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Department of Computer Science and Engineering  
- Master of Science in Telecommunications Software -

# INTERNET PROTOCOL DATACASTING

## Transparent Interactivity Using Different Communication Channels

Master's Thesis

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*To my wonderful parents Enrique and Graciela  
for their endless love, and who have given me so much  
without ever expecting anything in return*

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<p>DVB-H is a standard that makes it possible to deliver live broadcast digital television to mobile handsets through IP Datacasting. IP Datacasting takes the idea of television further. In addition to digital video, also IP content can be sent through the broadcasting system. Broadcasting systems are unidirectional. Therefore, in order for the receiver to communicate with the sender a different communication channel should be used. This communication channel can be used to provide interactivity and new services. However, in order to make the services appealing and interesting to the user, interactivity should be transparent. That is, the user should not be aware of the technology used. Likewise, mobile TV applications should provide a personalized experience to the user.</p> <p>This thesis focuses on investigating how full transparent interactivity can be obtained in IP datacasting using different communication channels such as GPRS or W-CDMA. To emphasize this, a set of specifications along with a prototype were developed to determine the feasibility of implementing an application of this kind. Finally, service concepts were developed to show how interactivity can be provided to the user. The study demonstrated that transparent interactivity can be achieved through different communication channels and explained the problems involved. This research places a base for different research topics regarding the business opportunities these kinds of services and applications can provide as well as their related value chains. This thesis was done as part of the INDICA research project at the Telecommunications Software and Multimedia Laboratory in Helsinki University of Technology.</p>		
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<p>DVB-H on standardi, joka mahdollistaa digitaalisen televisiokuvan jakelun langattomiin päätelaitteisiin IP datacasting –teknologian avulla. IP datacasting vie television palvelukonseptin aikaisempaa pidemmälle. Digitaalisen videokuvan lisäksi myös IP-pohjaista sisältöä voidaan jakaa samassa verkossa. Television jakelutiet ovat yksisuuntaisia. Jotta vastaanottaja voisi kommunikoida lähettäjän kanssa, joudutaan käyttämään toista jakelukanavaa. Tämä kanava tarjoaa interaktiivisuutta ja uusia palveluita. Kuitenkin, jotta tämä ei häiritse käyttäjän palvelukokemusta, täytyy interaktiivisuuden olla läpinäkyvää. Toisin sanoen, käyttäjä ei saa häiriintyä interaktiivisuuden mahdollistavasta teknologiasta. Digitelevision tavoin myös langattomien päätelaitteiden tulisi tarjota joustavia ja yksilöllisiä palveluita käyttäjälle.</p> <p>Tämä tutkimus tarkastelee mahdollisuutta tarjota läpinäkyvä interaktiivisuus IP Datacasting –mallissa, käyttäen erilaisia yhteyksiä kuten GPRS tai W-CDMA. Tämän takia kehitettiin joukko määrittelyitä ja prototyyppejä, jonka avulla voitiin tutkia toteutustavan toimivuutta. Lisäksi kehitettiin palvelukonsepteja, joilla voitiin demonstroida kuinka interaktiivisuus käyttäjän kanssa toimisi käytännössä. Tutkimuksen johtopäätös on, että läpinäkyvä interaktiivisuus voidaan saavuttaa erilaisissa kanavaratkaisuissa nykypäivän teknologioiden avulla. Tämä tutkimus luo pohjaa uusille tutkimuksille, jotka pohtivat mm. liiketoimintamallien ja arvoketjujen rakentamista aiheen ympärille. Tutkimus tehtiin osana INDICA-projektia Tietoliikenneohjelmistojen ja multimedian laboratoriossa Teknillisessä korkeakoulussa.</p>
<b>Avainsanat:</b> DVB-H, mobiili-TV, IPDC, IP Datacasting, läpinäkyvä interaktiivisuus, interaktiokanava, digi TV
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# Preface

This Master's thesis is the result of studies and research carried out at the Telecommunications Software and Multimedia Laboratory in Helsinki University of Technology (HUT). The work was part of the INDICA project in which I was part of the research group.

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# Abbreviations and Acronyms

3G	Third Generation wireless
ATSC	Advanced Television Systems Committee
CDMA	Code Division Multiple Access
cdmaOne	Original version of CDMA
CDMA2000	Multi-carrier Code Division Multiple Access
COFDM	Coded Orthogonal Frequency Division Multiplexing
codec	coder/decoder
DAB	Digital Audio Broadcasting
Digitag	Digital Terrestrial Action Group
DMB	Digital Multimedia Broadcasting
DRM	Digital Rights Management
DTV	Digital Television
DVB	Digital Video Broadcasting Consortium
DVB-H	Digital Video Broadcasting – Handheld
DVB-M	Digital Video Broadcasting – Mobile (obsolete)
DVB-T	Digital Video Broadcasting – Terrestrial
DVB-X	Digital Video Broadcasting – Mobile (obsolete)
DVD	Digital Video Disk
EDGE	Enhanced Data GSM Environment
ESG	Electronic Service Guide
EPG	Electronic Program Guide
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FLUTE	File Delivery over Unidirectional Transport
GPRS	General Packet Radio Services
GSM	Global System for Mobile communication
HDTV	High Definition Television
HSDPA	High Speed Downlink and uplink Packet Access
IPDC	Internet Protocol Datacasting
ISDB	Integrated Services Digital Broadcast

ITU-T	Telecommunication Standardization of the International Telecommunications Union
IMT-2000	International Mobile Communications 2000
IMG	Internet Media Guide
IPDC	Internet Protocol Datacasting
LAN	Local Area Network
MIME	Multi-Purpose Internet Mail Extensions
MP3	MPEG Layer 3
MPE	Multi-Protocol Encapsulation
MMS	Multimedia Messaging Service
MPEG	Moving Pictures Expert Group
OFDM	Orthogonal Frequency Division Multiplexing
PES	Packetized Elementary Stream
PDA	Personal Digital Assistant
QAM	Quadrature Amplitude Modulation
SDP	Session description Protocol
SDK	Software Development Kit
SFN	Single Frequency Network
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications Service
VHF	Very High Frequency
W-CDMA	Wideband Code-Division Multiple Access
WLAN	Wireless Local Area Network
XML	Extensible Markup Language

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# 1. Introduction

Over the last decade digital technology has encouraged a rapid growth in the personal consumption of media. Devices like video recorders, video-on-demand and pay-per-view offerings have enabled users to personalize the content they want to watch.

Alongside with this trend has been the amazing growth mobile telephony has experienced. Mobile terminals are packed with new technologies that broaden their functionality. The mobile terminal converges and can be used as an organizer, game console, music player, portable radio, agenda, camera, video camera and now, television. The place of viewing is no longer limited to a television set at home or in a vehicle. Instead, it is widened to allow personal viewing of television anytime at anyplace. Television has been brought to mobiles through the use of cellular networks. However, providing the service in this way results expensive and has not proven feasible enough.

DVB-H is a standard that makes it possible to deliver live broadcast television through the use of IP datacasting. IP datacasting takes the idea of digital television further, in addition to digital video, IP content can be sent in the broadcasting system. Furthermore, even though DVB-H is a unidirectional technology, interactivity can be achieved by the use of a cellular communication channel such as GPRS and W-CDMA. This provides very interesting possibilities for a wide variety of IP based mobile services.

There are other standards that enable IP datacasting. However, DVB-H is likely the technology that will be used to provide mobile TV content in Europe, and several pilots are underway to test the technology. However, interactivity in mobile TV

applications has not yet been explored in detail. The purpose of this study is to explore the feasibility of providing interactive services within mobile TV applications. The study builds upon results of preliminary studies on IP datacasting technology. The concepts are first structured and organized. Then, a software design for an application that provides transparent interactive services is proposed and a prototype is developed to test if the design is feasible and the transparency possible. Finally, interactive service concepts are explored in detail and presented.

This thesis is organized in the following way. This chapter serves an introduction to the entire thesis. Chapter 2 provides background information and defines the problem statement. Chapter 3 continues by providing an overview of the different technologies involved in mobile TV and those required for providing interactive services. Chapter 4 describes the methodology of the study, analysis plan and limitations of the study. Then, Chapter 5 and 6 delineates the whole study. Subsequently, chapter 7 analyzes the results of the study according to the methodology proposed. Finally chapter 8 presents the conclusions of the study, future challenges and work with respect to this Thesis.

## 2. Background

Digital video broadcasting provides the means for transmission of digital content to masses. Since its first appearance in Europe it has been widely accepted. Similarly the use of handheld devices has increased at a very fast rate. In Finland 90 percent of the people owns a mobile phone (IPDC Forum, 2003b). Nowadays, many services are available in mobile phones that range from simple text messages to Internet connections and email applications. Therefore, the idea of bringing television to mobile phones should not be surprising, and in fact, it is not a new idea. Receiving digital television in mobile phones has been available in the United States and Japan for some time already, and in Europe some pilots have been implemented (Teracom, 2003, Crown Castle Int'l, 2004).

The problems so far have been the methods in which the television signal is transmitted. For example, with the use of the cellular communication channels, data transmission is very expensive. As a result, services that provide digital television through the use of cellular communication channels have not been very successful due to the high price of the service. Contrastingly, a different means to transmit the video signal to mobile terminals is by broadcasting it with the same digital video broadcasting systems used for TV sets. However, several issues arise from doing so. It is not the same to broadcast digital video to a stationary device as to a mobile one. A stationary device is in a particular place while a mobile terminal can be located anywhere, moving at the same time and has very different limitations from ordinary receivers. Mobile terminals have small screen sizes, low battery life and move continuously.

IP datacasting enables sending IP content in the broadcasting system in addition to digital television. It is similar to the digital television broadcasting system, with the difference that instead of channels being transmitted over a radio connection to a wide audience, data and files are sent. IP datacasting is designed for mass reception of data services and the IP datacast signal can be received simultaneously by thousands of receivers within the transmitter coverage area. It contrasts with the traditional Internet in the sense that content is not requested individually but instead broadcasted to multiple receivers simultaneously (RTT, 2004). In theory, all content that can be carried through the Internet can also be broadcasted. However, many IP services are not designed to be delivered in a unidirectional fashion, such those in used in Transmission Control Protocol (TCP). Therefore, those services do not suit broadcasting or would have to be treated differently.

## 2.1. Mobile Reception

In Europe, the Digital Video Broadcasting Consortium (DVB) standards have been adopted for digital video broadcasting. DVB has several ways in which digital television can be broadcasted and DVB-T (Terrestrial) is the most widely used. DVB normally uses the moving pictures expert group MPEG-2 as the compression method. With the use of Internet Protocol Datacasting (IPDC), the compression method is not bound to MPEG-2 and any compression method can be used instead. Since DVB-T was not designed for mobile reception, there was a need for a mobile standard. This new standard would be based upon DVB-T, but it would take into consideration the requirements for mobile reception such as network parameters, power consumption, battery life, network coverage and interference tolerance. The mobile standard was originally called DVB-M, then DVB-X and finally DVB-H (Handheld). The DVB-H standard's most important feature is the idea of time-slicing. The basic functionality of time-slicing is to send the data in bursts; therefore the terminal is only turned on whenever relevant data is available. This results in an increase of battery life. Additionally, IPDC technology offers fast and reliable transmissions. Data bandwidth can be up to 22 Mb/s for fixed reception. IP services can be transmitted within the DVB multiplexers along with digital television programs. Multiplexers are collections of multiple transport streams that are transmitted as one. However, mobile reception

requires a more reliable transmission due to the small antennas and therefore a different modulation scheme and a multiplexer for mobile transmission is required as well. (DVB, 2004c, Sonera MediaLab, 2003)

Even though DVB-T and DVB-H are unidirectional technologies, interactivity can be achieved through a mobile terminal by the use of a different communication channel such as General Packet Radio Services (GPRS) and Wideband Code-Division Multiple Access (W-CDMA). This provides very interesting possibilities for a wide variety of IP based mobile services. IP datacasting transmissions are usually broadcasted, but the reception can be limited to one receiver (unicast) or groups (multicast). To control the use of services, encryption methods and Digital Rights Management (DRM) technologies can be implemented. With the use of the different communication channels, the IP datacasting services can be enhanced, for example, purchasing services that are related to other services or online browsing.

## 2.2. IP Datacasting as a Multimedia Platform

The digitalization of content and communication networks has provided the means to deliver more versatile content than just audio and video. This content can be graphics, audio, video, software and Web pages among many others. With the use of broadcasting to deliver this content, receiving terminals have access to much more services than those they used to provide before. A terminal could work as an agenda, ticket scheduler, mobile TV, radio, mp3 player, web browser and telephone at the same time. IP datacasting aims at making this convergence possible.

IP datacasting is a combination of digital broadcasting, IP based services and multimedia content. It enables a large scale distribution of multimedia content to users. The terminals are not limited to handheld devices. Therefore different opportunities can be explored such as in-car entertainment (Crown Castle Int'l, 2004, Xu et al., 2000). IP datacasting pilots have been launched in Helsinki, Pittsburgh and Berlin and more pilots are scheduled for 2005.

## 2.3. Mobile TV

Mobile TV is not a new idea and it has been available for some time already. Some mobile TV terminals were developed in the past but it seems people were never too attracted to buy them (Yoshida, 2004). On the contrary, mobile phones and Personal Digital Assistants (PDA) have become more and more popular day by day and the amount of applications they support is wider. Mobile phones do not function just as a phone anymore, but also as a scheduler, MP3 player, radio, etc. It seems the only important application missing from mobile terminals is TV. Adding TV to the mobile terminals is not a new idea either and it has already been tried.

The simplest way to add TV to a phone is by adding a TV receiver. In fact, in Japan nowadays almost all Third Generation wireless (3G) phones have an analog TV receiver. Likewise, digital television over 2.5G and 3G networks has also been tried several times. The main drawback of offering digital television in 2.5G and 3G networks is that it is expensive and users have not been attracted to purchase it at those prices. Regardless of the previous failures, in the USA digital television (DTV) over 3G has been widely promoted again in big campaigns in the late 2004 and early 2005 by offering mobile-only content. One of the biggest campaigns is based on advertising a set of episodes of 24<sup>th</sup> Century Fox's popular TV show "24" only for mobile terminals. The mobile episodes are 60 seconds long and have been referred as mobi-sodes. Other companies have also started to create mobile only content such as cartoons and news clips. Finally, in Japan digital TV is also available for mobile terminals over Integrated Services Digital Broadcast (ISDB-T). The problem that all these mechanisms have in common is the huge amount of battery consumption. The standards used to transmit TV signals (digital or analog) require too much battery power. Additionally, for 2.5G and 3G networks, the cost of transmission is quite expensive and, for ISDB-T the terminals require 2 antennas.

With the use of IPDC, the content and services are not limited only to digital TV and can be broadcasted to a great amount of users at the same time. Since broadcasting is unidirectional, a different communication channel should be used to provide interactivity. Thus, new business models can be developed. Offering customized content and services through different channels can provide the means for further revenues. The mobile terminal does not act only as a TV. Instead, it is a portal to access different kinds of services within the same application.

## 2.4. Services

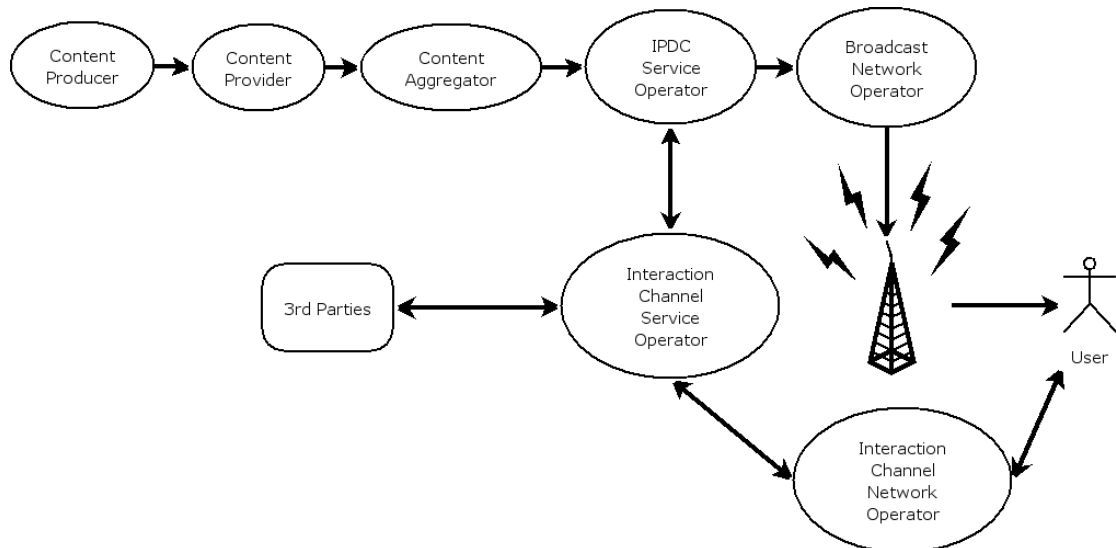
The variety of services that can be offered through IP datacasting is extensive. Much of the content that can be offered through the Internet can also be provided by using IP datacasting. Furthermore, by means of different communication channels, interactivity can be achieved in unidirectional networks. Therefore, content does not necessarily need to be broadcasted; it can also be requested, downloaded or streamed. Some of the services that can be used are the following (TI, 2005):

- Live television programs
- File downloads (music, images, ringtones)
- Electronic service guide
- Pay-per-view
- Packaged services (i.e. sport events as the World Cup)
- Live polls
- Chat

IPDC enables users to watch television in handheld devices. These devices are likely to be considered personal items. Therefore, the act of viewing television becomes an individual, rather than a social activity (Digitag, 2005). Services can be accessed when viewers are on the move, in public transportation or waiting for an appointment. The handheld device could be used, for example, to catch-up on the users favorite sports teams, news, or on events such as the Olympics or the World Cup (TI, 2005). While it may be less likely that viewers will use their handheld television while they can benefit from a larger television, this may not always held true. Viewers may be tempted to use the handheld if it provides different services and viewing experiences or extra functionality. Users may also wish to continue using their handheld device to individually interact or zap programs services, while simultaneously watching a television program with others on a larger television. It is worth mentioning that interactivity through games, chat and voting by SMS on ordinary television channels broadcasts has become very popular in Europe nowadays.

