGC database; *id* represents the unique number given to each video when they are added to the database. The *user\_Name* is the name of the user who has uploaded the video, *file\_Name* is the name of the video, *access* shows if the video is a public or private. *user\_name\_ID* is the unique number for each user; *category* is used to determine the pre-roll advert and the *description* of the video. Storing the data into MySQL database makes it easy for the service provider to delete any infringing content if a complaint is given to them.

id	user_Name	file_Name	access	user_name_ID	category	description
1	Alice	vid1	public	1	music	the new vid of me
2	Bob	vid2	public	2	sport	goals for 2010
3	Alice	vid23	public	1	music	crazy this
4	Jane	vid3	public	3	music	description of vid
5	Jane	vid4	private	3	other	funny things
6	Bob	vid7	public	2	sport	Rooney goals
7	Alice	vid8	public	1	entertainment	Enjoy
8	Bob	howtoflash	public	2	news	visit www.howto.com for more infomation
9	Joe	HTC unboxing	public	4	news	the unboxing of the new HTC phone
10	Alice	vid15	private	1	other	it must work one day
11	Alice	Transformers 3 trailer	public	1	entertainment	the last installment of the transformers movies
12	Alice	Jane bday party	private	1	other	A night to remember

Figure 5.3: UGC Database

### 5.1.2 Scenario 2: Bob

When Bob opens the UGC EPG to look for videos to watch the server will populate the EPG with all the public videos on the server. Figure 5.4 shows the EPG with the new video shared by Alice. When Bob selected the new video an advert was played and because the video in the entertainment category an advert in that category was selected as the pre-roll ad. Once the video finishes playing, the requested video is then streamed to Bob UE. After the video finished, Bob clicked on the private videos button which made the server check into Bob's buddy list to see if there is anyone who had uploaded a private video. The EPG did not display anything because Bob's friends had not uploaded a private video.

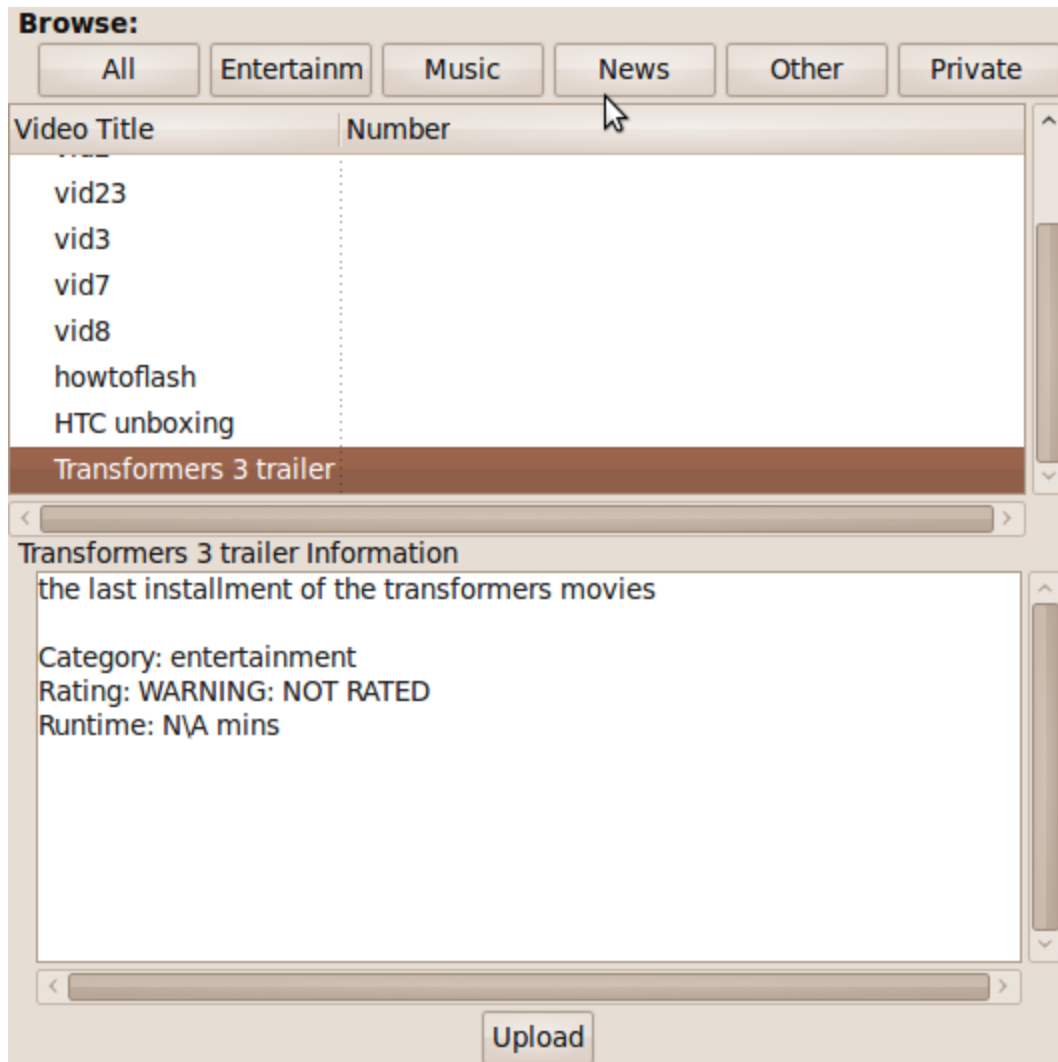


Figure 5.4: EPG showing the new video from Alice

### 5.1.3 Scenario 3: Jane

This scenario is the same as scenario 2 with the difference happening when Jane selects the private videos button. When she does this, the server will check at her buddy list and will notice that Alice has shared some private videos so it will populate the EPG with her videos and also with some of Jane own private videos. Figure 5.5 shows the populated EPG for the private videos when Jane clicked the private video button. When she requests the shared video, an advert in the category 'other' will play first and when it is done the requested video will then be streamed to her UE.