## 2.5. IPDC Value Chain

To provide a variety of services with the use of IP datacasting, several organizations must cooperate in producing and managing the services for the mobile users. Figure 1 depicts the roles identified in the IPDC value chain.



**Figure 1: IPDC Value Chain**

First, the content is created by the content producer. This content is delivered to the content provider who may modify or alter the content before selling it to the content aggregator. The content aggregator then schedules the content and creates combination of services that are delivered to the IPDC service operator. The IPDC service operator encrypts the content, creates the access rights objects and develops an electronic service guide as well as price listings. The resulting stream is broadcasted in the air by the broadcast network operator. The user receives the stream and consumes the services. The services may be accessible directly while some others have to be ordered through a different communication channel provided by the interaction channel service operator. Lastly, the interaction channel network operator maintains the physical interaction channel network, for example GSM or W-CDMA. (Staffans, 2004)

## 2.6. The INDICA Project

This Thesis is part of the result of the second phase of the INDICA project. This project develops concepts for IPDC based content services and investigates the related value chain and this way prepares for the emerging business in this area. The project sets out to investigate the business opportunities of the IPDC value chain.

The participants of the INDICA project of Elisa R&D include service operators, content producers, the city of Helsinki and universities. Furthermore, the INDICA project provides two experimental services for the Finnish mobile TV pilot. The pilot was underway at the moment this Thesis was written. Therefore, the results from the Finnish mobile TV pilot were not available. During the timeline of this project, guidance by experts in different fields as well as some service concepts and user storylines were provided for this Thesis.

## 2.7. Terms

**Transparent Interactivity** A means of interactivity in which a user can use an application without noticing the technology involved.

**Communication Channel** A communication channel to transmit information.

**General Packet Radio Services (GPRS)** A packet based wireless communication service.

**Wideband-Code Division Multiple Access (W-CDMA):** A third generation (3G) mobile wireless technology air interface.

## 2.8. Problem Statement

The main objective of this Thesis is to investigate how full transparent interactivity can be obtained in IP datacasting using different communication channels such as GPRS or W-CDMA. To accomplish this, a set of specifications were developed as well as a prototype to determine the feasibility of implementing an application of this kind. Finally, interactive service concepts were developed to show how they can provide interactivity to the users. The fundamental problem is: Can transparent interactivity be achieved through different communication channels in IPDC applications?

## 2.9. Scope of the Thesis

IP datacasting is an emerging technology and still much has to be done, particularly in standardization. However, the DVB-H specification has been approved as a standard and several pilots have tested the feasibility. This thesis will focus on analyzing how an application can be developed in a way that the user will not notice which technology is being used. A software requirements specification has been developed as well as a prototype of the specified software. For rights protection, it is still unclear how the security issues and copyright management are going to be implemented since different possibilities exist. DVB is expected to decide on which security approach to use at the earliest in June 2005. Based on this decision, further work will be necessary in order to finalize the DVB-H standard. Completion is expected by the end of 2005. Likewise, the application described in this Thesis requires an Electronic Service Guide (ESG). The standardization for the ESG for DVB-H is being performed by the Open Mobile Alliance (OMA) and the DVB Consortium. At the time this document was written, the standardization for the ESG was not completed either. Other attempts to specify a Service Guide are being developed such as the Internet Media Guide or which is developed by the MMUSIC group in the Internet Engineering Task Force (IETF).

## 2.10. Structure of the Thesis

First of all, background information of the research setting is provided by discussing the technologies involved in IP datacasting through digital video broadcasting systems and for its services. This part is carried out through a literature review.

Secondly, the Thesis focuses on describing the solution proposed to solve the problem, then, the service concepts are described. Thirdly, the results of the proposed solution are evaluated.

Finally, the conclusions, limitations, future challenges and work are discussed.

### 3. IP Datacasting (IPDC)

Digital media content such as music, video, magazines, games and web sites are inherently aimed to large audiences (Paila, 2003). “IP datacasting is a broadcast technology which enables cost effective and efficient distribution of digital content to mass audiences”. (IPDC Forum, 2003a) Anything that can be distributed in a unidirectional way over IP datagrams can be distributed with IPDC. IP services that require bi-directional communication need an alternate return channel. Additionally, information that is related can be grouped and sent over a single transmission. For example, a set of informational webpages about traffic jams could be sent together according to the region and cached in the terminal’s memory for quick access.

Delivery with IPDC has a fixed transmission cost. It costs the same amount of resources to broadcast content regardless of the number of users. On the other hand, the performance of transmission of multimedia content over 2.5/3G networks or Wireless Local Area Network (WLAN) hot-spots depends on the amount of users. Broadcast transmissions reach all its audience without bottlenecks and without dependence on the number of users. (Paila, 2003, Jäkel, 2001)

The main differences between IPDC aimed for mobile terminals and digital television are: built-in antennas, small screen and reliance on battery power. With the use of DVB-H technology, power savings of up to 90% can be achieved (DVB, 2004e). IPDC provides the capability to send 50-80 channels (128-384Kbps) over the same network vs. 3-4 channels (2-5Mbs) in digital television.

Due to the lack of battery power mobile terminals have, IPDC relies greatly on bandwidth transmission efficiency. The compression mechanisms selected have to be

optimal yet provide flexibility to suite different terminals. The compression should reduce the file size as much as possible to minimize the transmission times, and the decoder should not be too complex. Otherwise, decoding the compressed file will consume more battery power.

### 3.1. Digital Video Broadcasting Systems

The new digital television systems under development such as DVB-T or ISDB-T can support mobile distribution of multimedia services. These multimedia applications utilize simultaneous transmission of the same information to a large number of users. The different transmission systems used can provide data rates in the order of 20 Mbits/s in a 6 MHz bandwidth channel. This is sufficient to provide fixed locations with one high definition television program or with 3 or 4 standard definition television (HDTV) programs. Standard definition television (SDTV) provides quality similar to a digital versatile disk (DVD). High definition television provides an improved quality display which is similar to 35 mm. movies. Both HDTV and SDTV use MPEG-2 file compression method. The different broadcasting standards are explained below.

Advanced Television Systems Committee (ATSC) is the standard for digital video broadcasting in the United States. ATSC uses an 8-level vestigial sideband (8-VSB) as its radio frequency modulation standard. The standard provides the large bandwidth needed for HDTV and is quite robust to random noise. However, the 8-VSB system does not support mobility and has poor performance against multipath effects. The multipath effect comes into play when the transmitted signal meets obstructions such as high buildings or canyons, causing it to take two or more paths to reach its final destination. The late arrival of the signal causes ghost images. For these reasons, in order to provide digital video to mobile terminals different approaches have to be considered. (Wu, 1999)

In Japan, the ISDB (Nakahara et al., 1999, Sugimoto, 2003) standard is used. The terrestrial mode (ISDB-T) provides multimedia broadcasting services for terrestrial networks. ISDB-T can accommodate HDTV service or several SDTV program services in a channel bandwidth of 6MHz. It is robust enough against multipath fading interference which makes portable and mobile reception possible.

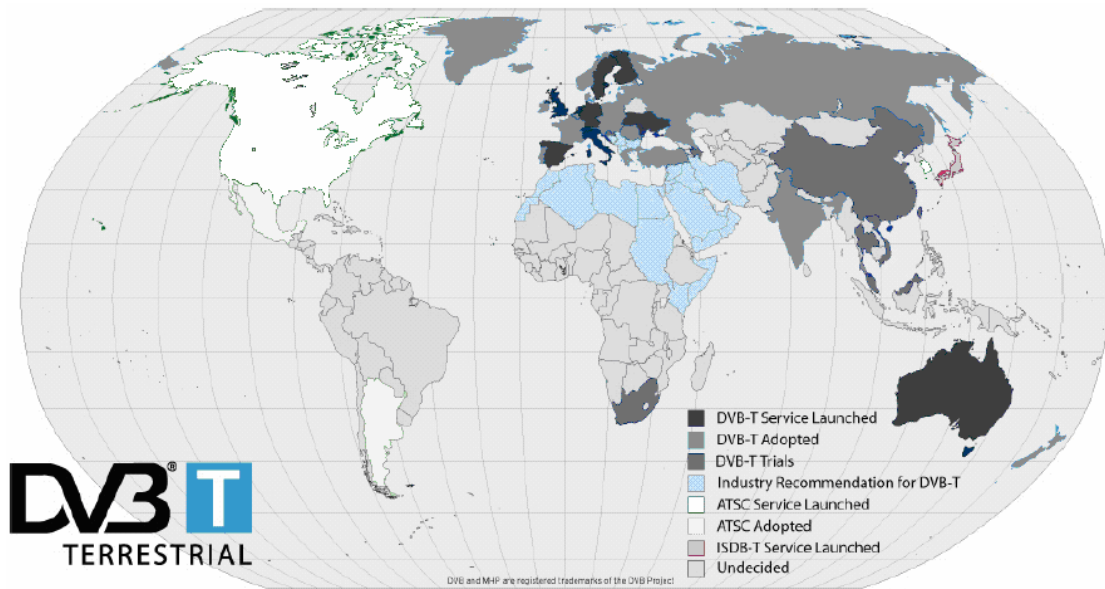
The system divides the 6MHz channel into 13 segments. Each of the segments can use a different modulation scheme. By doing so, different robustness levels can be provided within the same channel (Caron et al., 2002). ISDB-T uses Coded Orthogonal Frequency Division Multiplexing (COFDM). Applying an orthogonal frequency division multiplex combined with a convolutional coding for error protection leads to an undisturbed reception even under difficult conditions (Grube et al., 2001). With COFDM, a serial baseband bit-stream which needs to be transmitted is distributed over many closely spaced individual carriers. This makes the signal robust against the effects of multipath, narrowband interferences and interference caused by existing analog broadcasting signals. The multipath effects are avoided by COFDM's use of multiple carriers.

Some of the main differences between ISDB-T and DVB-T are that ISDB-T supports time interleaving and the 4k modulation OFDM mode (DVB-T only allows 2k and 8k modulation modes). The 4k mode is particularly useful with mobile terminals. For example, ISDB-T can be used successfully in trains to transmit DTV. Moreover, mobile reception is very sensitive to impulsive noise and time interleaving is effective against it. In Japan, DTV has been available commercially over ISDB-T for mobile terminals since 2004. Unfortunately, DTV transmission to mobile terminals still does not provide low battery consumption rates and the terminals require 2 antennas. However, the standard is now being modified to suit handheld devices.

The Digital Multimedia Broadcast (DMB) standard is a successor of the Digital Audio Broadcast (DAB) standard. The initial tests and deployment of DMB started in South Korea in the late 2004. DMB is well-suited for mobile multimedia, holding significant advantages over satellite broadcasting and WLAN, in terms of mobility. DMB uses MPEG compression and COFDM. It is also more price competitive than video-on-demand services delivered over the 3G network. LG Electronics has released a mobile terminal for the DMB standard and claims that the infrastructure needed for DMB is minimal compared to DVB-H. In South Korea several implementations are testing the advantage of using DMB over satellite as well. (Lee et al., 2004, Fazel et al., 1997)

DVB is a standard adopted in Europe for Digital Video Broadcasting and it is regulated by the European Telecommunications Standards Institute (ETSI). The DVB standards are based on COFDM and have several modalities such as Terrestrial,

Cable, Satellite, and Handheld. The DVB standards are the most widely assented and some modalities are suitable for mobile broadcasting. DVB-T and DVB-H are the standards selected for Finland, Europe and several other countries. Figure 2 shows the status of digital television standards around the world.



**Figure 2: Digital Television Status in 2004 (www.dvb.org)**

### 3.2. DVB-T (Terrestrial)

DVB-T (ETSI, 2004c) is the terrestrial mode for Digital Video Broadcasting. It has been selected as the common standard for digital television in Europe, and it is the base for DVB-H which enables IP datacasting for mobile handsets. In DVB-T, each program is sent over a separate logical channel that is identified by a unique packet identifier. All users subscribed to the service may receive any program on that logical channel. The control streams used with the packet identifiers such as the program and service information are transmitted repeatedly from the head end to the users by carrousel transmission (Grgic, n.d., Kellerer et al., 2000).

DVB-T (Mattei, 2005, McCann, 2005) uses MPEG-2 for compression. However, the newer DVB-T specification also allows H.264/AVC as an alternative to MPEG-2. The DVB-T standard has error protection and correction mechanisms, modulation schemes and network design. DVB-T divides the signal into several thousand orthogonal subcarriers using COFDM. The system is designed to operate with the Ultra High Frequency (UHF) spectrum, and can be used with 6, 7 or 8 MHz

channel bandwidths depending on the regional demands. Operation with Very High Frequency (VHF) band is also available. Furthermore, DVB-T has several modes that make the standard suitable for different operating conditions and specific needs. (Nokia, 2002)

The parameters for DVB-T transmission are the number of subcarriers, guard interval, whether a hierarchical signal is used, error correction level and the modulation scheme (DVB, 2004a, 2004b). The number of subcarriers affects the signal tolerance to the Doppler Effect. The Doppler Effect is the shift in frequency and wavelengths caused by relative motion. DVB-T has two modes that determine the number of subcarriers, 2k and 8k. The 2k mode has around 2000 subcarriers and the 8k mode around 8000. The guard interval parameter determines the signal's tolerance to echo. The ability to withstand echoes makes it possible to use spectrum efficient single frequency networks. A single frequency network is a network of several stations that broadcast the same signal simultaneously using multiple transmitters (ETSI, 2004d). An important benefit of the single frequency network principle is the possibility to enhance the receiving conditions with cheap gap-fillers and repeaters.

DVB-T originally defined MPEG-2 as the compression standard because it enables the multiplexing of separate elementary streams associated with the same service, the display of a synchronized electronic program guide announcing each service's scheduled events, as well as the authorization of end users, and the encryption of all MPEG-2 transport streams. (Epstein, 2000)

DVB-T has proven effective in meeting more than its initial requirements. For example, DVB-T has been used to provide television services in public transportation in Taiwan and Singapore, and recent developments make its use possible in cars and in trains (Digitag, 2005). However, even though it is possible to offer IP datacasting over DVB-T or ISDB-T networks, the major problem is that these networks and standards were not designed to target mobile handsets. Therefore, the requirements in which they are based do not take in mind the necessities of this kind of terminals. The problem with IP datacasting over DVB-T or ISDB-T is the battery consumption.

### 3.2.1. Electronic Program Guide (EPG)

An Electronic Program Guide (EPG) is an application used in digital TV to list the available programs on each channel and a summary or commentary for each program.

The EPG is the electronic equivalent of a printed television program guide. The guide provides programs listings of the programs for up to the next seven days. Each digital TV manufacturer offers its own user interface and content for its EPG. Therefore there is no common standard among the several digital TV manufacturers. Depending on its functionality, the EPG allows viewers to:

- See what programs are available either by subject, theme or time.
- Provide background information, for example on the actors, directors, films locations, etc.
- Build personal lists of favorite channels.
- Build personal lists of programs to watch in the days ahead. The EPG will then remind you when the program is about to start or will start the video/DVD recorder.
- Buy video on demand
- Pay-per-view
- Block out specific channels above a certain rating.

It is expected that newer EPGs allow the user to use customized profiles in order to identify likely programs of interest. Furthermore, new services might include home banking and shopping as well as accessing related Internet sites.

So far, most of the EPG standards are proprietary and are designed in different ways. One of the few EPGs that is open is TV-Anytime (ETSI, 2004a, 2004b). TV-Anytime is an EPG standard based on extensible markup language (XML) developed by ETSI. This standard specifies all the details of the EPGs metadata, rights management and access controls. TV-Anytime's objective is to create a standard that is network independent, interoperable and contains the necessary security structures to protect the data (ETSI, 2004a, 2004b). In Finland, Sofia Digital has created the EPG for digital television broadcasts.

### 3.3. DVB-H (Handheld)

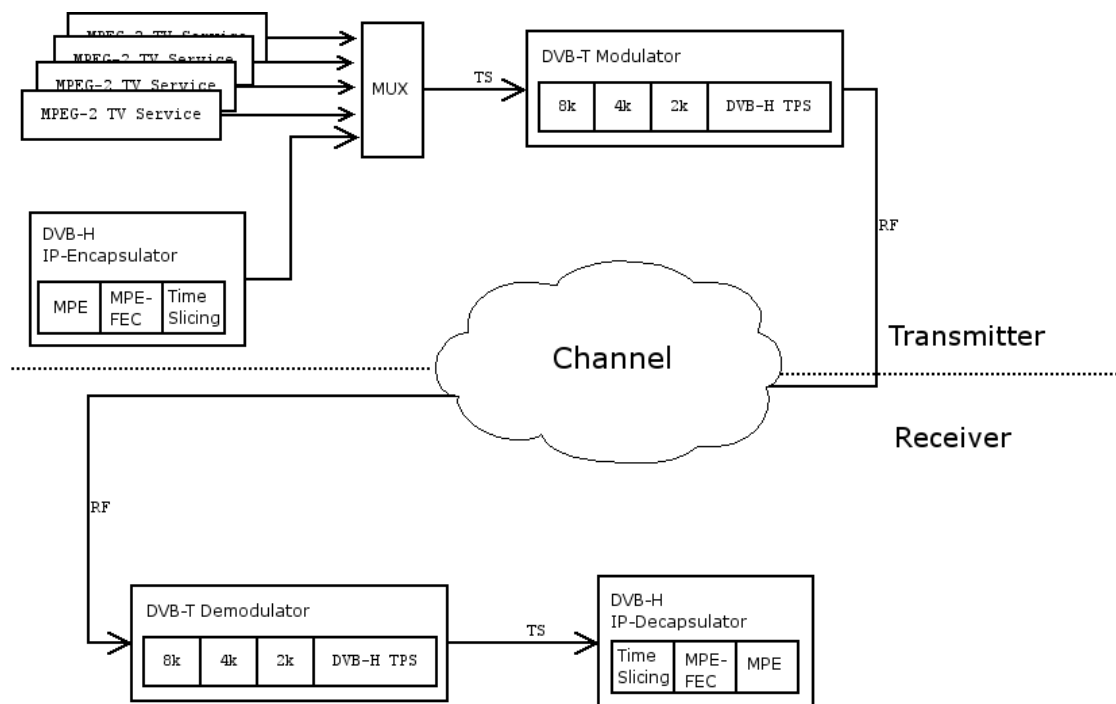
DVB-H is a technology that is based on DVB-T. However, DVB-H enables IP datacasting taking into consideration the necessities of mobile handsets. Power savings are achieved with the time-slicing technology. IP datacasting receives the content in bursts, which are buffered and played back. Between the bursts, the

receiver can be shut down and therefore save power. The handsets can receive digital content and the corresponding electronic service guide to select services. Figure 3 shows IPDC terminals developed by Nokia and Siemens for DVB-H.