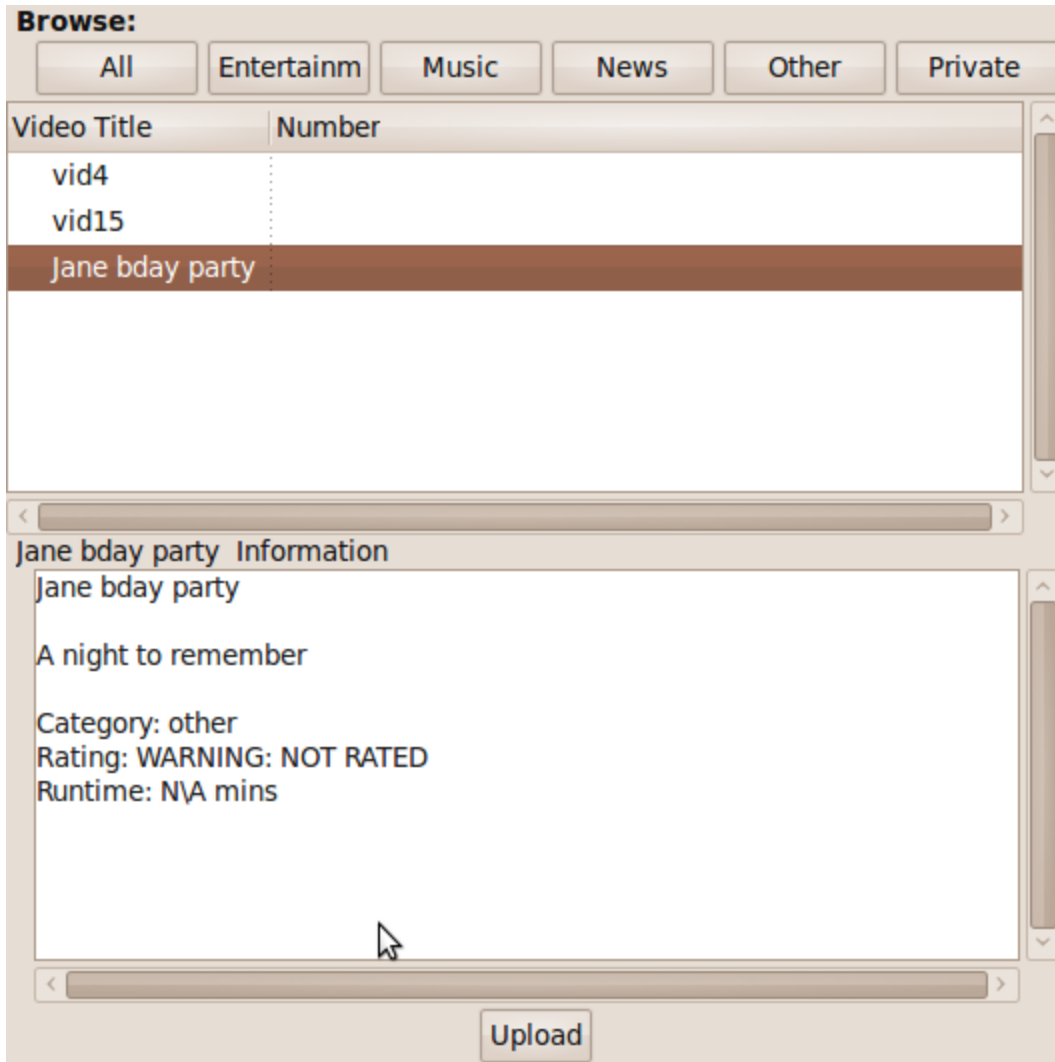


Figure 5.5: EPG showing the private videos for Jane

The outcome observed for all three scenarios corresponds to what is expected based on the theoretical framework. As a result, the proof of concept tests may be considered successful therefore, 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 UGC framework on the user's QoE of the IPTV service.

## 5.2 Evaluation of the Proposed Framework

Quality of Experience is determined by a number of factors which are objective and subjective factors as shown in figure 4.1. The objective factors include service factors, transport factors and application factors. Service latency is used to measure the service factors and application factors

thus it will measure QoE objectively. Transport factors are beyond the scope of this thesis so it will not be measured. The subjective factors are human related relating to user emotions, billing and user experience. Service features and service quality are the metrics used to measure QoE subjectively by comparing them to those offered in similar services.

### 5.2.1 Service Latency

To measure service latency, session setup delay for the VoD session was used. Session setup delay offers a comprehensive metric because it depends on a number of factors. Transmission delay over the network is one factor, which may experience losses, and the queuing delays. This transmission delay can be affected by the transport protocols used and their error recovery strategies. The other factors are signalling plane delays, and the delays on the client and server sides hence why it was used. Other delays like propagation delay were not measured because they are out of scope, the thesis was only looking at the effecting of signalling, not data traffic transport issues. From the time when the video is uploaded to the media server requesting the video will be similar to a VoD session. This delay include, the delays experienced in the network, at the AS and in the UE. Scenario 4 was created to compare service latency with scenarios 2 and 3. In scenario 4, user John, uses the classic IPTV system, before the proposed framework was added to the IPTV service, i.e., before the UGC services are added to the AS and the UE. As discussed in chapter 4 service latencies are expected to be less than 10 seconds for the IPTV service [39]. Table 5.1 shows the standard typical latencies expected for the VoD service in particular [45]. The VoD access delay refers to session setup.

Table 5.1: Timing measurements for typical VoD functionalities. [45]

Functionality	Elapsed time (seconds)
UE Registration	0.8
IPTV Service Subscription	1.3
VoD access	<5
Channel Changing	0.4

#### **Scenario 4: John**

In this scenario John will be using UE that has not been modified for the UGC services and will also connect to an unmodified IPTV AS. This will result in a normal VoD session taking place, i.e. John will request a VoD channel from his UE. The service request message is routed through the IMS core 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 John'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.

It is expected for this scenario that the session setup delay is shorter than that of Bob and Jane's case. This is because there is no processing to determine which advert is to be played with which content.

Each scenario was run a total of 26 times, and the session setup delay was recorded for each instance. Figure 5.6 plots these latencies for each scenario. The latencies obtained for scenario 2 (Bob) are shown in lime, scenario 3 (Jane) are shown in red and scenario 4 (John), using classic IPTV, are shown in blue. The y axis depicts delay in milliseconds. The results show that the delays of all the scenarios are all within the 5 seconds that is required for IPTV services. It is noted that most of the times are under 1 second with some outliers probably caused by activity on the network and at the AS and UE. These are much more observed in scenario 2 and 3 because of the process of determining the advert to be played. This was not a problem because the longest time was 1.1s which is still under 5s.

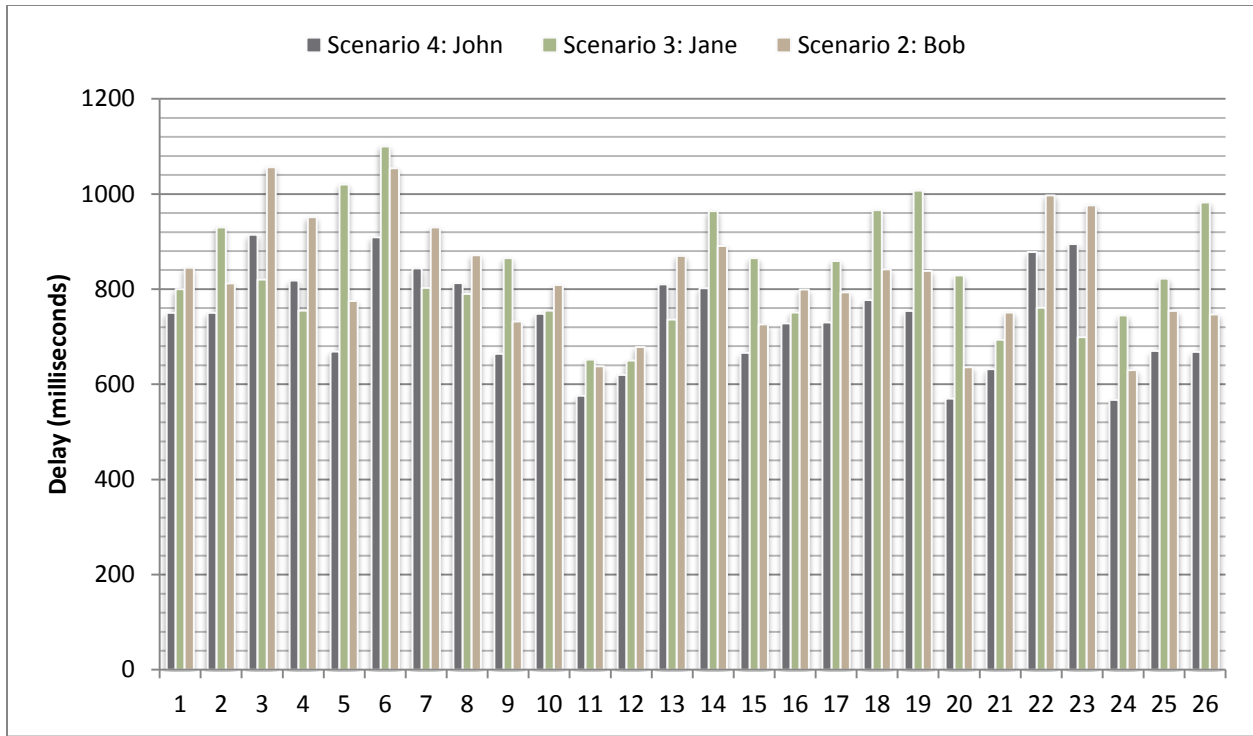


Figure 5.6: Setup latency results for the three scenarios

Table 5.2 shows the averaged latency results and the standard deviations for the three scenarios. It is clear that the proposed framework adds to session setup delay, as expected. The extra delay experienced by Bob and Jane is due to the fact that the AS has to search for the advert that is relevant to the selected video. However, it only adds delays between 83-92 milliseconds which are not noticeable with human eye. It can also be noted from Table 5.2 that Jane had a larger delay than Bob and this was because the server had to do extra processing to find the private videos.

Table 5.2: Average latency results

	User	Description	Average latency (milliseconds)	Standard deviation
Scenario 2	Bob	Accessing a public UGC video	823.1153	120.723
Scenario 3	Jane	Accessing a private UGC video	831.5385	119.090
Scenario 4	John	Classic VoD service	739.3076	104.519

In scenario one the time it took for the uploaded video to appear on the media server was determined by the size of the file the user is uploading as expected. The time is directly proportional to the file size the bigger the file the more time it takes to completely upload the video file. The time is also determined by the network speed and the available network, but in this case we are assuming that IMS-based IPTV is offered over a managed SDP, meaning all the bandwidth needed to upload will be available.

The time it takes for the video to appear on the media server and service latency is bound to increase with the number of parallel sessions, since the server will be required to deal with requests from more many simultaneously.

### **5.2.2 Service Features**

IPTV is a paid service meaning that users will be expecting a service that will have features that will attract them away from live television and PVR services. Therefore, IMS-based IPTV should have features that will be at least on par or even better than of live television, PVR services and other UGC service. Having these features is expected to help to boost user's QoE. A GUI is required to make it easy for the users to register to the IMS and makes it easy to find the IPTV services. Figure 4.3 shows the UCT IMS Client [8]. The user can easily register and request the UGC service by clicking on the IPTV Advanced tab and then clicking on the UGC listings. The UGC EPG will appear, Figure 5.7 shows this and the EPG shows the available videos. The user can easily select videos in different categories and clicking on a file, will show the information about the video.