**Figure 3: IPDC Terminals for DVB-H**

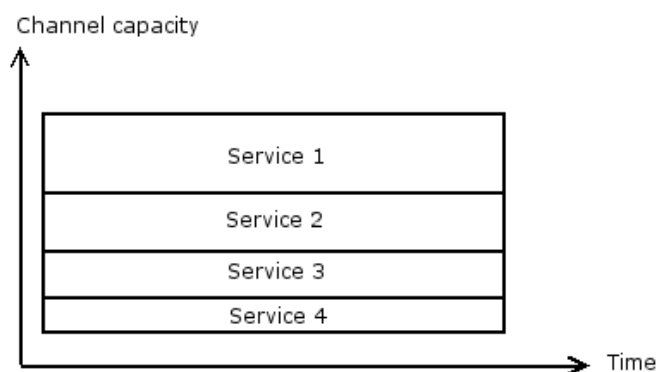
IP datagrams that are broadcasted over DVB-H are encapsulated inside the MPEG Transport Stream (TS) using Multiprotocol Encapsulation (MPE) to improve mobile performance. File delivery is likely to be performed by using File Delivery over Unidirectional Transport (FLUTE). FLUTE is a protocol for unidirectional delivery of files over the Internet (Paila et al., 2004). Figure 4 describes the DVB-H system. Subsequently, the DVB-H features are described in detail.



**Figure 4: DVB-H System**

### 3.3.1. Time-Slicing

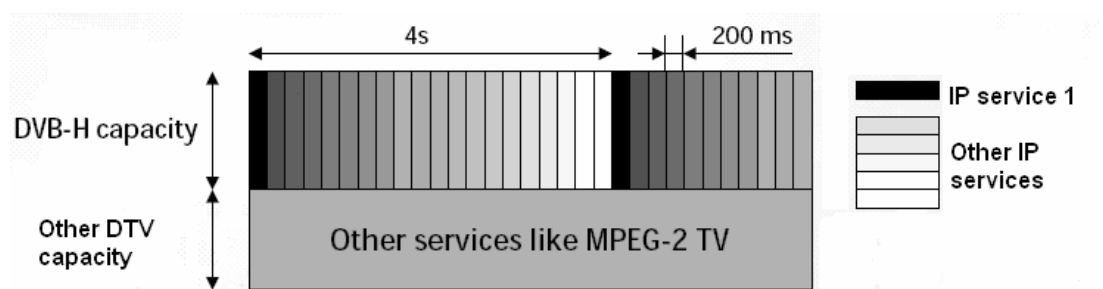
Time-slicing is the technique used in DVB-H to reduce the battery consumption. In DVB-T transmissions all services are multiplexed together and sent in parallel. Therefore, the DVB-T receiver cannot select the packets desired due to the short intervals of the high-multiplexing rate. All the data transmitted has to be received resulting in high power consumption. Figure 5 shows the structure of a DVB-T multiplex.



**Figure 5: DVB-T Multiplex**

In time-slicing, DVB-H services within an MPE data service are organized in the following way:

- (a) One service uses the data capacity for a time period (i.e. 200ms).
- (b) Following that service, different services are lined one after another.
- (c) After a long period, the first service is available again (i.e. 4 seconds). See Figure 6.



**Figure 6: DVB-H Multiplex (Henriksson, 2005)**

The DVB-H service is a pipe in the MPE for the DVB system and can be freely multiplexed with other transport streams.

### 3.3.2. 4k Mode

The 4k modulation mode was first introduced in ISDB-T (Nakahara et al., 1999). This modulation mode is available only in dedicated DVB-H networks because it is not included in DVB-T. DVB-T has only two modulation modes, 2k and 8k. The 2k mode is four times more robust to terminal speed than 8k, but with that mode, the realization of single frequency networks is difficult due to interference. In the 8k mode, multi frequency networks are used instead but the terminal speed that can be achieved is considerably lower. With the 4k mode, advantages from both 2k and 8k modes are obtained. It can use a wide area single frequency network and also reach considerable high terminal speed.

### 3.3.3. MPE-FEC

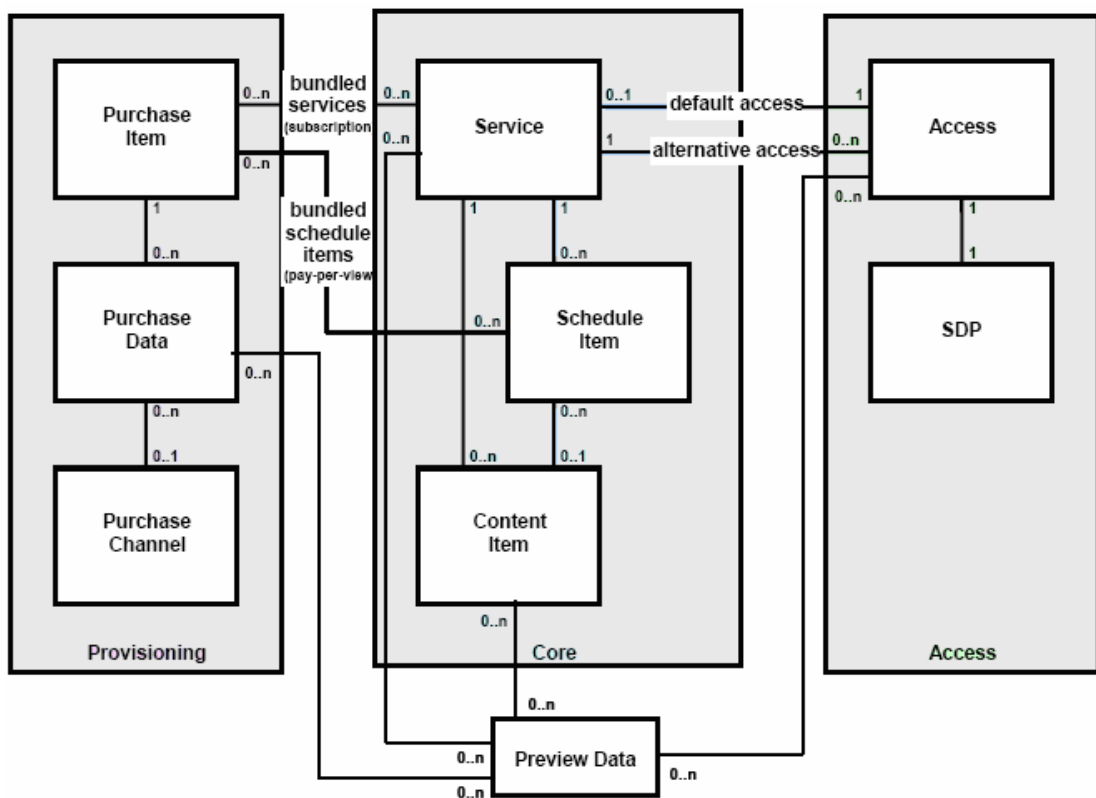
The Multiprotocol Encapsulation (MPE) is used in DVB-H to transmit IP streams. This encapsulation adds a header and a trail to any datagram. In a generic case, the use of MPE will add a 13-15% overhead (Clausen et al., 1999). MPE also provides forward error correction (FEC) features. If the forward error correction option is used the overhead is increased to 25%. However, MPE-FEC improves the carrier to noise ratio, and tolerance to impulse interference and Doppler Effect. These improvements result in better mobile performance despite a bad reception condition.

### 3.3.4. Electronic Service Guide (ESG)

Since IP datacasting enables the transmission of all sorts of services, the current electronic program guides used for DVB-T, or any other terrestrial video broadcast are not suitable for IP services. The EPG focuses only in describing programs, while with IP datacasting the services are of a much wider range. For example it would be very hard to describe a video game with an existing EPG. Therefore, a new guide to describe media in IP datacasting is required. This new guide is referred as the electronic service guide or ESG. The standard for the ESG is being developed jointly by OMA and the DVB consortium and it is expected to be finished during 2005.

The ESG (OMA, 2005) is a structured document that contains information on all available services. The guide is built upon the skeleton of TV-Anytime since most of the expected services that will be carried over DVB-H are likely to be audio and video programs. The ESG and TV-Anytime are based on XML. However, the ESG

introduces new features that are applicable to the specific requirements of IP datacasting over DVB-H. It is not restricted to content with audio and video as the main component. For that reason, different kinds of services can also be proposed to users, for example, file downloading. Additionally, each piece of content can be delivered using a different media format. Unlike MPEG-2 TV programs, new Audio/Video coding formats may use several media, like MPEG-4 (Refer to Section 3.4 for details on audio/video compression). Also, it introduces the idea of multi-component services as kinds of content packages to which users can subscribe and obtain access. The technical service descriptions are described with Session Description Protocol (SDP). Figure 7 describes the ESG structure (OMA, 2005).



**Figure 7: Structure of Service Guide**

The objects of the service guide are described in the following way. A Service is what the user wants to use (or purchase). The Access object provides the information on whether the terminal is able to consume the service or not. It is also linked to the session description object (SDP) which is provided using session description protocol syntax. This description tells the terminal how to consume the service selected. The Schedule Item tells the schedule of the service that it refers to. Analogously, the

Content Item describes the service. The Purchase Item is a set of Services (one or more) and/or Schedule Items (one or more) that can be subscribed to or purchased as a whole. The Purchase Data object serves to express from which Purchase Channel a certain Service bundle can be purchased. A Service bundle is a set of one or more services. This contains all the information about a Service bundle that is specific for the Purchase Channel (including the price information). The Purchase Channel represents a system from which access and content rights can be purchased by the terminal. Finally the Preview Data contains information that is used by the terminal to present the service or content outline to users. By doing so, users can have an idea of what the service is about. The Preview Data could contain text, images (i.e. a logo), short video clips, or references to another service that could be a low bit rate version for the main service (OMA, 2005).

In parallel to the ESG development, a group called MMUSIC which is part of the IETF is developing their own media guide framework called Internet Media Guide (IMG). This guide is supposed to support any kind of media possible and it is still under development (Nomura et al., 2004a, 2004b). Their idea is not only to use it for IP datacasting but also for any other application that needs a guide to describe media. However, the development of this guide has been extremely slow and it is unclear whether the MMUSIC group will continue to develop it further. At the time this thesis was written, most of the documents regarding the IMG were expired or close to being expired. The MMUSIC group is also in charge of standardizing the session description protocol.

### 3.3.5. DVB-H Worldwide

Digital Video Broadcasting has been performed in different ways throughout different countries. Most standards seem to be innovative but some flaws have already been detected in some of them. Nevertheless, acquiring a global standard still sounds unlikely but DVB-H is the one that at least has the most support from different countries and vendors. Europe has already decided to use DVB-H, but in Asia, Korea uses DMB and Japan ISDB. Japan will not adopt DVB-H since the ISDB-T standard is being modified to suit mobile handsets. The next big step for DVB-H would be to be used in China and America. In China there is still no decision on which standard they will use, but digital video broadcasts for mobile phones are expected to be aired

during the 2008 Olympics. Therefore, the standard they will adopt will be decided soon. Finally, for the United States, it is still not clear if DVB-H will become the standard for digital video broadcasting to mobile handsets. In the USA in particular, spectrums are sold in auctions. Crown Castle owns the 5-MHz of L-band spectrum at a national level that was previously used for weather services and intends to use it for DVB-H broadcasts. Qualcomm on the other hand owns the 700-MHz spectrum and has stated that they will release their own standard suitable for mobile terminals called MediaFLO. However, Qualcomm does not own the spectrum at a national level. For this reason, their spectrum is limited to only one area of the United States.

### 3.4. Audio/Video Compression

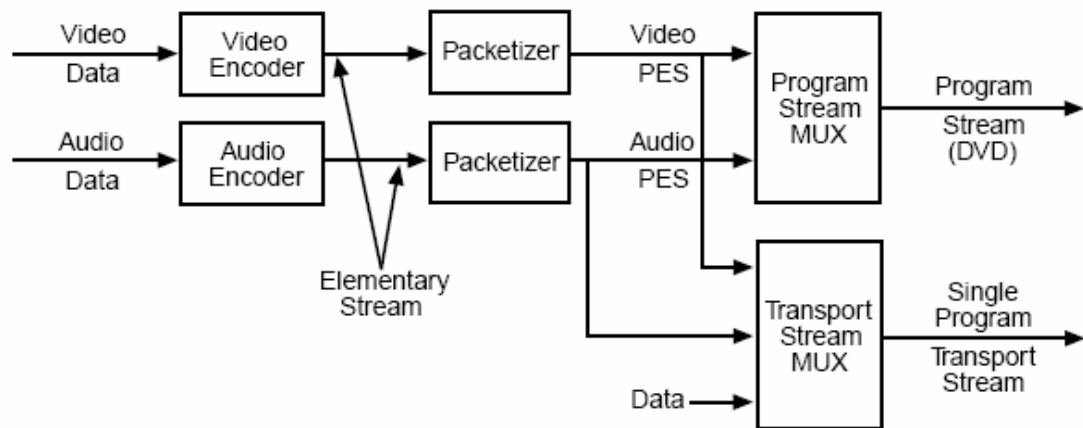
Compression plays an important role in digital video broadcasting because it is a way of expressing digital audio and video by using less data and thus, less bandwidth is required to transfer the data.

In all real program material, there are two types of components of the signal, those that are novel and unpredictable and those that can be anticipated. The novel component is called entropy and is the true information in the signal. The remainder is called redundancy because it is not essential. The redundancy can be spatial, where adjacent pixels have almost the same value, or temporal, where similarities between successive pictures are used. All compression systems work by separating entropy from redundancy in the encoder. Only the entropy is recorded or transmitted and the decoder computes the redundancy from the transmitted signal. Audio compression on the other hand, takes advantage of frequencies that are not simultaneously present and, of the phenomenon of masking. The human hearing cannot discern every detail of an audio signal. This inability is known as auditory masking, defined as the reduced sensitivity to sound in the presence of another. (Tektronix, 2003)

#### 3.4.1. MPEG Fundamentals

MPEG (Tektronix, 2003) is a range of standards for audio/video compression suitable for different applications, and it is the standard used in most broadcasting systems such as DVB, ATSC and ISDB. The power of MPEG is that it is not a single compression format, but a range of coding tools that can be combined to suit different applications. In MPEG-2 and MPEG-4 coding is divided into several profiles that

have different complexity, and each profile can be implemented in a different level depending on the resolution of the input picture. These profiles are necessary because not all the entropy can always be sent. In order to comply with different bandwidth restrictions, the compression factor has to be increased. Moreover, certain applications require different qualities, allow different delay rates, and decoders require different processing capabilities. For example, a news broadcast might not require the same quality in the picture as a movie, since the importance of a news clip is the news itself, and not so much the image of the journalist. Likewise, the same video clip might require even less video quality if it is intended for a mobile terminal which has a significantly smaller screen and less processing power. Figure 8 shows how the program and transport streams are generated in MPEG audio/video coders.



**Figure 8: MPEG Streams**

The output of a single MPEG audio or video coder is called an elementary stream. This stream can be divided into data blocks of manageable size forming a packetized elementary stream (PES). These blocks are identified by the addition of header information. As shown in the figure above, one video PES and several audio PES can be combined to form a program stream. For transmission and digital broadcasting, several programs and their PES can be multiplexed into a single transport stream. Within the transport stream, metadata that describes the bit stream is included. This data is organized in tables and provides information about the streams. (ETSI, 2004f)

### 3.4.2. MPEG Compression Techniques

The Moving Pictures Experts Group has developed several standards for compression. MPEG-1 was designed to compress image streams and associated video to approximately 1.5 Mbits/s total compress data rate. This is close to the resolution of a consumer video recorder. The MPEG-1 standard defines a tool set, the syntax of the bit stream, and the operation of the decoder. It does not define the operation of the encoder, its quality nor the quality of the picture. This allows the evolution of the encoding technology without changes in the standard.

To accommodate the needs for broadcast quality video with the MPEG-2 standard was developed. It is far more flexible than MPEG-1 and it is the basis for DVB, ATSC, ISDB as well as DVD. MPEG-2 images can have four times the resolution of MPEG-1. MPEG-2 uses a two-dimensional structure of profiles and levels for classifying bit streams and decoders. Profiles define the tools that may be used, levels relate just to scale. With the use of different profiles and levels, video compression can be adjusted to different applications.

The MPEG-4 is an open standard that allows easy deployment of multimedia content for different platforms. It enables the distribution of content and services from low-bandwidths to high-definition quality (expected to go up to 1.2 Gbits/s in the future). MPEG-4 is very suitable for use in error-prone environments, such as transmission to personal handheld devices (M4IF, 2002, Tektronix, 2003). MPEG-4 is also a much more ambitious standard. It addresses speech recognition and video synthesis, fractal geometry, computer visualization and an artificial intelligence approach to reconstructing images.