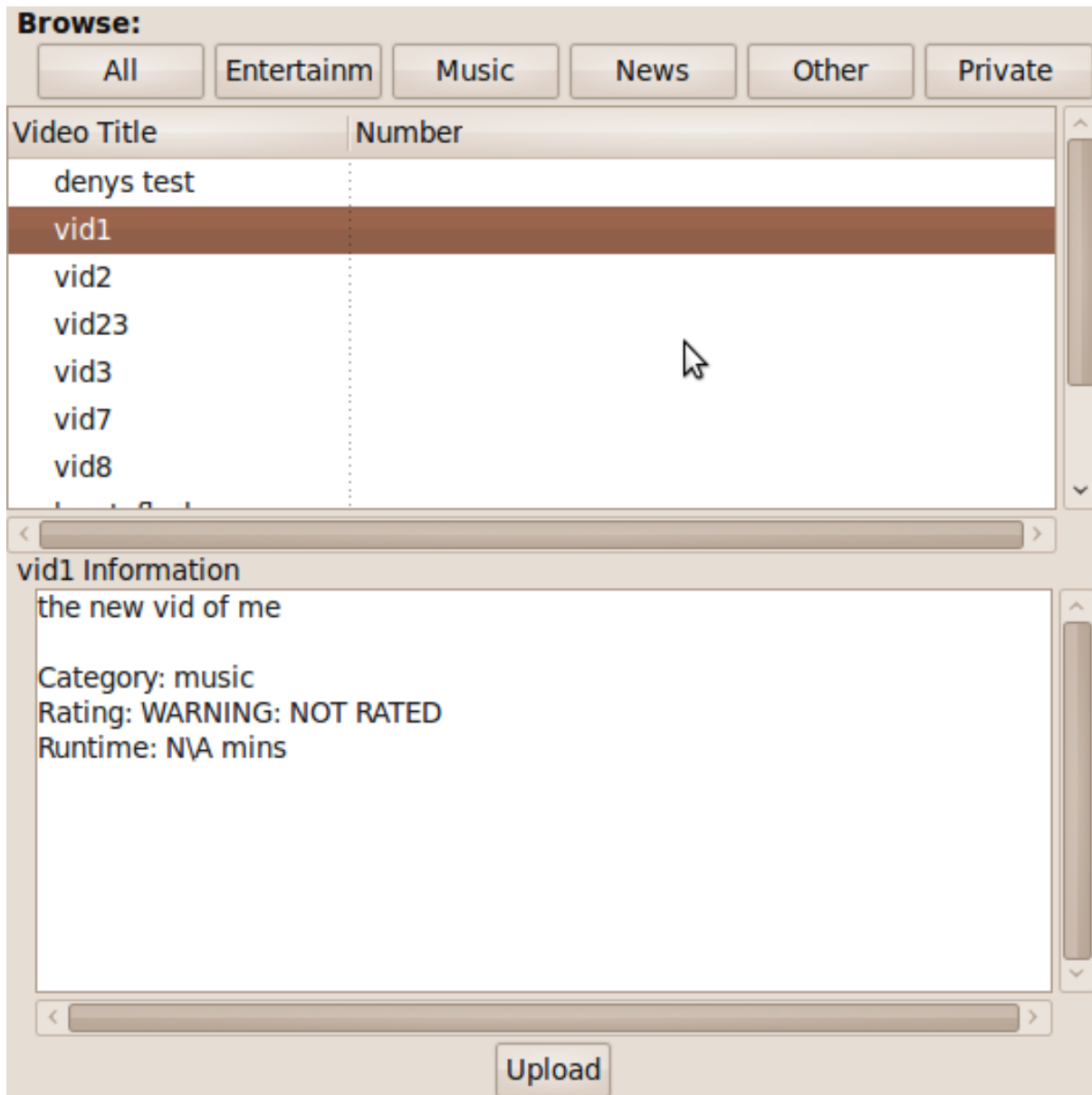


Figure 5.7: EPG with available Videos

On the EPG GUI the user can easily see the upload button which will also bring another user friendly GUI shown in Figure 5.8 which is the user video uploading GUI. This will allow users to easily provide all the information about the video and choose who can watch it.

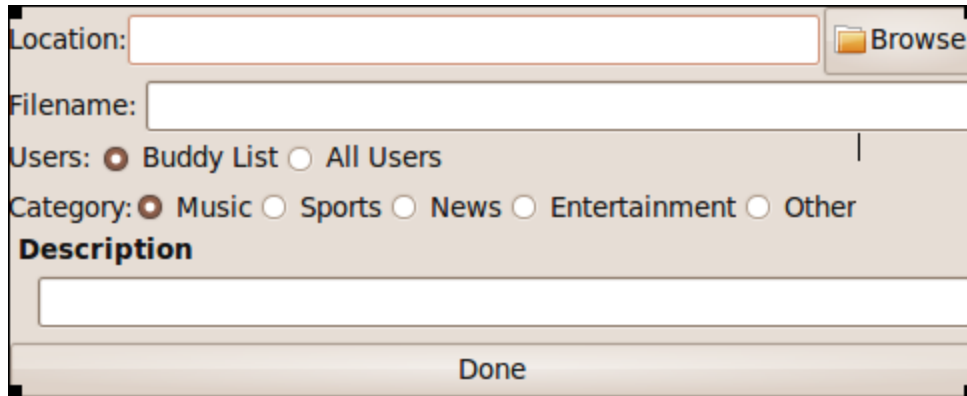


Figure 5.8: Upload dialog

Triple play functions are the key features of PVR services and this is what set it apart from live television. As a result, IPTV has to have these functions; Figure 5.9 shows a screenshot of the video window, indicating the trick play buttons available to the user.

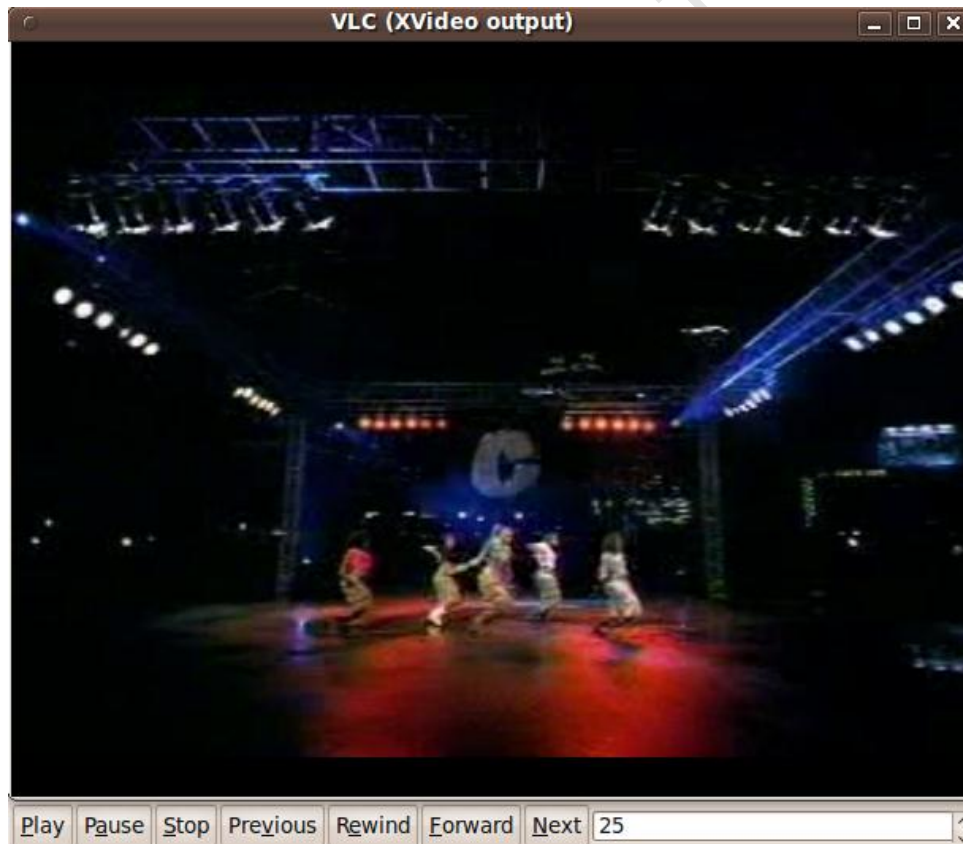


Figure 5.9: Triple play functions

It can be seen that IPTV services offer service features that are up to par and better than those offered by live television, PVR and UGC service because it can offer the best of each of these services. Since IPTV services are operated on a subscription fee, it was expected that it will be

better than live TV. As shown in Figure 3.1 billing affects the perceived QoE if the users can see the value of their money through the good features they will be happy with the services. Users are able to perform trick play functions on UGC media and can easily upload and provide information for their uploaded videos. These features contribute positively to user QoE.

### 5.2.3 Service Quality

Service quality will affect the user's QoE. Even through the videos uploaded by the user will differ from user to user, users will still expect good quality adverts being played just like the ones played on competing services like live TV. To ensure the user will not have to wait long the pre-roll advert is limited to at most 30 seconds. With the size of the adverts being that small it will be easy to keep high quality files. All the adverts stored at the media server were in AVI format. Since IMS-based IPTV is offered over a managed SDP, it was assumed the QoS required to stream the video at full quality is guaranteed. In addition, the fact that the adverts are stored in categories will help in the quality of the advert shown in the video since it will be related to the video requested. Having relevant or targeted adverts shown to users improves the quality of the service because the user will be viewing adverts that are useful to them. With the credit system that is implemented with targeted advertising, value is added to the service because they will getting the same service for less money.

The following are QoE requirements for IPTV EPG stated by the ITU-T [39]:

1) User-friendliness:

The EPG user interface is recommended to be designed for ease of use.

2) Response time to display EPG page:

The response time is the time interval elapsed between the moment the EPG button of the remote control is pushed and the moment the EPG page is displayed. It is recommended for it to be sufficiently short.

In Figure 4.5 which shows the EPG it can be noted that the EPG is easy to use and all the important information the user needs is there. The first requirement is satisfied. It is expected that as the number of videos uploaded by the users increase the time taken for the EPG to be loaded with all the videos will also increase. The MySQL database containing the UGC content was populated with large number of entries. This database was used to populate EPG. The test

revealed as the number of videos on the server increased the response time for the EPG was not affected much and the user could not tell the difference. The response time was not affected much and this satisfies the second requirement thereby ensuring good QoE for the users.

#### **5.2.4 Scalability of the evaluation platform**

This test was designed to test if the evaluation platform could handle a large load of streams. To do this the CPU and memory usage of the PC which had the IPTV AS and media functions was monitored. This will help to determine when the server is overloaded and will not be able to service any other requests from clients. Furthermore this can also be used to help determine specification that maybe needed for a real-life media server.

When the clients are only streaming, the server was able to stream 20 videos simultaneously without the videos chopping. This number could be more because this did not have any big effect on the CPU and memory usage meaning the server could have supported more requests from the clients. The number of streams went considerably down when uploading was involved. The server was only able to handle 3 clients who were both uploading and streaming and only 5 clients who were only streaming. This was because each upload process used between 20-30% of the CPU power. This shows that the media servers needs to have really powerful machines to be able to handle a large number of clients who will be uploading to the servers.

### **5.3 Chapter Discussion**

This chapter offered the verification and evaluation techniques used on the evaluation platform that was introduced in chapter 4. Three scenarios were used to perform the proof of concept test. The outcomes observed for all the scenarios were as expected based on the theoretical framework. These tests validated the evaluation platform as an accurate testing environment to evaluate the proposed framework.

To evaluate the proposed framework three parameters were used to measure the effect of the proposed framework on the user's QoE of the IPTV service. These were service latency, service features and service quality. Service latency tests compared the setup delay of scenarios 2, 3 and 4 in which scenario 4 represented the reference, using a classic IPTV VoD service. The test showed that the delays of scenarios 2 and 3 were slightly higher than of scenario 4. This was because of the extra processing occurring at the IPTV AS and the UE when selecting the advert

to play. Session setup delay included the delays experienced in the network, at the AS and in the UE. The latencies observed for all the scenarios fell within the commended service delay for VoD services. Scenario 1 showed the completion of the creation procedure depends mainly on the network speed and the size of the file. But since we assume that IMS-based IPTV is offered over a managed SDP, QoS is guaranteed so the bandwidth to upload the file will be available. Hence, the only thing that will affect the time it will take to finish uploading is the size of the file. Service features and service quality were compared to that of TV, PVR services and other UGC services. This was done to determine user expectations since this system competes with these services. The proposed framework was found to meet user expectations in these regards due to its easy to use graphical user interface for the client, the EPG, the upload video interface, high entertainment value and trick play functions. Moreover, having targeted adverts improves the service quality since relevant information is being delivered to the users. Therefore, the addition of the UGC services to the IMS-Based IPTV did not degrade the user's QoE. It was observed that the UGC service improved the users' quality of experience. The chapter also showed the limitations of the evaluation platform. The platform could only handle 3 clients who were simultaneously streaming a video and uploading another in the background. This was in addition of only 5 more clients who were only streaming video without uploading.

# Chapter 6

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## 6. Conclusions and Recommendations

The thesis proposed and evaluated a platform for UGC for an IMS-Based IPTV, to provide IPTV subscribers with UGC services i.e. the ability for the user to upload and share a video with everyone or just a group of people. It integrates UGC with the ETSI TISPAN's IMS-based IPTV. It streamed pre-roll adverts before the requested media, the adverts and the media were stored in categories. Targeted advertising system was used to determine which advert to stream to the user and when the user does not provide the required information for targeted advertising the video category was used.

### 6.1 Conclusions

Telcos around the world are looking for ways to extend their businesses and many are looking to offer IPTV. For IPTV to be competitive and take in more market share it should have a unique selling point compared to the competition like live TV, online streaming, PVR services. It should be able to do this but at the same time bring in revenue to Telcos to justify the investment. This thesis proposed user-generated content system for an IMS-Based IPTV with targeted advertising in the hopes to solve this problem.

UGC sites like YouTube, Break.com, Metacafe and Daily motion among others, generated more than 230 billion domestic US views in 2010, a 146.9% year-to-year increase [44]. This shows this is a maturing field with high chance of success. This huge audience has attracted investments from advertisers. YouTube generated an estimated \$213 Million (Net) in Pre Roll Advertising in 2010[44]. This shows the potential of investing in such a business. IPTV service providers can offer such a service on their network as it has the potential of attracting users because of the social aspect of sharing and attract advertisers who are attracted by the number of views. As a result, we can conclude that offering a UGC service like YouTube has the potential of bringing in revenue by attaching both users and advertisers, which in turn make their service

better, for example subsidised service costs for users.

An evaluation platform was used to test the effect of the proposed framework on the user's QoE of the IPTV service. QoE can be divided into two components namely, an objective component and a subjective component. Thus to test these components the following parameters were tested: 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 the service latency of the modified system was slightly more but this was expected due to the additional processing functions, required at the IPTV AS and UE. However, the service delays were below those recommended for VoD service which is 5 seconds. Live TV, PVR services and other UGC services were used to compare the service features and service quality of the system. They were found to meet user expectations due to the functions available to the user, the ease of use of the features, the good response of the EPG and the relevant adverts limited to 30 seconds all contributed in passing the QoE tests. It is therefore concluded that the addition of the UGC service does not negatively affect user's QoE of the IPTV service.