The most significant feature of MPEG-4 (M4IF, 2002) regarding other compression systems is the concept of objects. Different parts of the final scene can be coded and transmitted separately as video objects and audio objects to be brought together, or composited, by the decoder. With MPEG-4, multiple objects can be encoded using different techniques. These objects can be of different kinds (text, pictures, animation, 2D and 3D objects, etc.) and, instructions in the bit stream and/or user choice may enable different presentations from the same bit stream. These features emphasize the opportunities for user interaction. Nevertheless, these capabilities do not have to be used. MPEG-4 provides traditional coding of audio and video that compared to MPEG-2, provides improved efficiency and resilience to

errors. Moreover, newer digital video cameras, PDAs and mobile terminals support MPEG-4 and, it is expected that TV sets and DVD Players comply with the standard in a near future.

The MPEG-4 standard has been widely adopted and several vendors have implemented the standard. Some of these companies are Apple, RealNetworks, DivX and Xvid. One of the most important implementation is MPEG-4 Part 10 AVC/H.264. H.264 improves coding efficiency over other existing standards such as MPEG-2 and other MPEG-4 based compression mechanisms. This standard has been chosen as the compression mechanism for the Korean DMB and it has been included as an option for DVB-T. H.264 improves the coding efficiency over MPEG-2 by a factor of 2. Despite the improvements of H.264, decoders can still be developed at low power consumption rates (Lee, 2004). DVB-H also encourages the use of H.264 as the compression mechanism for handheld devices.

For compression of audio, the MPEG compression techniques are MPEG Layer 3 (MP3), MPEG-2 audio, and MPEG-4 Audio. The details of these audio compression techniques are not relevant for this study. What should be noted though is that both the video and audio streams are used by the Multiplexers to create the program and transport streams.

## 3.5. Communication Channels

Different communications can be used to provide interactivity in IPDC applications. These communication channels are sometimes referred as “return channels” or the “interaction channel”. Nevertheless, they will be referred only as communication channels throughout this Thesis.

### 3.5.1. 2G (GSM)

Global System for Mobile communications (GSM) is a second generation of mobile technologies (2G). GSM was designed to support basic voice, data services and international roaming. GSM is based on Time Division Multiple Access (TDMA) providing low data rates (28kbps). One of the most important factors in GSM’s success is the standard open interfaces that allow vendors to supply any elements of the

network, and let operators deploy multi-vendor systems. Among the main features that GSM provides are:

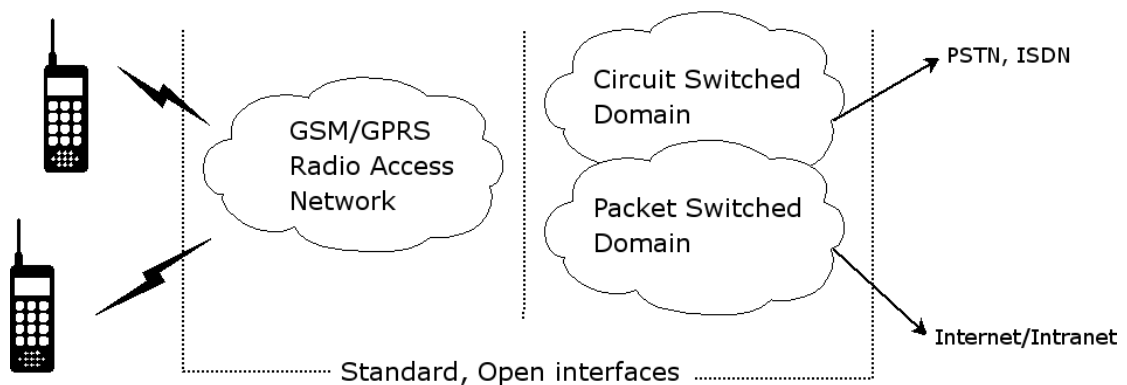
- Short Message Service (SMS) which allows sending and receiving 126 character long text messages.
- Use of the same terminal in countries that use similar networks.
- Data and Fax transmission.
- Data encryption.
- Call forwarding, teleconference and hold.
- Calling line information presentation/restriction, to allow or deny users to see incoming call numbers.

### 3.5.2. 2.5G (GPRS/EDGE)

GSM Phase 2+ (Nokia, 2002) now referred as 2.5G, is an upgrade to the 2G GSM networks. It allows better services than 2G using similar infrastructure. The improvements made to 2G are GPRS and Enhanced Data GSM Environment (EDGE). Most of the services for GPRS and EDGE are based on CDMA (Code Division Multiple Access), which is a digital wireless technology that enables fast power control and soft handover. Fast power control is required so that users do not generate extra interference and do not block the reception of the signals from other users. By doing so, users can share the same radio frequencies at the same time without interfering with each other. Without power control, a mobile terminal transmitting near the base station would block the reception of the other consumers further away. Additionally, telephone and data calls are assigned a unique code that distinguishes them from each other. The original version of the CDMA technology is known as cdmaOne.

The GPRS data transmission technology is optimized for bursty data communication services such as wireless Internet and multimedia. One of the main benefits of GPRS is that users are always connected (“always on” feature) and may be charged only for the amount of data that is transported. GPRS introduces 3 classes (A, B and C) for mobile terminals. In Class A, voice calls can be made simultaneously while a data connection is operating. However, most terminals belong to Class B, which only allows one active connection at a time. With GPRS the network is enhanced to access the packet switched domain, adding new IP-connected network

elements. GPRS connects users directly to internet service providers. With GPRS, data transmission speeds can reach up to 150-170kbps. GPRS solutions differ depending on the vendor and mobile terminal type. Figure 9 shows the 2.5G added support for packet data, enabling an early taste of “3G-like” services. (UMTS Forum, n.a.)



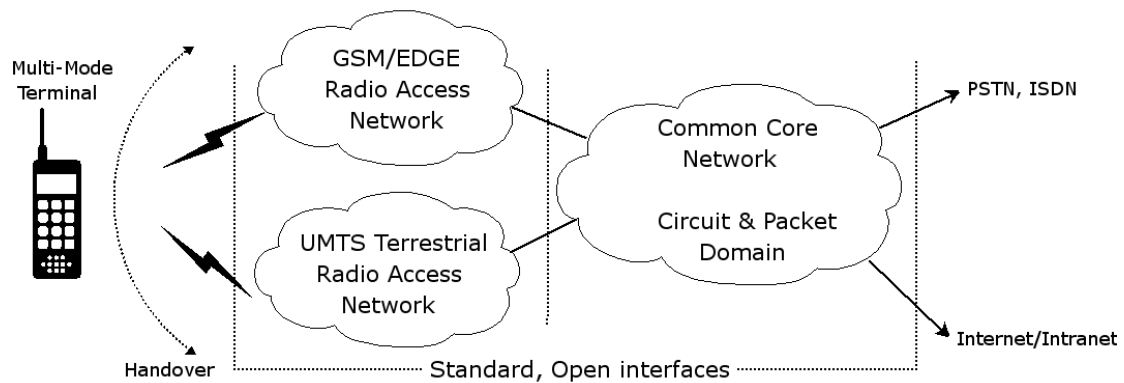
**Figure 9: 2.5G Added Support for Packet Data**

In EDGE, GPRS is improved by adopting a new modulation technology to achieve higher data rates using the same radio spectrum. With EDGE data rates can reach 384kbps and thus, provide the capability to offer almost all 3G services. EDGE data rates are significantly limited compared to 3G.

### 3.5.3. 3G (W-CDMA/CDMA2000)

3G (Nokia, 2002) is defined as the third generation for a set of mobile technologies which use a host of high-tech infrastructure networks, handsets, base stations, switches and other equipment to offer mobile terminals high-speed Internet access, data, video and CD quality music services. The main requirements for 3G technologies are: high bit rates, variable bit rate to offer bandwidth on demand, multiplexing of services with different quality requirements on a single connection (speech, video, data) and, coexistence of 2G and 3G systems and inter-system handovers (Nokia, 2001). The speeds that can be reached with 3G are up to 2 Megabits per second. However, with the use of High Speed Downlink and Uplink Packet Access (HSDPA) data rates of 14 Mbps can be reached theoretically. 3G will not necessarily replace 2.5G, but instead co-exist with it and share the common network. To do so, multi-mode terminals that can access GSM/EDGE radio access

network for 2.5G and UMTS terrestrial radio access network for 3G would be used. Figure 10 shows how dual radio access allows 3G operators to provide services via GSM/EDGE and W-CDMA networks via dual-mode terminals. (UMTS Forum, n.a., Holma, 2004)



**Figure 10: Dual Radio Access**

Most of the 3G services are based on CDMA, but they use a high-speed variant of it. All the 3G technologies and CDMA variants fall under the Telecommunication Standardization of the International Telecommunications Union (ITU-T) generic name of International Mobile Communications 2000 (IMT-2000). The reason there are different technologies under the same name is that ITU-T could not reach a consensus in order to unify and standardize the 3G technologies. Thus, there are five terrestrial standards developed as part of the IMT-2000 since no radio interface could be optimized for all applications. IMT-2000 supports time-division duplex (TDD) and frequency-division duplex (FDD) to enable asymmetric and symmetric data services in a spectrally efficient way. The transport in the radio access network is based on asynchronous transfer mode and IP. (Mohr & Konhäuser, 2000)

Depending on which part of the world the 3G technology is implemented, the 3G standard will be based on CDMA variants; most likely W-CDMA or Multi-carrier CDMA (CDMA2000). The five IMT-2000 variants are the following (UMTS Forum, n.a.):

- IM-DS Direct Sequence (referred as UTRA-FDD, W-CDMA, UMTS-FDD)
- IMT-MC Multi-Carrier (referred as CDMA2000)
- IMT-TC Time Code (referred as UTRA-TDD) and China's TD-SCDMA

- IMT-SC Single Carrier (referred as UWC-136/EDGE)
- IMT-FT Frequency Time (referred as DECT)

The primary variants are W-CDMA and CDMA2000. Even though both technologies are based on CDMA they are different and are competing technologies.

For W-CDMA technology several terms and acronyms are used depending on the implementation. Universal Mobile Telecommunications System (UMTS) is the term for Europe's implementation of W-CDMA. Sometimes it is also referred as UMTS/W-CDMA or 3G/UMTS. The implementation in the United States is only referred as W-CDMA. The main difference between the implementations in Europe and in the United States is the frequency spectrum used. In Japan, W-CDMA is available as well as variant that is strongly based on W-CDMA. Before W-CDMA was standardized, NTT DoCoMo developed a variant based on W-CDMA's close to final drafts. Therefore, this technology was available earlier but still differs in some aspects to W-CDMA. The technology is called Freedom of Mobile Multimedia Access (FOMA) and it is compatible at a great extent with W-CDMA. (Holma, 2004)

W-CDMA (Holma, 2004) is based on CDMA but uses a wider spectrum, for that reason it can transmit and receive information faster and more efficiently. All users share the same carrier and also share the carrier's power. The transmission bandwidth is the same for all data rates. It is backed by most European mobile operators and the Japanese NTT DoCoMo. W-CDMA offers mobile operators significant capacity and broadband services capabilities to support greater numbers of voice and data customers. W-CDMA uses a 5MHz channel carrier in contiguous blocks of spectrum (typically 2 x 10MHz up to 2 x 20MHz). This reduces the cost of deploying 3G networks and provides optimum use of radio resources. W-CDMA can also provide uplink and downlink data rates independently of each other and thus, facilitate uplink and downlink asymmetry on a per connection basis.

CDMA2000 is the other most widely used variant. There are various types of CDMA2000. The type that is included in IMT-2000 is CDMA2000 3X. It uses the 5MHz spectrum (3 x 1.25 MHz channels) to give speeds of around 2-4 Mbps. Migrating from the existing cdmaOne infrastructure requires relatively modest hardware and software upgrades. Furthermore, operators can upgrade only some parts of the network where they require the services and enhancements. CDMA2000 can be deployed in existing spectrums along with the existing cdmaOne systems, overlaying

its new feature set and increased capacity. Most importantly, it uses existing (and already paid for) 1.25 MHz spectrum. The flexibility in the migration to CDMA2000 allows operators to upgrade until it is required by their individual markets without significantly upgrading infrastructure or purchasing new spectrum. CDMA2000 is considered by some as better cost efficient since it uses the same spectrum, opposed to W-CDMA, which uses a completely new spectrum. (UMTS Forum, n.a.)

## 3.6. Digital Rights Management (DRM)

DRM technologies are used to provide and store content in such a manner that use and copying is authorized and controlled. By doing so, content providers can enable secure distribution and protect intellectual property copyrights. This is typically done by either encrypting the data or marking the content with a digital watermark or similar method so that the content cannot be freely distributed (Arjona, 2004, Pitkänen, 2002).

### 3.6.1. OMA DRM v2.0

OMA DRM v2.0 (OMA, 2004a, 2004b) is an open standard developed by the Open Mobile Alliance. The scope of OMA DRM is to enable the controlled consumption of digital media objects by allowing content providers the ability, for example, to manage previews of DRM content, to enable super-distribution of DRM content, and to enable transfer of content between DRM agents. A DRM agent is a software solution that enables the DRM scheme.

OMA DRM makes a logical separation between DRM content from rights objects. These can be requested separately or together, and they may be delivered separately or at the same time. Rights objects associated with DRM content have to be enforced at the time of consumption. A rights object is cryptographically bound to a DRM Agent, so only the DRM agent can access it. DRM content can only be accessed with a valid Rights Object, and so can be freely distributed. The DRM agents are securely authenticated by using standard public key infrastructure procedures. The DRM Content Format is a secure content package for encrypted content, with its own Multi-Purpose Internet Mail Extensions (MIME) content type. Besides the content, it can hold additional information such as vendor, version, url,

etc. The architecture of OMA provides the capability for users to transfer the files to any device but only be played on the device that has the rights object key. Depending on the provider, the content may be played on only one device at a time or in many. (OMA 2004a, 2004b, Arjona, 2004)

### 3.6.2. Windows Media DRM 10

The Microsoft Windows Media DRM 10 for Portable Devices (Windows Media DRM) is a flexible lightweight technology that allows portable devices, to store and play protected content. This technology is also available for non-Windows devices. Microsoft requires the manufacturer to sign a licensing agreement (MS, 2003). This license specifies design requirements that help secure the protected content and Windows Media technology during the device manufacturing and customer use.

This DRM scheme is very flexible and allows implementation of features that suite the content provider's best interests as well as business models. The main properties that Windows Media DRM can establish are the number of times content can be played, validity time of the content, content protection with encryption mechanisms and copy permissions. (Cohen, 2004, Arjona, 2004)

### 3.6.3. DVB Conditional Access

DVB Conditional Access is a scrambling algorithm proposed by ETSI in order to protect content rights. It allows restriction of certain programming products to certain viewers. The technical details of the scrambling algorithm can only be available to bona-fide users upon a signature of a non-disclosure agreement to ETSI administered by a custodian. The clause contains a summary of the scrambling method and some of the implementation issues. Among the capabilities offered are pay-per-view, video-on-demand, games, and ability to restrict access to certain material and to direct messages to specific terminals (ETSI, 1996, Massel, 2001).

The scrambling algorithm can operate on two different levels, TS or PES level. For TS-level scrambling, the algorithm operates on the payload of a transport stream packet. Likewise, for PES-level scrambling, a structuring of PES packets is used for the implementation within the same scrambling algorithm (ETSI, 1996).

### 3.6.4. Other Technologies

In addition to the previously mentioned DRM schemes, some other technologies exist such as Helix DRM and MPEG-21. MPEG-21 opposed to the most of the standards in the MPEG family is not a compression mechanism but content protection scheme. It seeks to create a complete structure for the management and use of digital assets, including all the infrastructure support for the commercial transactions and rights management that must accompany this structure. Several parts of the MPEG-21 framework are in various draft stages. Likewise, Helix DRM is a DRM scheme developed by RealNetworks. Even though it is a proprietary scheme, it includes OMA DRM v2.0 specifications in it to provide interoperability (RealNetworks, 2004).

## 3.7. Content Purchasing and Payment Systems

When a user buys a service, most likely what it pays for is the rights object. A rights object is a data package that contains the information needed to decrypt a specific service. The payment system must be able to authenticate and bill the user (Staffans, 2004). Depending on the business model, these rights can be provided through different communication channels. The complexity of these payment systems depends on the DRM scheme used and the restrictions enforced by the service operator.

Purchasing rights objects is not always the case. Purchases can involve buying the content itself, participating in a poll or a chat, or downloading files. For this type of purchases it is likely to use the Multimedia Messaging Service (MMS) to provide the content to the user. This service allows encapsulation of a wide variety of media files, including text, photographs, video, screen savers, audio files, animations, ringtones, etc. The encapsulated files are attached to the message and can be downloaded. Later developments of MMS will provide streaming capabilities. The size of an MMS message is unlimited and therefore it is suitable for providing purchased content. The following sections explain some of the payment methods currently available.

### 3.7.1. Premium SMS

SMS is a service that allows users to send messages to up to 160 or 224 characters depending on the operator. The service is similar to paging but it does not require that

the receiver to be active or within the coverage area. The SMS service is similar to a phone call, with fixed costs per messages sent or received. For that reason it is not suitable for purchasing purposes. However, Premium SMS is a service similar to SMS but it works similarly of a “900 number”. Sending an SMS to a “premium” number generates a billing event which is charged to the user’s phone bill. The service acts as a micro-payment system and the billing is conducted by the mobile operator. It can be used to purchase low cost services, for example ringtones or downloads. Furthermore, customers are already familiar with it and it is easy to use.

### 3.7.2. Mobile Cash (Mobiiliraha)

Mobile cash is a service that is available in Finland. It is basically money that is “carried” on the mobile phone. It can be used to pay for different kinds of services. Mobile cash is a payment method that can be used regardless of the time and place. The purchases are viewed in Sampo’s or Nordea’s online bank. In order to start using mobile cash the things needed are access to Sampo’s or Nordea’s online bank and a functioning mobile phone subscription (Nordea, n.d.). After opening the service, Mobile Cash can be used immediately. Cash is transferred from the bank account to the mobile purse whenever wished or at the same time the mobile purse is created. The maximum balance for the mobile purse is 400 euros, and the minimum amount for transferring into the purse is 5 euros per transaction. One bank account can be used for five different mobile purses, linked to different mobile phone numbers. The locations where mobile cash can be used are increasing and they can be identified by the mobile cash logo (Sampo, n.d.).