## **6.2 Recommendations and Future work**

While conducting this research, a number of avenues for further research emerged to improve the system.

Creation of content will not only be limited to uploading of videos but the user can broadcast video. In this scenario the user can have webcam connected to the STB and so the user can make a movie which will be streamed and recorded on the network. The other user can view this recorded stream at a later time. In addition the user can add to the social aspects of the UGC services, having the ability for the users to comment on the videos will be good. So this should be added in so that the users will be able to view and post their comments on the videos they like. Since the media server can only serve a finite number of clients, it will be useful for the server to be able to tell when it reaches this limit. So that it will let the clients know that it won't be able to meet further requests. It is better that the user get a message that the server is busy than getting a substandard video because this will affect the user's QoE negatively. Service providers are looking for quad-play solution for new services so adding support mobility is necessary. This can

be done by testing the performance over wireless access networks like WiMAX and LTE. Adding this will enhance the user's experience.

University of Cape Town

# Appendix A

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## A. IMS and IMS-Based IPTV Architectures

### IMS Architecture

The 3GPP architecture is split into planes or layers, which are: Service or Application Plane, Control or Signalling Plane, and User or Transport Plane. Figure 2.3 illustrates these planes.

The Application Plane provides an infrastructure for the provision and management of services, and defines standard interfaces to common functionality in form of SIP Application Servers (AS). The 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 [11].

The Control or Signalling Plane includes the Home Subscriber Server (HSS) which is a master user database that supports IMS network entities that handles calls. It contains the subscription-related information (subscriber profiles), performs authentication and authorization of the user, and can provide information about the subscriber's location and IP information. The IMS Core is also part of the Control Plane which is made up of three SIP servers collectively known as Call Session Control Functions (CSCF), which are responsible for all session controls. These servers are the Proxy CSCF (P-CSCF), the Interrogating CSCF (I-CSCF) and the Serving CSCF (S-CSCF). P-CSCF is the first point of contact for IMS users; it is responsible for security of the messages between the network and the user and allocating resources for the media flows. It can be located either in the visited network or in the home network. I-CSCF is responsible for querying the HSS to determine the S-CSCF for a user and may also hide the operator's topology from peer networks. S-CSCF is the main control entity within the IMS. It is responsible for processing registrations to record the location of each user, user authentication, and call processing (including routing of calls to applications). The operation of the S-CSCF is controlled by policy stored in the HSS [35].

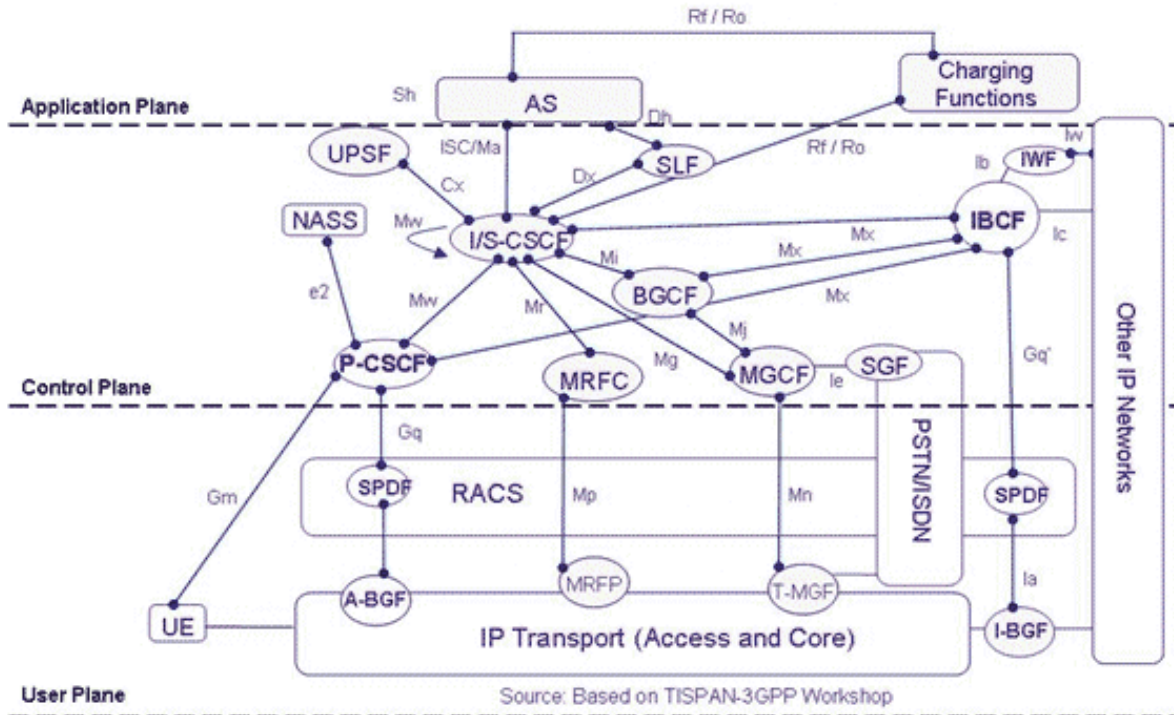


Figure A.1: IMS Architecture [35]

The User plane provides a core QoS-enabled IPv6 network with access from User Equipment (UE) over mobile, Wi-Fi and broadband networks. This infrastructure is designed to provide a wide range of IP multimedia server-based and P2P services. Access into the core network is through Border Gateways (GGSN/PDG/BAS). These enforce policy provided by the IMS core, controlling traffic flows between the access and core networks [35]. The description of the reference points and signalling protocols of the IMS architecture shown in Figure A.1 are detailed table A.1

Table A.1: Interfaces and protocol for communication between IMS entities

Interface Name	IMS entities	Description	Protocol
Cr	MRFC, AS	Used by MRFC to fetch documents from AS and also used for media control related commands.	TCP/SCTP channels
Cx	I-CSCF, S-CSCF, HSS	Used to send subscriber data to the S-CSCF; including Filter criteria and their priority. Also used to furnish CDF and/or OCF addresses.	Diameter
Dh	AS(SIP AS, OSA, IM-SSF) SLF	Used by AS to find the HSS holding the User Profile information in a multi-HSS environment. DH_SLF_QUERY indicates an IMPU and DX_SLF_RESP return the HSS name.	Diameter
Dx	(I-CSCF or S-CSCF) SLF	Used by I-CSCF or S-CSCF to find a correct HSS in a multi-HSS environment. DX_SLF_QUERY indicates a IMPU and DX_SLF_RESP return the HSS name.	Diameter