### 3.7.3. Simpay

Simpay is a payment method that enables mobile phone subscribers to purchase goods with the mobile phone (Simpay, n.d.). The purchases made will be invoiced to the mobile phone bill. Initially, it is designed to buy media such as music, ringtones and games. But in the future Simpay is expected to work along with credit and debit cards enabling the possibility to buy higher priced items such as flights and cinema tickets. Simpay is open to all customers of participating mobile phone operators regardless of the handset used. It also enables users to make transactions across national borders.

## 3.8. DVB-H Pilots

IP datacasting and DVB-H have been tested during the last years in several pilots that are or have been released in countries such as Finland, UK, Germany and the USA. New pilots are expected to be released during the year 2005 in Finland and UK among others.

### 3.8.1. Previous Pilots

**Teracom, Stockholm, Sweden (2000):** The project was not a DVB-H pilot. However, it was meant to explore business opportunities and critical technical aspects of providing multimedia content over radio and television broadcasting networks with IP datacasting. The idea was to use digital terrestrial networks for radio and television to transport data. The business perspective of the project was based on how the customers could benefit from these possibilities, reactions to the system, feasibility of providing fast access Internet and what kind of services were the most suitable. The project ended in May 2002. The project was divided in two, 50 test participants for the broadband Internet access to test the services, and the rest for the Teracom R&D. Mobility, file downloading and live streaming were tested in Teracom's labs. The results of the evaluation were promising both for the technical and business points of view. The parameters used for the network were 2k mode, 16QAM and CR=1/2 (Teracom, 2003).

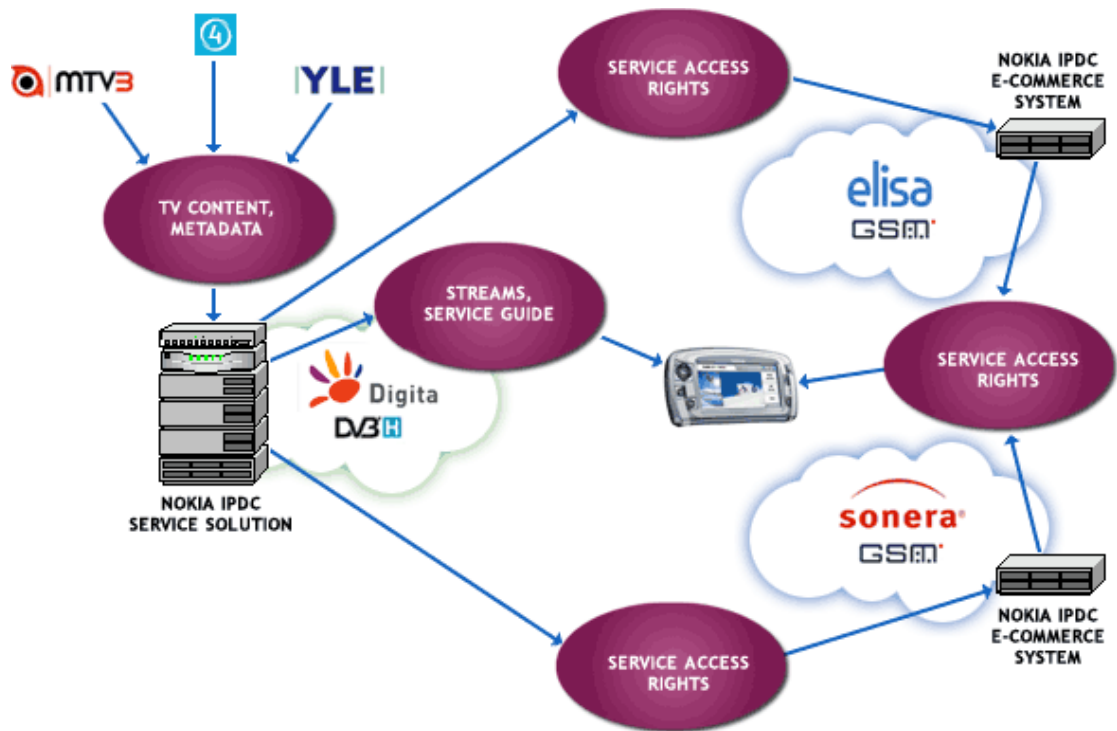
**RTT, Helsinki, Finland (2002):** The project was an IP datacast test network conducted by media houses, teleoperators and network technology companies in Finland. The purpose of the pilot was to understand the possibilities IPDC can provide and look at which services were the most promising. The pilot included different kinds of terminals, beginning with PCs and additional equipment connected to them. Actual IPDC terminals were not available at the time when the pilot was launched. In 2002, Nokia released an IPDC prototype terminal (Nokia 7700) which included a streamer capable of receiving IPDC streams. In the end of 2004 users were able to test mobile TV. The tests showed that people like watching TV in different places and that many of them are interested in purchasing a terminal with those capabilities. The test network covered a big part of Helsinki and lasted for 3 years. The test network included one transmitter and four gap-fillers. The parameters used were 8k mode, 16QAM, CR=1/3 (RTT, 2004, Nokia, 2002a, Nokia, 2005).

**Broadcast Mobile Convergence (BMCO), Berlin, Germany (2004):** The pilot was aimed at testing the convergence of DVB-T and mobile communication technologies. The pilot started in March, 2004 and finished on October, 2004. The companies involved were Nokia, Vodafone, Philips and Universal Studios Networks Deutschland. With the pilot, user requirements, economic, technical and regulatory requirements were examined. Berlin was the first city in Europe to change its television transmissions completely from analog to digital (Sather, 2004, BMCO, 2004).

### 3.8.2. Future Pilots

**Crown Castle/Nokia, Pittsburgh, USA (2004):** Crown Castle and Nokia are testing a three site Single Frequency Network using DVB-H technology. The test aims to prove and test the feasibility of DVB-H and related services in the USA. The test network aims at demonstrating that DVB-H can be used regardless of the Digital TV standard used. The ATSC standard does not interfere with the deployment of a dedicated DVB-H network because ATSC does not provide mobility. The test network also will be expanded to examine consumer experiences and acceptance of mobile phone TV service (Crown Castle Int'l, 2004, 3G, 2004).

**Helsinki, Finland (2005):** This pilot was launched on the beginning of March 2005, and it is aimed to test mobile TV services and examine consumer experiences as well as the underlying technology. The pilot consists of 500 participants selected from the two telephone operators in Finland (Telia Sonera and Elisa) in the Helsinki region. The testers are able to view real-time TV and radio programs on a Nokia 7710 smartphone equipped with a special accessory to receive broadcasts. The pilot is scheduled to last about 6 months. Some of the companies involved in the pilot are Finnish TV channels, Elisa, TeliaSonera, Nokia, and Digita (Nokia, 2005). Users can subscribe to a basic channel package (3 television channels and 3 radio channels) and opt for supplementary services. Figure 11 shows the network topology used in the Finnish mobile TV pilot (Finnish Mobile TV, 2005).



**Figure 11: Finnish Mobile TV Network Topology**

**NTL/O2/Nokia/Sony, Oxford, UK (2005):** NTL announced that it is to collaborate with UK cellular operator O2 for a large scale commercial trial composed of 500 participants in Oxford, UK. The trial will cover 120km using 10 transmitters. The aim of the trial is to test the business case for mobile TV in the UK (Harris Co., 2005).

**Bridgenetworks, Australia (2005):** According to Harris Corporation (2004, 2005), a DVB-H trial network will be deployed in Australia during 2005.

**Crown Castle International, Pittsburgh, USA (2005):** During the summer of 2005, Crown Castle plans to extend its three-site single frequency network to a nine-site single frequency network, reaching about 600,000 homes. However, the number of consumers scheduled for the trial is in the low hundreds.

**Nokia/Canal Plus/SFR/Tower Cast, France (2005):** According to Phillips (2005), a DVB-H pilot will be tested in France during the second quarter of 2005. The pilot would consist of about 500 people. The different partners will test how consumers respond to television services broadcast to a mobile terminal. These terminals may include mobile phones, tablet PCs and likely, in-car devices (Digitag, 2005).

**Nokia, Taiwan (2005):** According to Huang (2005) from DVB Scene magazine. The first trial of DVB-H in Asia will kickoff in summer 2005 in Taiwan.

### 3.9. Regulatory and Spectrum Allocation Issues

The future of DVB-H and IP datacasting relies in part to the administration of frequency spectrums. Broadcast frequency spectrum is administered by national telecommunication agencies in alignment with international agreements at the ITU. ITU is presently part way through the process of developing a new frequency plan for Europe, Africa and the Middle East for the all-digital future (Digitag, 2005). All-digital refers to the complete transition from analogue to digital systems.

According to the Digital Terrestrial Action Group (Digitag), the way to determine the use of spectrum allocated to each country is based on the characteristics of DVB-T as a reference and applies three reception scenarios: fixed roof-top antennas, outdoor portable reception and indoor portable reception. National administrations have submitted their service requirements for the initial planning studies carried out in 2005. The planning process should be completed by summer 2006. However, DVB-H has not been taken into consideration for this planning process because it was not standardized at the time of the submissions. DVB-H is based on DVB-T and it should be possible to introduce DVB-H services into the frequency bands where DVB-T allocations are given. Unfortunately, the topology of DVB-H network and the signal strengths required for handheld terminals are different from DVB-T. Any spectrum assigned to a DVB-H network will reduce the spectrum available for DVB-T networks and national regulators will need to decide which operators are given access to the spectrum. Currently, the most pragmatic approach would be a situation where the requirements for a DVB-H network are anticipated and submitted as service requirements for indoor portable reception of DVB-T to match signal conditions of DVB-H services.

Handheld terminals have much smaller antennas than those used for fixed or portable television. Additionally, handhelds must be able to receive the signal in different conditions, location and speeds. All these factors need to be compensated by making existing networks more dense and selecting more robust modulation parameters. For that reason, the coexistence of DVB-T and DVB-H in the same signal

channel is unlikely to be ideal, even though possible (Digitag, 2005). DVB-H provides the capability to transmit up to 50 services simultaneously. Nevertheless, this is only possible if an entire channel for DVB-H services is provided. By making more services available it is likely that consumers will be more attracted than if only a few program services are available.

The preference stated by the DVB-H designers has been to use Band IV in UHF, which is a spectrum between 470MHz and 650MHz. This spectrum band is low enough to offer long distance propagation characteristics and high enough to avoid man made noise interference. Additionally, this frequency range minimizes potential interference at the receiver between the DVB-H reception and the 2.5G/3G transmissions. This is particularly important for products that include mobile phone capabilities. In the United States, trials in the L Band (1.5GHz) are underway. This contrasts with Europe where the L Band cannot be used for DVB-H since it is already assigned for DAB.

The other alternate option is to use the VHF television broadcast frequency in Band III. This would require an international planning coordination to make use of DVB-H in this band prior to the transition from analogue television to digital. Furthermore, terminals would require telescopic antennas. Therefore, this is unlikely to happen.

## 4. Methodology

### 4.1. Purpose of the Study

The main objective of this Thesis is to investigate how full transparent interactivity can be obtained in IP datacasting using different communication channels such as GPRS or W-CDMA. Therefore, the fundamental problem is described as:

*Can transparent interactivity be achieved through different communication channels in IPDC applications?*

The approach to attack the fundamental problem was to order the main unsolved issues regarding IPDC applications in a structured way. Then, it was followed by a study and a solution to address each of these issues. This research gave the base to address the problem mentioned above and propose a solution. The problems were structured and addressed in the following chronological order.

#### **Requirements Analysis**

- Q1. What kind of services will be offered through IPDC?
- Q2. What kind of services will be offered through other communication channels?
- Q3. What are the high-level goals of a mobile TV application that provides interactive services?

### **Software Design**

- Q4. How can the services provide interactivity to the user?
- Q5. What are the requirements for providing interactivity and user sensitive customization in mobile TV applications?

### **Software Implementation**

- Q6. What technology is required to develop such application?
- Q7. Is it feasible to develop such application with the current technologies?

### **Evaluation**

- Q8. What will the interactive services look like?
- Q9. What are the major challenges the interactive services face?

## **4.2. Instrumentation and Validity**

This Thesis utilizes and takes previous project results as base instrumentation for the study. The INDICA project has involved a joint work from different companies and organizations. As part of the project, field studies and service ideas have been developed. The project has also investigated IPDC technology and its layers. Furthermore, Elisa R&D, which is conducting the INDICA project, has been part of the Finnish mobile TV pilot itself. Expert opinions, literature research, and pretest open-ended questions were used to verify the content validity of this study.

## **4.3. Analysis Plan**

The research was divided in four different phases which were carried out in the following order: a) requirements analysis b) software design c) software implementation and d) evaluation.

The *requirements analysis* phase consists on retrieving the preliminary service ideas that resulted from the first phase of the INDICA project. This will be followed by interviews and discussions with experts in the field. The experts range from people involved in the DVB-H pilots, standardization organizations such as OMA and the IETF, content providers, and researchers of the same field. This collection of ideas will provide the base to define and understand the services that can be offered with

IPDC and also by communication channels such as GPRS and W-CDMA. Within this phase, the high-level goals of a mobile TV application that provides interactive services will be defined. Therefore, the following questions are investigated in this phase:

- *Q1. What kind of services will be offered through IPDC?*
- *Q2. What kind of services will be offered through other communication channels?*
- *Q3. What are the high-level goals of a mobile TV application that provides interactive services?*

The *software design* phase will take place posterior to the requirements analysis. In the software design phase, a full set of software specifications will be deployed to provide the architecture and functional requirements. The software design will fulfill the requirements and high-level goals that resulted from the requirements analysis phase. The following questions are investigated in this phase:

- *Q4. How can the services provide interactivity to the user?*
- *Q5. What are the requirements for providing interactivity and user sensitive customization in mobile TV applications?*

The *software implementation* phase will be initiated after the software design is completed. This phase will test the feasibility of implementing an application as specified in the software design phase. The feasibility test will be carried out by developing a prototype application with limited functionality regarding the interfaces to the different communication channels. The following questions are investigated in this phase:

- *Q6. What technology is required to develop such application?*
- *Q7. Is it feasible to develop such application with the current technologies?*

Finally, the *evaluation* phase will be initiated after the previous phases have concluded. This phase will provide service concepts which are the result of all the previous phases of the study. Finally, it will conclude by addressing the future problems this technology can face. The following questions are investigated in this phase:

- *Q8. How will the interactive services look like?*
- *Q9. What are the major challenges the interactive services face?*

#### 4.4. Assumptions

This study assumes that eventually, mobile TV will be available commercially in Europe using DVB-H technology. DVB-H technology has not yet proven to be completely feasible and the standard has spectrum implications. Likewise, it is assumed that the mobile TV concept will be appealing to consumers and will result in a need to develop improved services and applications. These assumptions are taken because the DVB-H pilots and trials have not finished or published any clear results. Moreover, we assume that the electronic service guide standard being developed by the Open Mobile Alliance will be used in mobile TV applications. It is also assumed that the standard will be robust enough to describe services in detail and allow complex filtering mechanisms.

#### 4.5. Scopes and Limitations

During most of the timeline of this project, an IPDC terminal was not available for use. For that reason, the software development and testing took place within an emulator. Moreover, access to the air broadcasting system was not possible. Furthermore, the IPDC programming libraries needed to develop the software are not publicly available. Additionally, the standardization of many of the areas is not yet concluded and it directly affects this study, particularly regarding the electronic service guide. Also, mobile only content was not available and for that reason many of the scenarios are fictitious.

Lastly, a shortcoming of the study is the lack of empirical material regarding mobile broadcast services. Since the mobile broadcast services were still in initial

trial/pilot stage at the time of this study, no real commercial mobile broadcast business systems existed.

# 5. Implementation

This Chapter presents the results that correspond to the first three phases of the analysis plan: requirements analysis, software design and software implementation. The evaluation phase is presented in Chapter 6.

## 5.1. High-Level Requirements

This study was initiated by gathering the high-level requirements for a software application that provides interactivity with mobile TV. These requirements were the result of previous project results, conducting meetings with experts, personal interviews, extensive literature research and attending seminars. Then, the requirements were summarized and the most important ones selected. Only the most important high-level requirements regarding interactivity are mentioned in this Thesis. The requirements are the following:

- The application shall provide file download capabilities.
- The banners shall provide user sensitive advertisements.
- The banners shall be able to provide one-click purchase functionality.
- The application should recommend keyword and content related searches.
- The application should provide chat.
- The electronic service guide should be filtered according to the user preferences.

## 5.2. Software Design

The software application designed, referred as “Mobile Media Viewer” from now on, provides the means to purchase a variety of services within the same application. Its main characteristic is that the Mobile Media Viewer can use different communication channels to perform the purchases and thus, provide a transparent interactivity experience to the user.

The services can be of different kinds, and are listed in the electronic service guide. The ESG is broadcasted through digital television networks, but it can also be retrieved through a different communication channel such as GPRS. When the user opens the ESG, the list of services are filtered and shown to the user according to his personal preferences. Many of the services listed in the ESG are broadcasted, but the user needs the encryption keys to decrypt them and make use of them. The encryption keys which are referred as “content rights” are purchased from the service operator through a different communication channel. Additional interactivity and content that is not broadcasted is also provided in this way.

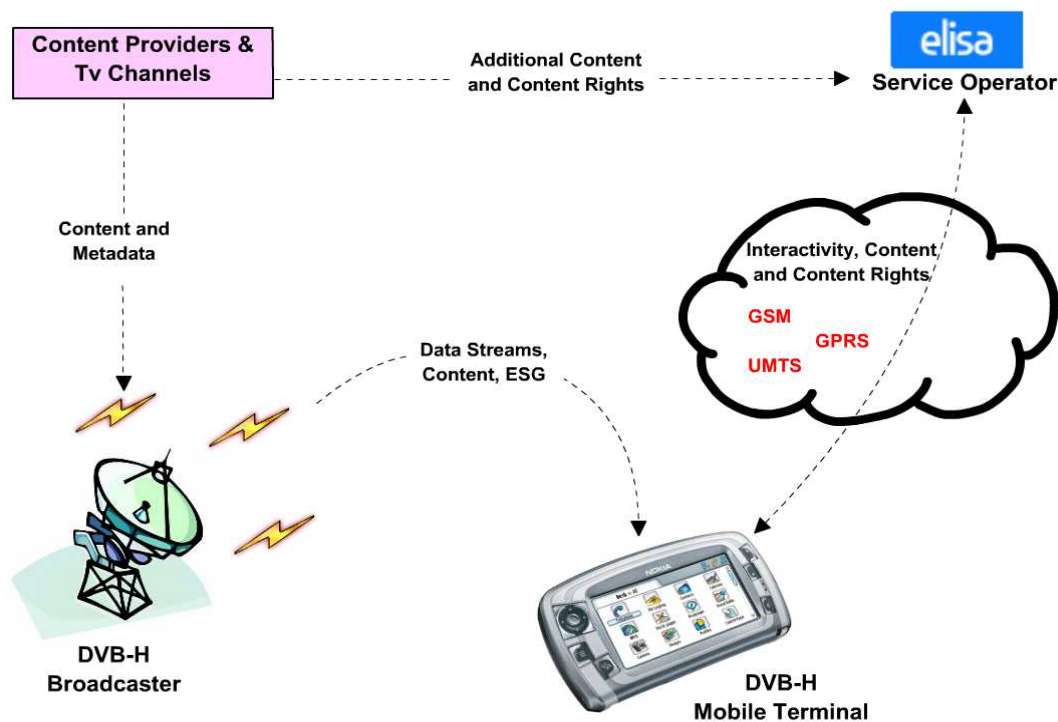
Furthermore, the Mobile Media Viewer displays a variety of banners to the user. These Banners advertise services related to the service currently in use and to the user preferences (i.e. advertisements related to the same TV show). Usually these Banners are not broadcasted but, the metadata describing them is contained within the ESG. With the Banner metadata, the banners are requested from the service operator through a communication channel and displayed afterwards.

### 5.2.1. Business Objectives

The main objective of the Mobile Media Viewer is to provide services that relate to each other. These services interact transparently with users. The list of services and many of the services are mainly delivered as IP content through digital video broadcasts. Additional services and content rights are purchased by using different communication channels.

An application of this nature provides benefits to users, service operators, and content providers. Users will be offered a wide selection of services, the services are offered according to the individual user preferences as well as the services it uses. Furthermore, interaction and community services such as chat are also provided. The service operator benefits from the increased usage of the cellular communication

channels and its own billing system. Moreover, by offering a wide selection of services it can attract new customers. Customer loyalty is reinforced by offering customized services. Finally, content providers benefit from offering their services to a base of potential customers. Additionally it provides the possibility to offer a wider selection of services. Figure 12 shows the context of the Mobile Media Viewer.



**Figure 12: Simplified Context of the Mobile Media Viewer**

### 5.2.2. External Hardware/Software

The Mobile Media Viewer interacts either directly or indirectly with the following significant external hardware:

- The user client terminal, which is used to browse and select services.
- The DVB network, in which content and metadata will be broadcasted.
- The GSM, GPRS and W-CDMA networks, which are used to provide the means of communication between the mobile terminal and the service operator to request and receive content and content rights.

The Mobile Media Viewer interacts with the following significant mobile terminal software:

- A web browser, which is used to display and access the web links offered by the Mobile Media Viewer.

- The Symbian operating system, which is the system used by the Nokia 7710 terminal which the Mobile Media Viewer is designed for.

### 5.2.3. Functional Requirements

A full set of specifications were developed for the application described. However, for the purpose of this Thesis, only the concepts and functionality that is tied directly to provide interactivity will be explained in detail. The functional requirements are explained in concordance with the UML diagramming standard as defined by Rumbaugh, Jacobson and Booch (1997). Figure 13 shows the class diagram for the Mobile Media Viewer.

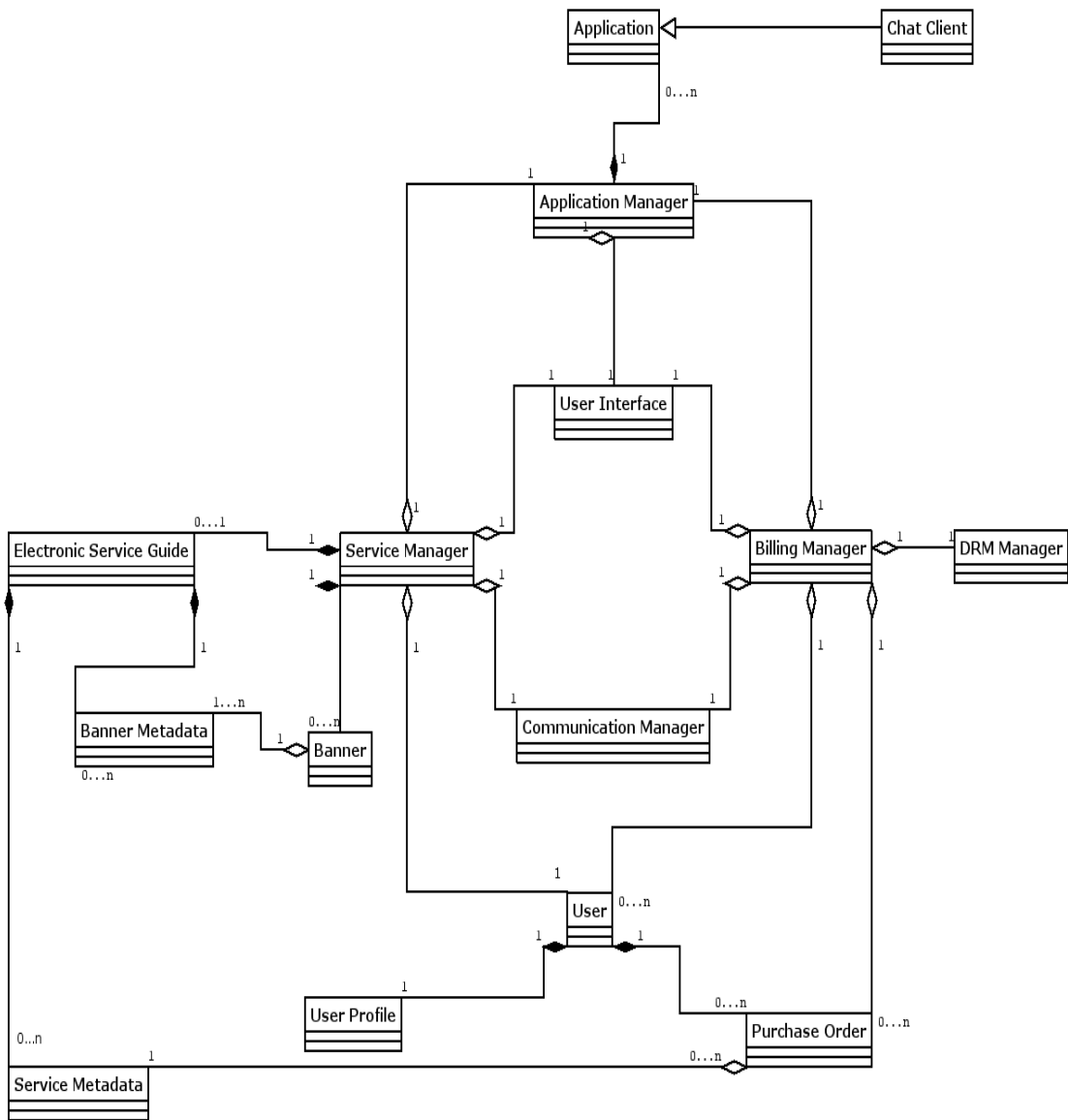


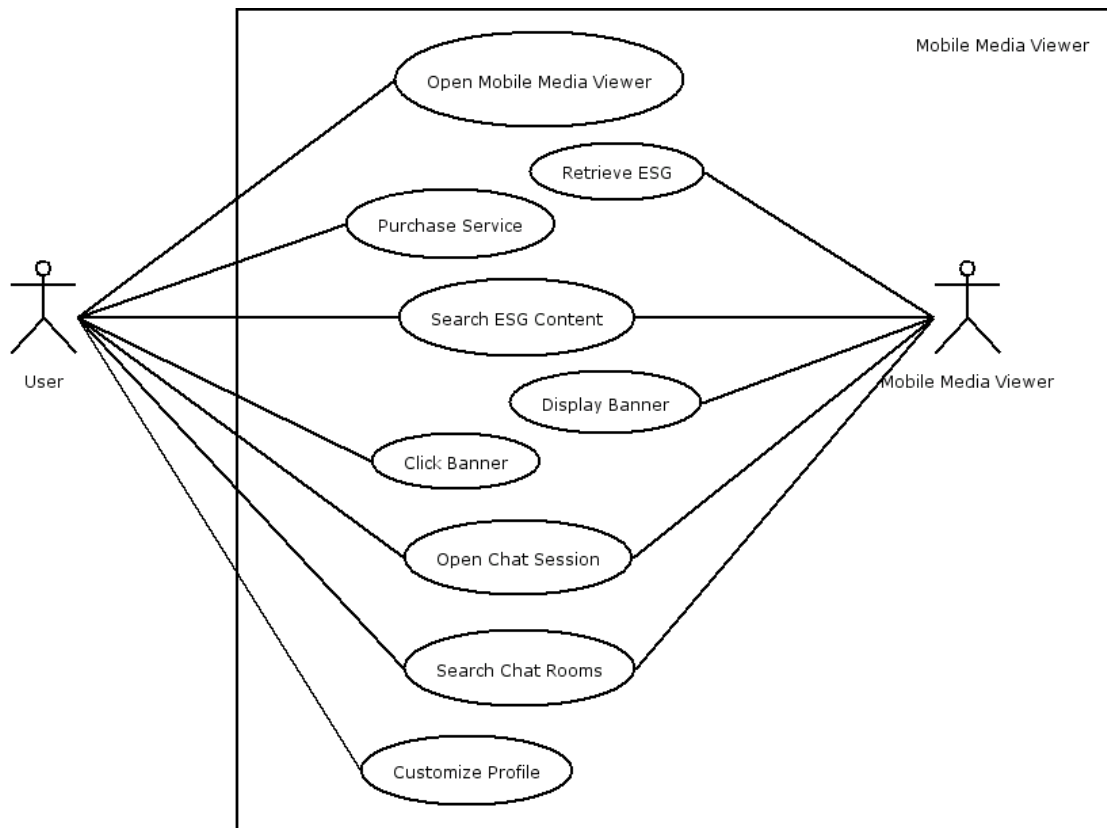
Figure 13: The Mobile Media Viewer's Class Diagram

The objects of the Mobile Media Viewer are organized in the following way:

- The *Service Manager* orchestrates the activities of the different objects involved in the system.
- The *Electronic Service Guide* contains descriptions of services (*Service Metadata*) and banners (*Banner Metadata*). A *Banner* object is the banner itself.
- A *User* object represents the user of the system. This object has a *User Profile* which contains the user information, user preferences and a list of services consumed by the user.
- A *Purchase Order* refers to a service to be purchased by the user.
- The *Billing Manager* is in charge of purchasing the services. For this purpose, it uses a *Digital Rights Management Agent (DRM Agent)* to handle the content rights of the services purchased.
- The *Communication Manager* opens the communication ports to request and receive data.
- The *User Interface* provides the means for the user to interact with the system.
- The *Application Manager* controls the software applications involved with the system. The *Application* is the base class for the applications, such as the *Chat Client*. If other applications are to be used with the system, they will derive from the *Application* class as well.

In a high level view, the Mobile Media Viewer has the following functional requirements. When the Mobile Media Viewer application is executed, it is able to receive the IPDC stream and save the electronic service guide. If the electronic service guide is not available through broadcasts, the Mobile Media Viewer will retrieve it through an alternate communication channel. After the electronic service guide is available, the Mobile Media Viewer opens it in a browser. The user can select services to purchase or consume from the service guide and search for other services as well. When a service is in use, the Mobile Media Viewer will display banners to the user. The user will be able to click the banners to purchase the service advertised. Furthermore, the Mobile Media Viewer has chat room capabilities, in which the user can log in, search for chat rooms and chat. Finally, the user can customize its profile

with its preferences. Figure 14 shows a summary of the use cases for the Mobile Media Viewer.



**Figure 14: Mobile Media Viewer Summary Use Case Diagram**

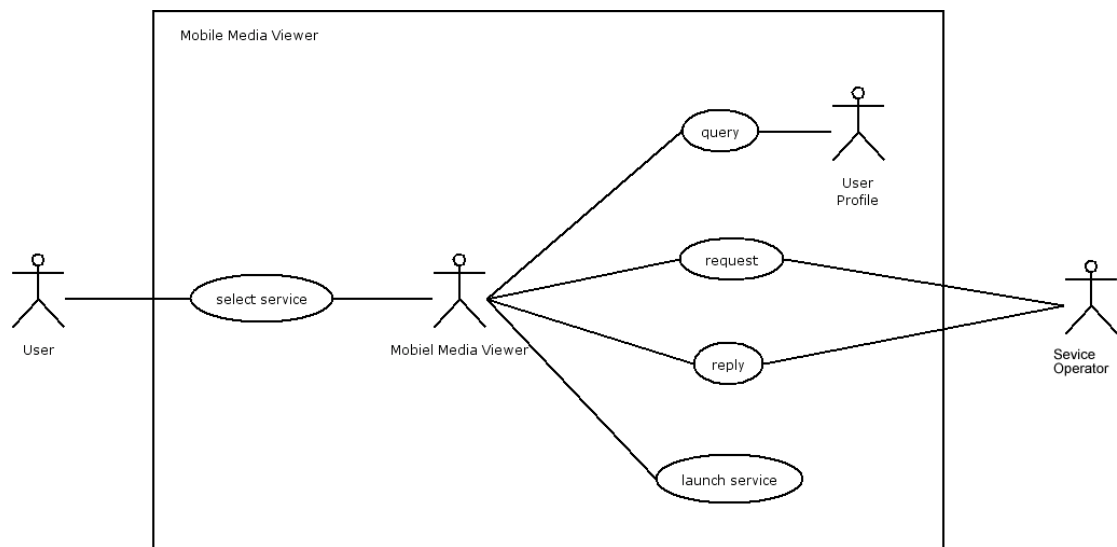
### Actors and Roles

A *User* is defined as a person that selects and consumes services using the Mobile Media Viewer. The *User Profile* is a record that contains user information, preferences and a log of the user activities such as services selected, performed searches and votes. The *Service Operator* provides the content rights as well as additional content upon request. It handles the identification, billing and provides interactivity through different communication channels. *ESG Current* is the ESG information accessible to the Mobile Media Viewer at the moment. The ESG has to be updated periodically. The *Mobile Media Viewer* itself is the client application in the user's mobile terminal. It serves as a coordinator between actors. It manages the access to services and the display of Banners. Furthermore, it requests content and content rights through the different communication channels. The *Chat Server* is the provider of the chat and messaging system. It creates chat connections upon request, handles identification and listens for chat commands.

The use cases that are involved in providing transparent interactivity and access to the different communication channels are purchase service, display banner, and click banner correspondingly.

### Purchase Service Use Case

When a user wants to use or purchase a service, it selects it either from the electronic service guide or by clicking on a banner. The success of the use case guarantees that the user is validated and billed, the content and content rights have been received successfully and the according service has been launched. Since different business models allow users to access services in different ways (i.e. monthly rentals) the necessary requirements to launch the service can vary. Depending on the service selected, a particular service might require for example a file download, content rights (keys to decrypt the content), or the content itself. Figure 15 shows the Purchase Service use case diagram.