Gm	UE, P-CSCF	Used to exchange messages between UE and P-CSCF	SIP
Go	PDF, GGSN	Allows operators to control QoS in a user plane and exchange charging correlation information between IMS and GPRS network	COPS (Rel5), Diameter (Rel6+)
Gq	P-CSCF, PDF	Used to exchange policy decisions-related information between P-CSCF and PDF	Diameter
ISC	S-CSCF <-> AS	Reference point between S-CSCF and AS. Main functions are to notify the AS of the registered IMPU, registration state and UE capabilities, supply the AS with information to allow it to execute multiple services and convey charging function addresses	SIP
Ma	I-CSCF <-> AS	Main functions are to forward SIP requests which are destined to a Public Service Identity hosted by the AS, Originate a session on behalf of a user or Public Service Identity, if the AS has no knowledge of a S-CSCF assigned to that user or Public Service Identity and convey charging function addresses	SIP
Mg	MGCF -> I-S-CSCF	ISUP signaling to SIP signaling and forwards SIP signaling to I-CSCF	SIP
Mi	S-CSCF -> BGCF	Used to exchange messages between S-CSCF and BGCF	SIP
Mj	BGCF -> MGCF	Used for the interworking with the PSTN/CS Domain, when the BGCF has determined that a breakout should occur in the same IMS network to send SIP message from BGCF to MGCF	SIP
Mk	BGCF -> BGCF	Used for the interworking with the PSTN/CS Domain, when the BGCF has determined that a breakout should occur in another IMS network to send SIP message from BGCF to the BGCF in the other network	SIP
Mm	I-CSCF, S-CSCF, external IP network	Used for exchanging messages between IMS and external IP networks	SIP
Mp	MRFC, MRFP	Allows an MRFC to control media stream resources provided by an MRFP.	H.248
Mr,Mr <sup>2</sup>	S-CSCF, MRFC AS, MRFC	Used to exchange information between S-CSCF and MRFC Used to exchange session controls between AS and MRFC	SIP
Mn	MGCF, IM-MGW	Allows control of user-plane resources	H.248
Mx	BGCF/CSCF, IBCF	Used for the interworking with another IMS network, when the BGCF has determined that a breakout should occur in the other IMS network to send SIP message from BGCF to the IBCF in the other network	SIP
Mw	P-CSCF, I-CSCF, S-CSCF	Used to exchange messages between CSCFs	SIP
Rc	MRB, AS	Used by the AS to request that media resources be assigned to a call when utilizing MRB In-Line mode or In Query mode	SIP
Rf	P-CSCF, I-CSCF, S-CSCF, BGCF, MRFC, MGCF, AS	Used to exchange offline charging information with CDF	Diameter
Ro	AS, MRFC, S-CSCF	Used to exchange online charging information with OCF	Diameter

Rx	P-CSCF, PCRF	Used to exchange policy and charging related information between P-CSCF and PCRF Replacement for the Gq	Diameter
Sh	AS (SIP AS, OSA SCS), HSS	Used to exchange User Profile information (e.g. user related data, group lists, user service related information or user location information or charging function addresses (used when the AS has not received the third party REGISTER for a user)) between an AS (SIP AS or OSA SCS) and HSS. Also allow AS to activate/deactivate filter criteria stored in the HSS on a per subscriber basis	Diameter
Si	IM-SSF, HSS	Transports CAMEL subscription information including triggers for use by CAMEL based application services information.	MAP
Sr	MRFC, AS	Used by MRFC to fetch documents (scripts and other resources) from an AS	HTTP
Ut	UE, AS (SIP AS, OSA SCS, IM-SSF)	Facilitates the management of subscriber information related to services and settings	HTTP(s), XCAP

## IMS-Based IPTV Architecture

Table A.2 shows the names of the interfaces identified in Figure A.2 above and the signalling protocols associated with those interfaces.

**Table A.2:IMS based IPTV functional entities and protocols used on reference points [1]**

FE/ Reference 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/RTP /RTCP/ HTTP) (Note 1)	Dj, Di IGMP/ MLD
IMS core	Gm (SIP/SDP)	---	Cx (Diameter)	ISC (SIP/SDP)	---	ISC (SIP/SDP)	y2 (SIP/SDP)	---	---
UPSF	---	Cx (Diameter)	---	Sh (Diameter)	---	Sh (Diameter)	---	---	---
SDF	via Core IMS (SIP/SDP)	ISC (SIP/SDP)	Sh (Diameter)	---	---	---	---	---	---
SSF	Xa (HTTP, DVBSTP, FLUTE)	---	---	---	---	Ss' (not defined)	---	---	---
SCF	Ut (HTTP), via Core IMS (SIP/SDP)	ISC (SIP/SDP)	Sh (Diameter)	---	Ss' (not defined)	---	via Core IMS and y2 (SIP/SDP) ---	---	---
MCF	Xc (RTSP)	y2	---	---	---	via Core	---	Xp (not	---

	(Note 1)	(SIP/SDP)				IMS and y2 (SIP/SDP)		defined)	
<b>MDF</b>	Xd (UDP/RTP/ RTCP/HTTP) (Note 1)	---	---	---	---	---	Xp (not defined)	---	---
<b>ECF/ EFF</b>	Dj, Di IGMP/ MLD	---	---	---	---	---	---	---	---
<p>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, and the HTTP is used for the content download.</p> <p>NOTE 2: Annex H lists compliance requirements for the protocols listed in table 4.1.</p>									

Below are the more detailed descriptions of some the functions shown in Figure A.2 which were not properly described in chapter 2.

### **Service Discovery and Selection Functions (SDF and SSF)**

The SDF and SSF are functions which provide information necessary to the UE to select IPTV services. In more detail the SDF tasks are to generate and/or provide the service attachment information which consists of SSF addresses in the form of URLs and/or IP-address. SDF also provides personalized service discovery. The SSF provides the service selection information, e.g. list of available services that the UE can then browse and select. The SSF may generate this service selection information or it may retrieve from other sources and then forward the service selection information.

### **IPTV Service Control Functions (SCF)**

SCF is a SIP Application Server (AS) which is responsible for authorization during session setup and modification, which includes checking the user's profiles to grant or deny access to the services; credit limit and credit control using online charging systems; also selecting the relevant IPTV media functions.