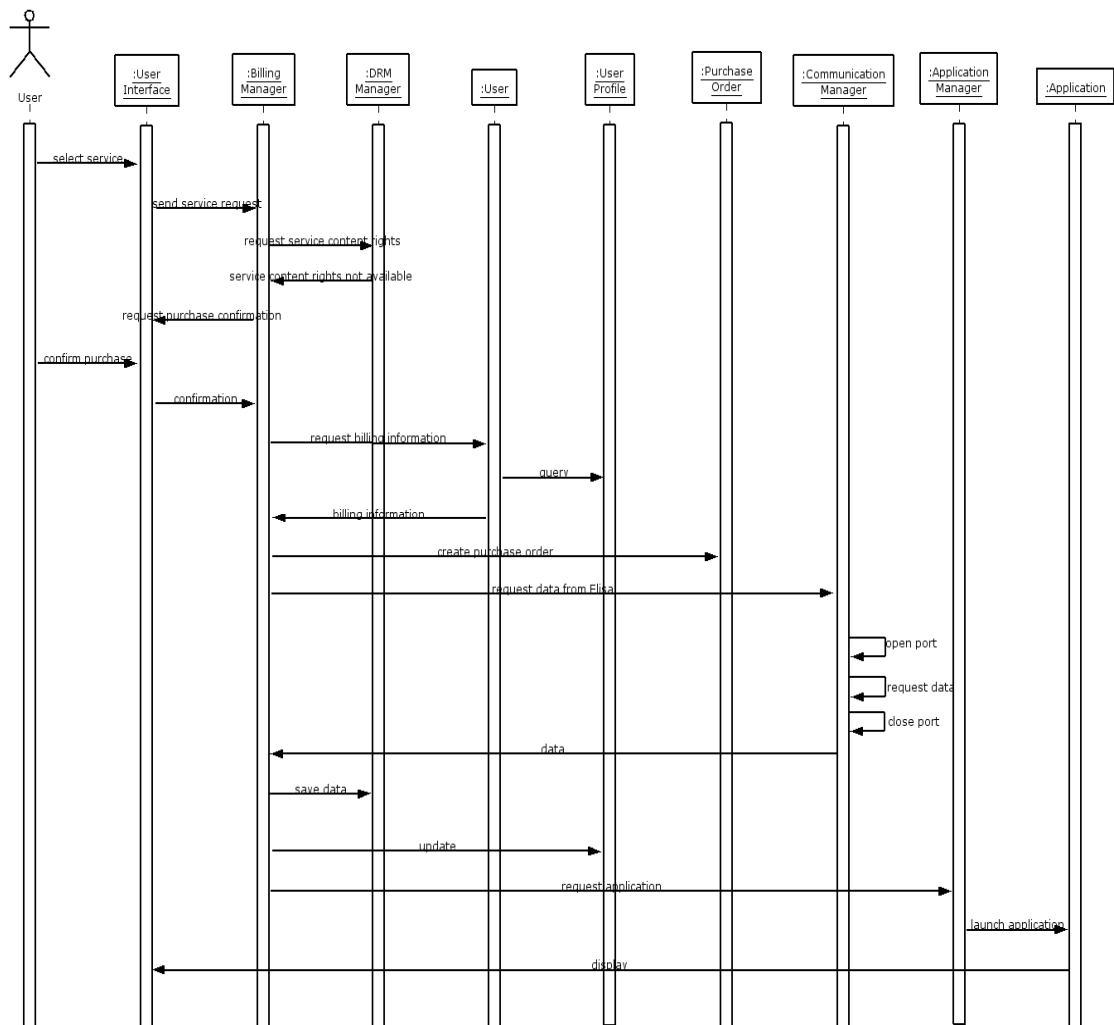
**Figure 15: Purchase Service Use Case Diagram**

#### Main Success Scenario

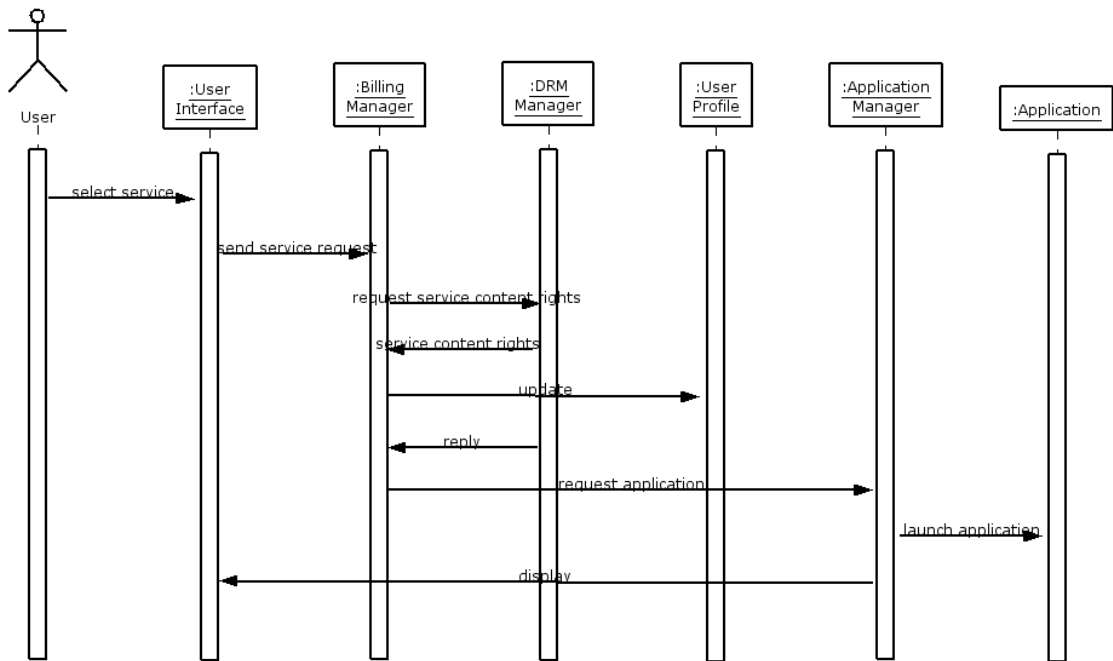
1. User selects a service.
2. Mobile Media Viewer gets the identifier of the service selected.
3. Mobile Media Viewer checks if the content rights and content are already available.
4. Mobile Media Viewer queries the User Profile to retrieve the billing information and payment method.

5. Mobile Media Viewer requests content rights or content, and sends billing information to Service Operator through a communication channel.
6. Service Operator performs the transaction and replies by sending the requested content or content rights back to Mobile Media Viewer.
7. Mobile Media Viewer records the service purchased in the user preferences defined in User Profile.
8. Mobile Media Viewer launches the corresponding application required for the service requested.

The sequence diagram depicted in Figure 16 describes a scenario in which the content rights are not available by the mobile terminal. Therefore, they have to be requested to the Service Operator through a communication channel. Figure 17 describes a scenario in which the content rights are already available by the mobile terminal.



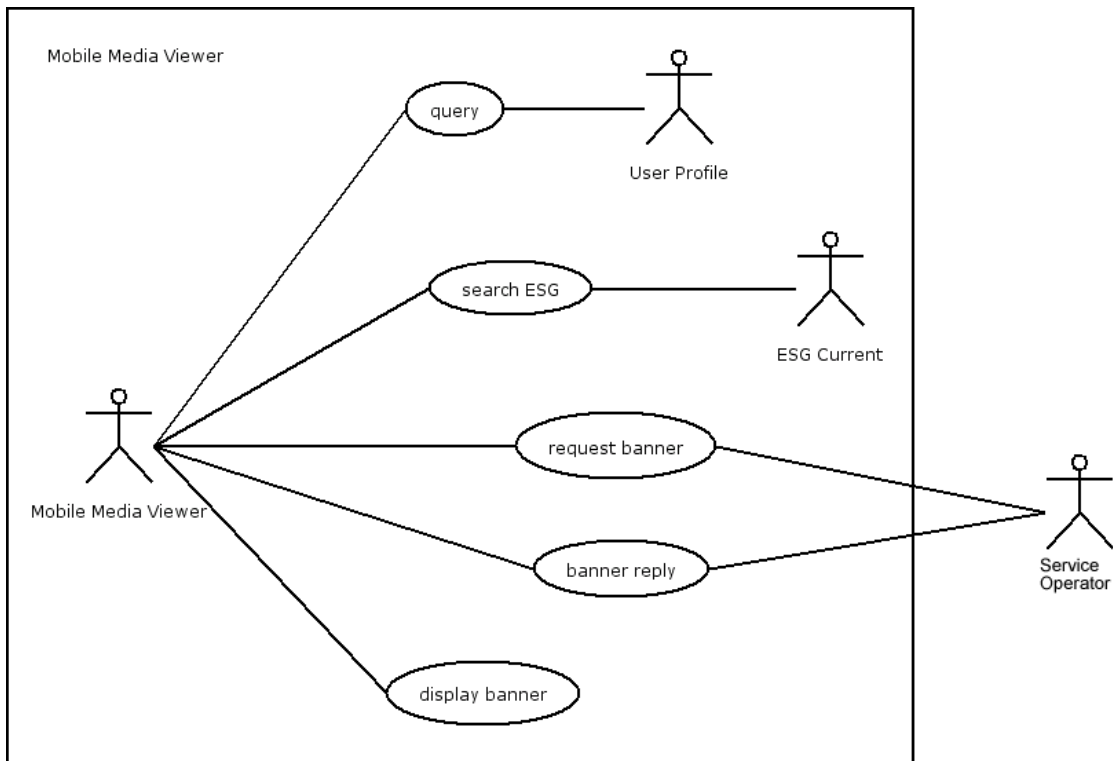
**Figure 16: Purchase Service (Content Rights are Not Available) Scenario**



**Figure 17: Purchase Service (Content Rights are Available) Scenario**

### Display Banner Use Case

The Mobile Media Viewer displays a banner related to the service that is currently active and related to the preferences defined in User Profile. The banners displayed can act as purchase buttons to sell services described in the electronic service guide or to provide interactivity. The banner metadata that describes the banner is located in the ESG. The Mobile Media Viewer uses the banner metadata to request the banner from the Service Operator. The success of the use case guarantees that a search for banners was performed in the ESG, the banner was requested and received in case the banner is not available, and displayed to the User. Figure 18 shows the Display Banner use case diagram.

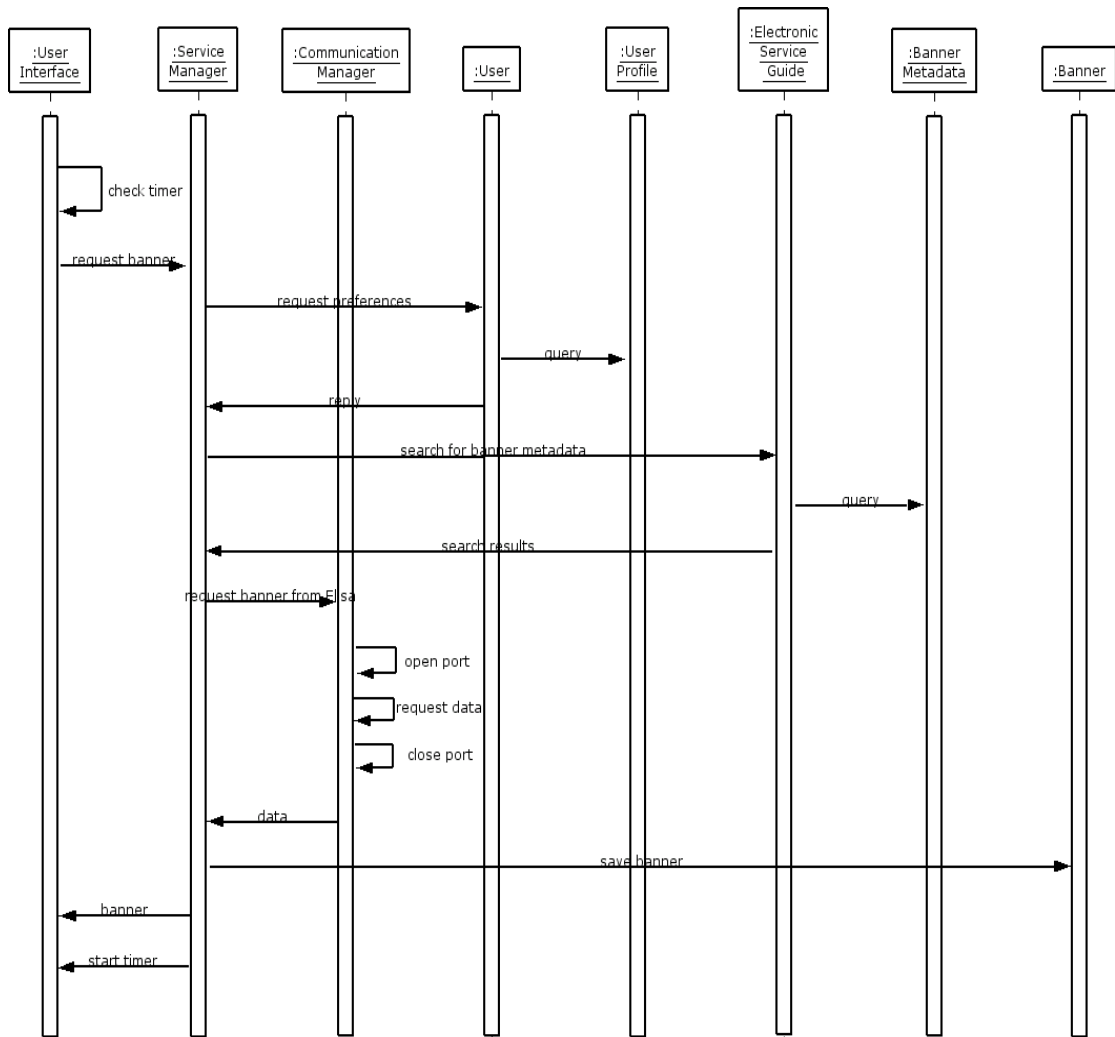


**Figure 18: Display Banner Use Case Diagram**

Main Success Scenario

1. Mobile Media Viewer queries User Profile to know which service is in use and get the user preferences.
2. Mobile Media Viewer Search ESG (UC) to retrieve the banner metadata. The service in use and the user preferences are used as a filter for the search.
3. Mobile Media Viewer requests the banner from Service Operator.
4. Service Operator replies by sending the banner.
5. Mobile Media Viewer receives and saves the banner.
6. Mobile Media Viewer displays the banner.

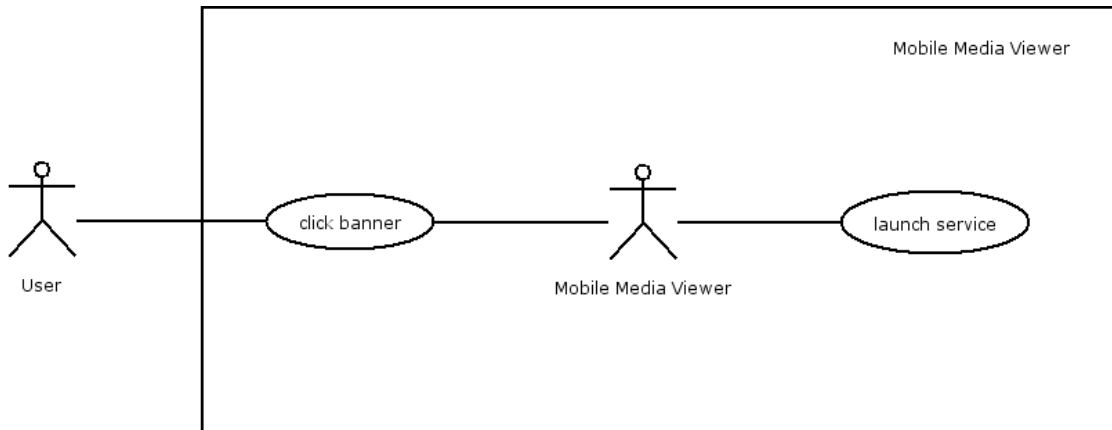
The sequence diagram depicted in Figure 19 describes the main success scenario for displaying a banner.



**Figure 19: Display Banner Main Success Scenario**

### Click Banner Use Case

When a User clicks a banner, the Mobile Media Viewer launches the corresponding application the banner requires. For example, if a banner is a web banner, the Mobile Media Viewer will open a web browser. The success of the use case guarantees that the corresponding application for the banner is launched and the main information of the banner is logged. A log of the banners clicked is kept in order to provide a customized service. For example, the log could be used later for filtering purposes. Figure 20 shows the Click Banner use case diagram.



**Figure 20: Click Banner Use Case Diagram**

### Main Success Scenario

1. User clicks the banner.
2. Mobile Media Viewer gets the identifier of the banner.
3. Mobile Media Viewer launches the application required for the banner.
4. Mobile Media Viewer logs the banner information in the user preferences defined in the User Profile.

Generally speaking, the banners can fit into five categories depending on their functionality. Nevertheless, it is possible to implement banners that use different applications to the ones described in this study.

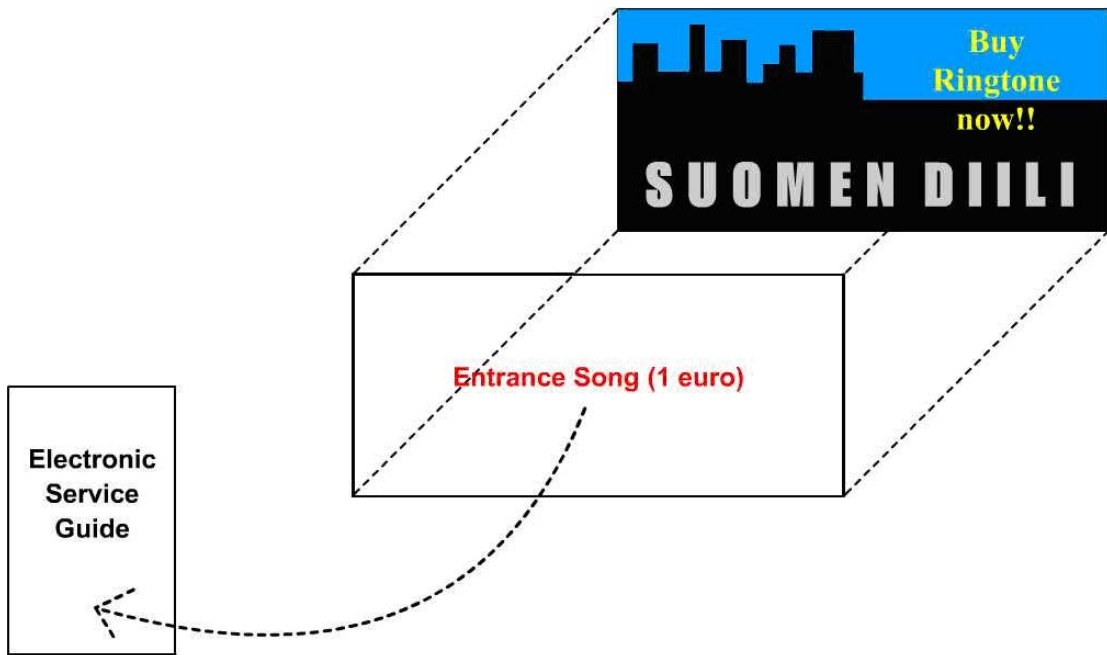
- *Informative Banner*, which does not provide interactivity. This kind of banner is used to display a static advertisement or message. The static messages could be news alerts or additional information related to the service.
- *Purchase Banner*, which aims at purchasing a service. When the banner is clicked it generates a purchase request as described in Purchase Service use case. The details on how to purchase the service as well as its cost are defined in the electronic service guide.
- *Web Banner*, which is linked to a webpage. When a web banner is clicked, it requests that the webpage which is linked to is opened with a web browser application.
- *Vote Banner*, which is used to cast votes. When the banner is clicked it will send the vote through a communication channel.

- *Quiz Banner*, which is used to provide interactivity. When the banner is clicked, it provides interactivity to the user displaying a set of questions for the user to answer. Moreover, the whole set of questions can be contained within the same banner.