### **User Profile Section Function (UPSF)**

The UPSF holds the IMS user profile and possibly IPTV specific profile data. It communicates with the IPTV Service Functions at the Sh reference points and with the Core IMS at the Cx reference point. If multiple instances of UPSF exist, the Core IMS and the IPTV

Service Control Functions may use the services of a Subscription Locator Function (SLF) to fetch the address of the UPSF.

### **IPTV Media Control and Delivery Functions (MCF and MDF)**

IPTV Media Functions are in charge of controlling and delivering the media flows to the UE. They are split into Media Control Functions (MCF) and Media Delivery Functions (MDF)

The tasks of Media Control Function (MCF) are as follows:

- Handling media flow control of MDF
- Manage the media processing of MDF.
- Monitoring the status of MDF
- Managing interaction with the UE (e.g. trick mode commands).
- Handling interaction with the IPTV service control function SCF.
- Keeping an accurate view on status and content distribution related to the different MDFs that it controls.
- Detecting IPTV service state information
- Selecting an MDF, in the case where an MCF controls multiple MDFs different criteria, may be applicable
- Generate charging information, e.g. for end-user charging based on the viewed content
- In case of live User Generated Content consumption there is a direct relationship on the media delivery and media control levels between downstreaming and upstreaming UGC sessions, which both terminate at the MCF. The MCF ensures that session descriptions of the downstreaming and upstreaming UGC sessions match. UE's subscribed to the particular Live UGC are notified when this Live UGC starts.
- Handle ad insertion control of MDF, i.e. control the fetching of the ad content and synchronization between ad content and IPTV content, including accounting for delay or drift in broadcast TV schedules.

Tasks of MDF:

- Handling media flow delivery (for delivering multimedia services to user).
- Status reporting to MCF (e.g. reporting on established IPTV media streams).
- Store of media (e.g. CoD assets) and may also store some service information stored with

media for IPTV services.

- In particular, it may be used for storage of the most frequently accessed content or user specific content (e.g. recording PVR, Time-shift TV, BC service with Trick mode, user generated content) if the same tasks are not performed by UE.
- May additionally process, encode or trans-code (if required) media to different required media formats (e.g. TV resolution depending on terminals capabilities or user preferences).
- MDF may act as source for multicast streams of IPTV services e.g. BC or UGC media streams.
- For UGC services, receiving content from UE through an up streaming/upload media channel.

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# Appendix B

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## A.Details of machines used in the test-bed

This appendix gives the details for each machine used in the test-bed architecture.

The information was obtained using the following commands in ubuntu:

1. head /proc/cpuinfo
2. head /proc/meminfo
3. lsb\_release -a
4. uname -a

### I-CSCF and P-CSCF

```
processor      : 0
vendor_id     : GenuineIntel
cpu family    : 6
model         : 23
model name    : Pentium(R) Dual-Core CPU E5300 @ 2.60GHz
stepping      : 10
cpu MHz       : 1203.000
cache size    : 2048 KB
physical id   : 0
siblings      : 2
```

```
MemTotal      : 2052412 kB
MemFree       : 1084172 kB
Buffers       : 189832 kB
Cached        : 418996 kB
SwapCached    : 0 kB
Active        : 642364 kB
Inactive      : 209540 kB
```

Active(anon) : 307320 kB  
Inactive(anon) : 8 kB  
Active(file) : 335044 kB

istributor ID : Ubuntu  
Description : Ubuntu 9.04  
Release : 9.04  
Codename : jaunty

Linux imsuser-desktop 2.6.28-19-generic #64-Ubuntu SMP Wed Aug 18 20:55:57 UTC 2010  
i686 GNU/Linux

### **HSS and S-CSCF**

processor : 0  
vendor\_id : GenuineIntel  
cpu family : 15  
model : 2  
model name : Intel(R) Pentium(R) 4 CPU 3.00GHz  
stepping : 9  
cpu MHz : 2992.687  
cache size : 512 KB  
physical id : 0  
siblings : 2

MemTotal : 1016500 kB  
MemFree : 137952 kB  
Buffers : 207768 kB  
Cached : 242980 kB  
SwapCached : 0 kB  
Active : 422796 kB  
Inactive : 256116 kB

HighTotal : 113852 kB  
HighFree : 224 kB  
LowTotal : 902648 kB

Distributor ID : Ubuntu  
Description : Ubuntu 8.10  
Release : 8.10  
Codename : intrepid

Linux imscore 2.6.27-11-generic #1 SMP Thu Jan 29 19:24:39 UTC 2009 i686 GNU/Linux

### **IPTV AS, Media Server and MySQL database**

processor : 0  
vendor\_id : GenuineIntel  
cpu family : 15  
model : 3  
model name : Intel(R) Pentium(R) 4 CPU 3.20GHz  
stepping : 4  
cpu MHz : 3191.992  
cache size : 1024 KB  
physical id : 0  
siblings : 2

MemTotal : 1016500 kB  
MemFree : 211840 kB  
Buffers : 92488 kB  
Cached : 321216 kB  
SwapCached : 0 kB  
Active : 417460 kB  
Inactive : 226556 kB  
HighTotal : 113852 kB

HighFree : 224 kB  
LowTotal : 902648 kB

Distributor ID : Ubuntu  
Description : Ubuntu 8.10  
Release : 8.10  
Codename : intrepid

Linux icscf 2.6.27-11-generic #1 SMP Thu Jan 29 19:24:39 UTC 2009 i686 GNU/Linux

### Client Terminals (Alice, Bob, Jane and John)

processor : 0  
vendor\_id : GenuineIntel  
cpu family : 6  
model : 23  
model name : Pentium(R) Dual-Core CPU E5400 @ 2.70GHz  
stepping : 10  
cpu MHz : 2700.318  
cache size : 2048 KB  
physical id : 0  
siblings : 2

MemTotal : 2052156 kB  
MemFree : 1374264 kB  
Buffers : 79196 kB  
Cached : 319916 kB  
SwapCached : 0 kB  
Active : 378500 kB  
Inactive : 245996 kB  
Active(anon) : 314976 kB  
Inactive(anon) : 8 kB  
Active(file) : 63524 kB

Distributor ID : Ubuntu  
Description : Ubuntu 9.10  
Release : 9.10  
Codename : karmic

Linux denys-desktop 2.6.31-22-generic #60-Ubuntu SMP Thu May 27 00:22:23 UTC 2010 i686  
GNU/Linux

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# Appendix C

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## **B. Accompanying CD-ROM**

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

- Research Literature - Electronic copies of the research papers and other literature used during the course of this research can be found in the directory labelled “Research Literature”.
- Software - All the source code developed for the evaluation framework can be found in the directory labelled “Software”.
- Thesis - An electronic copy, in PDF format, of this document can be found in the directory labelled “Thesis”.

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