Use Case Extensions:

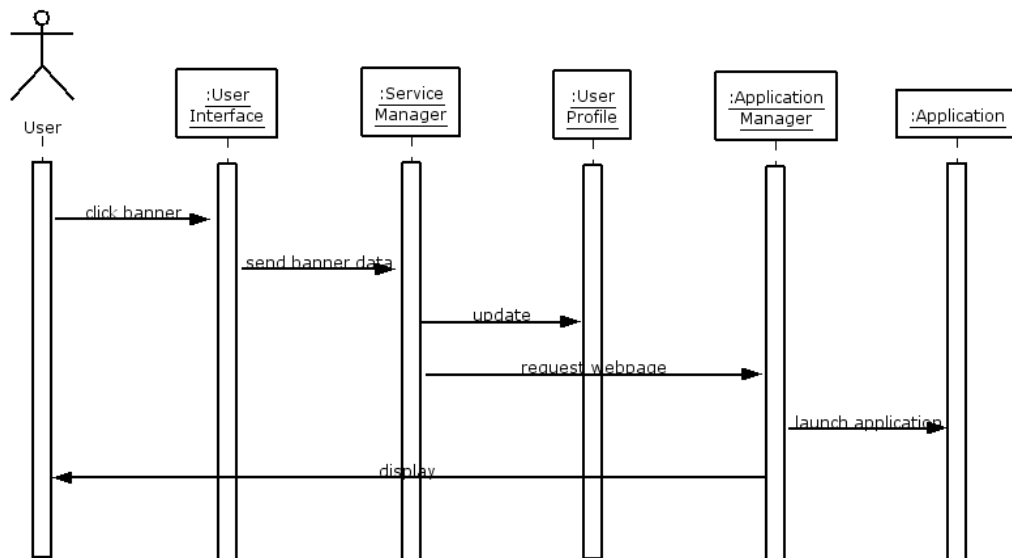
- 1a. The banner is an Informative Banner and does not provide interactivity, end use case.
- 2a. The banner is a Purchase Banner.
  - 2a1. End use case and continue in Purchase Service use case.
- 2b. The Banner is a Web Banner.
  - 2b1. Mobile Media Viewer retrieves the Web Link.
  - 2b2. Mobile Media Viewer launches the Web Browser using the Web Link.
  - 2b3. Continue in step 4 of the use case.
- 2c. The banner is a Vote Banner.
  - 2c1. Mobile Media Viewer sends the vote to the recipient through a communication channel.
  - 2c2. Mobile Media Viewer notifies the User explaining if the vote was performed successfully or not.
  - 2c3. Continue in step 4 of the use case.
- 2d. The banner is a Quiz Banner.
  - 2d1. User continues answering the quiz, continue in step 1 of the use case. End use case when the quiz is completed.

Figure 21 shows how a user can initiate a purchase by clicking on a banner that functions as a Purchase Banner.

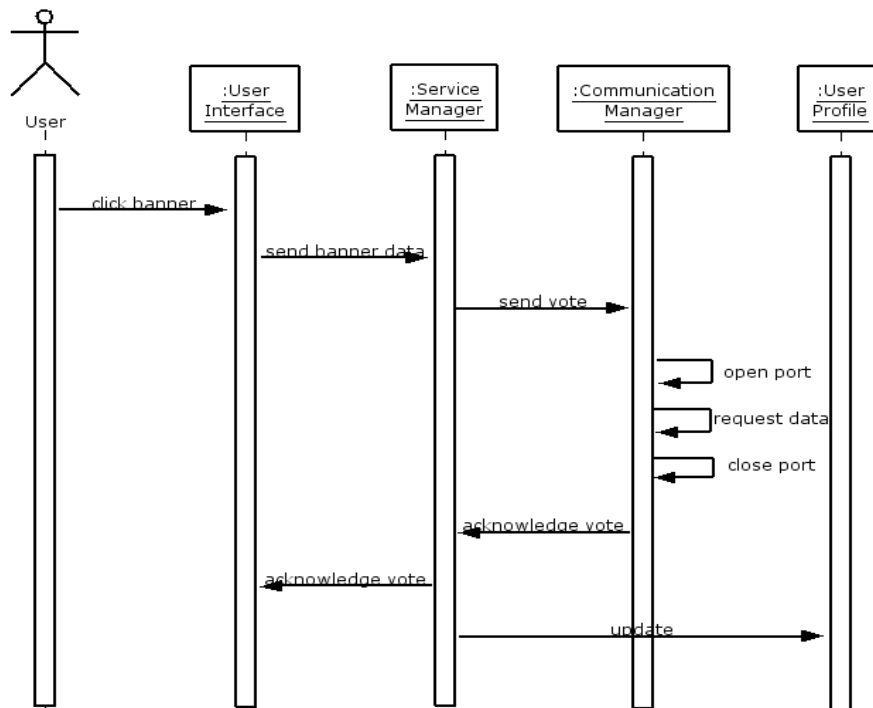


**Figure 21: A Purchase Banner**

The sequence diagrams depicted in Figures 22 and 23 describe scenarios where banners are clicked. Figure 22 depicts the click Web Banner scenario, and Figure 23 corresponds to the click Vote Banner scenario.



**Figure 22: Click Web Banner Scenario Sequence Diagram**



**Figure 23: Click Vote Banner Scenario Sequence Diagram**

### 5.3. Software Implementation

To test the feasibility of developing an application as described by the specifications, a prototype that provided limited functionality regarding interactivity was developed. The prototype aimed at discovering the necessary functions to provide the different communication interfaces and connection options, as well as the major problems that are likely to be encountered.

#### 5.3.1. The Nokia 7710 SDK and 7710 Emulator

The Nokia 7700 and 7710 are mobile terminals that have been used in the DVB-H pilots around the world. For the pilots, the terminals had a special IPDC streamer referred as “Nokia SU-22 streamer”. These terminals use the Symbian operating system. For that reason the software prototype in this Thesis was developed for the Nokia 7710 terminal and, in Symbian programming language.

The Nokia 7700 terminal was never commercially available. The Nokia 7710 terminal became commercially available in late 2004, but without the SU-22 streamer.

Originally, the developer platform used by these terminals was referred as Series 90. Later on, the platform name was changed to only “7710”. The Software

Development Kit (SDK) required to develop applications for the Nokia 7710 is the 7710 SDK available from Nokia Forum. Additionally, the usual software used to develop Symbian applications is required. This includes the Java Runtime Environment, Active Perl, and a proper compiler such as the Metrowerks CodeWarrior for Symbian. Whether an Integrated Developer Environment (IDE) is used or not depends on the developer's preference. The programming tasks and compiling can be carried out directly from the command line as well.

### 5.3.2. Symbian OS Connectivity

In Symbian, connectivity is obtained in the same way regardless of the communication channel. Therefore, it is crucial to understand the Symbian OS connectivity functionality in order to develop any application that connects to a communication channel. Furthermore, several issues have to be taken in mind whenever Symbian applications are developed. One of the most important ones is the use of Active Objects.

Symbian applications are likely to use Active Objects rather than multi-threads. The Active Object concept is specifically developed for the Symbian operating system. It allows handling several asynchronous requests "at the same time" and in the same thread. It is sometimes defined as a cooperative framework. In Symbian, the thread is the unit of execution, and all the Active Objects and an Active Scheduler are within the same thread. The Active Scheduler is a waiting loop within the single thread that will detect the completion of the asynchronous events and locate the relevant Active Object to handle them. For a complete description on the use of Active Objects please refer to Edward and Barker (2004). Connections in Symbian are likely to use Active Objects and that is the reason why they are of importance for this study. The procedure to start any connection in Symbian is the following:

#### **1. Setup a Socket Server**

The setup will create an IPC communication channel. The command used is:

```
RSocketServ::Connect()
```

#### **2. Attach the connection to the Socket Server**

The attachment will start an Internet access point. The Internet access point can be of any kind, such as: Circuit Switched Connection, GPRS, EDGE, W-

CDMA/UMTS, Wireless LAN, Ethernet or IPDC. The emulator uses Ethernet Internet access point, while for broadcasts, the IPDC is used. The command used is:

```
RConnection::Open(RSocketServ, aSocketServer)
```

This will open the connection by giving the socket server handle and attach the connection to the socket server.

### **3. Start the Connection based on the connection preferences**

The connection preferences for the Internet access point IDs are defined in the `commsDB` file of the application. The IDs of the Internet access points are integer numbers, for example 1, 2, etc. These preferences will be used when a connection is started. The command used is:

```
RConnection::Start(TConnPref& aPref, TRequestStatus& aStatus)
```

### **4. Open the Socket and attach it to the started connection**

After the connection has been started, the next step is to create a socket and attach it to the connection that was started. The command used is:

```
RSocket::Open(RSocketServ& aServer, TUint addrFamily, TUint sockType, TUint protocol, RConnection anRConnection)
```

The parameters available define the socket server session, whether IPv4 or IPv6 will be used for the address, the socket type, the protocol (i.e. TCP or UDP), and the connection to which the socket will be attached to.

### **5. Use the Socket**

Using the socket means to send or receive data. In Symbian terms, “write” is used to send data, and “read” is used to receive data. To send data, the command used is:

```
Rsocket::Write(TDesc8 &aDesc, TRequestStatus &aStatus)
```

The descriptor used as the first parameter is the data that will be sent by the communication channel. The second parameter refers to status. The status will be requested once the data begins to be sent and will complete until all the data has been sent. In the case of receiving data, the approach is slightly different. The command used to receive data is:

```
Rsocket::Read(TDesc8 &aDesc, TRequestStatus &aStatus)
```

In this case, the descriptor is the data that will be received and the status is triggered whenever data is being received. The process of receiving data is not necessarily a continuous event. This means, that data may not be received all the time. Also, this process can take a long time, for that reason the application will only run

whenever data is received. This is developed in Symbian by creating an Active Object that will handle the data whenever it is being received. A way to perform the receiving functions with an Active Object is the following:

```
CActive{...
    StartReading(){...
        RSocket::Read(desc, iStatus)
        SetActive();
        ...}
RunL(){...
    Process the descriptor
    RSocket::Read()
    SetActive();
    ...
    DoCancel()
    ...}}
```

In this example, an Active Object is created. The Active Object implements the function `StartReading()`, and in this function it issue the function `RSocket::Read()`, which is used to receive data from the socket. The function `StartReading()` then activates the Active Object by using the `SetActive()` function. When data is received, `RunL()` function is triggered. The `RunL()` function is a special function that has to be implemented in every Active Object. `RunL()` is called by the Active Scheduler when it detects that an Active Object's request is completed. This function will process the data received and call `RSocket::Read()` iteratively within the Active Object to receive the data. This iteration will continue until the iteration condition fails to be true or the Active Object is cancelled by the function `DoCancel()`, or an error occurs.

## 6. Cleanup

Finally the cleanup is done by closing the socket, connection, and socket server.

The commands used are

```
RSocket::Close()
RConnection::Close()
RSocketServ::Close()
```

### 5.3.3. IPDC Streams Processing

IPDC connections follow the same connection structure as that used for other communication channels. For an IPDC application, it is required to set up an IPDC connection in order to receive the IPDC stream. When the IPDC connection socket is in use, the way to process the data received is defined in the `RunL()` function of the Active Object. For example, this function will describe whether the file is saved or streamed. In IPDC broadcasts, both types of files are sent. Therefore, the connection should handle both cases. Moreover, the application should only receive the data relevant to the services that the terminal will consume. The instructions required for the filtering process will be included in this function as well. Additional filtering functionalities can be included in this function according to the user preferences defined in the “User Profile”. For example, if a user has set up a preference for a particular service, the terminal could save the file for later use without a direct user request when the file is being broadcasted.

### 5.3.4. Connection Preferences

In Symbian, the connection preferences are defined with the `TConnPref` class. The preferences in this class define the Internet access points, and most importantly, which connection is preferred and if a prompt dialog should be brought up whenever a connection is attempted. The way in which these preferences are defined controls the way connections are established in the application. For example, the following code forces the application to use the Internet access point with ID “1” and skips the prompt dialog. The `TCommDBPref` class used in the example is inherited from the `TConnPref` class.

```
TCommDBPref prefs;  
prefs.SetIapId(1);  
prefs.SetDialogPreference(ECommDbDialogPrefDoNotPrompt);
```

The previous example shows that the connection preferences do not have to be static and can be assigned dynamically. By doing so, different preferences can be set up for different connections. This is of great importance for the application proposed because services can have one or more communication channels from which they can be accessed. The choices of communication channels from which the service can be available are defined within the electronic service guide. The objects that define such

channels are the “Purchase Data” and the “Purchase Channel” objects. The ESG architecture is described in Section 3.3.4. By handling the data defined in those objects, different connection profiles can be created. Moreover, the application could use the “User Profile” data to gather additional preferences and customize the connections even further. The “User Profile” could for example, declare a preferred communication channel over another.

## 6. Interactive Services

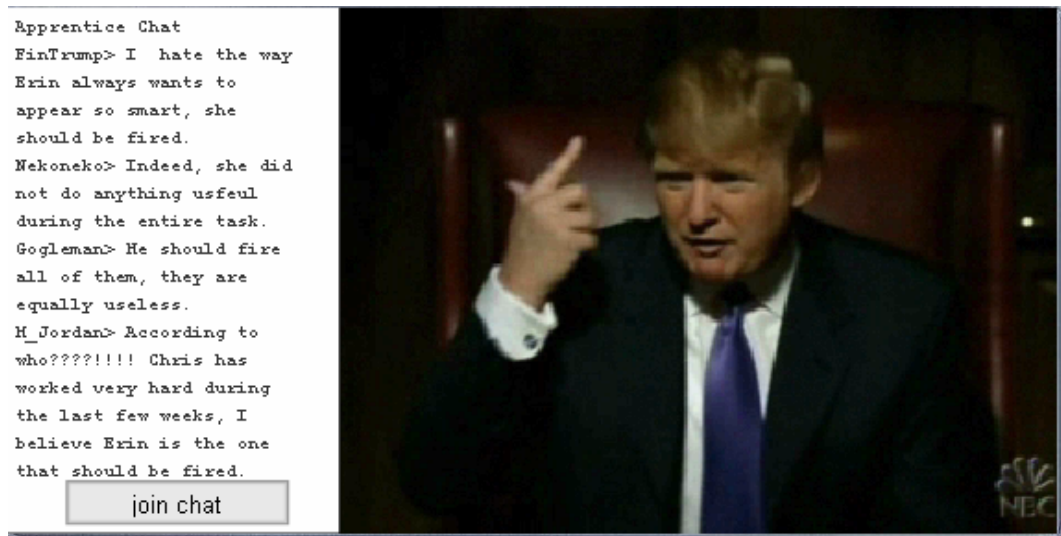
During the timeline of this project, several concepts were discussed and developed regarding interactive services. The services should be related to the service in use (i.e. a TV program), related to the user preferences, or to both. By doing so, the user will be provided with a focused variety of services that is likely to match its interests. These services can be offered through banners that provide interactivity.

In this Thesis, two TV services are considered. The first one depicts the banners that could be displayed during a TV reality show. The second example describes a situation of a sports show, where the banners are displayed taking into consideration the user preferences as well as the service in use.

The interactive service concepts were implemented as an animation to provide the look and feel of what the real services would look like. The animation is included as complementary software in this thesis. For a description and additional information about it refer to Appendix A.

### 6.1.1. Services Related Banners

The following example describes service concepts that are related to the reality TV show “The Apprentice”. The banners are displayed and changed during the show.



**Figure 24: A Chat Service**

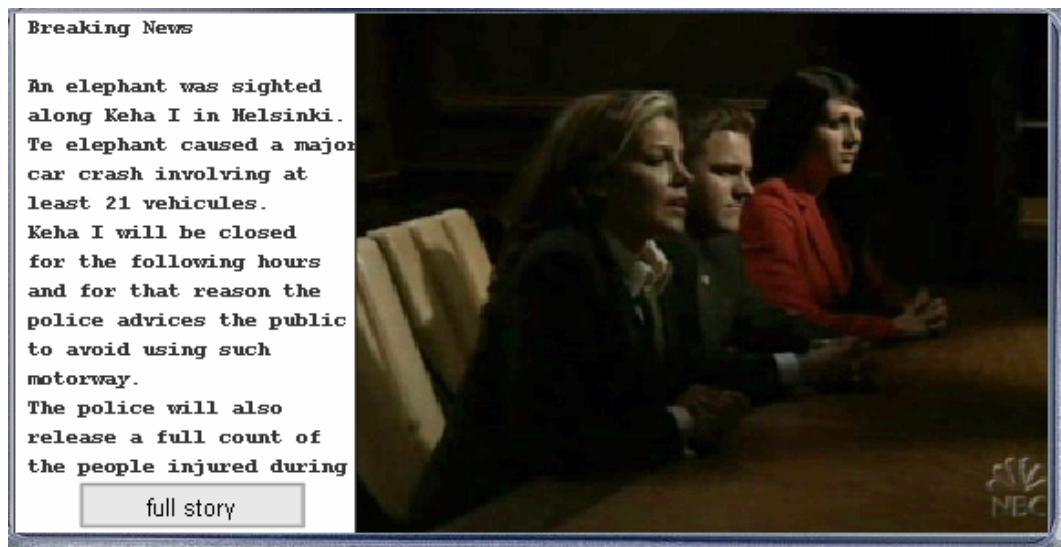
**A Chat Service-** The user can interact with other people watching the same show by posting messages in a chat room dedicated only for this purpose. Depending on the chat system, the chat could be controlled either by the service operator or the TV channel that is broadcasting the TV show. If the chat is controlled by the TV channel, the messages would be sent directly to the TV station as it occurs nowadays on normal TV chat. On the other hand, if the service is provided by the service operator, the chat messages could be sent in the same way, or by GPRS or W-CDMA data connections. See Figure 24.



**Figure 25: A Web Banner**

**A Web Banner-** This banner is linked to the TV show's website. By clicking on the banner, the user would be taken to the website of the TV show. In this example, the

banner is linked to the application form to participate in the next season of the TV show. See Figure 25.



**Figure 26: An Overriding Banner**

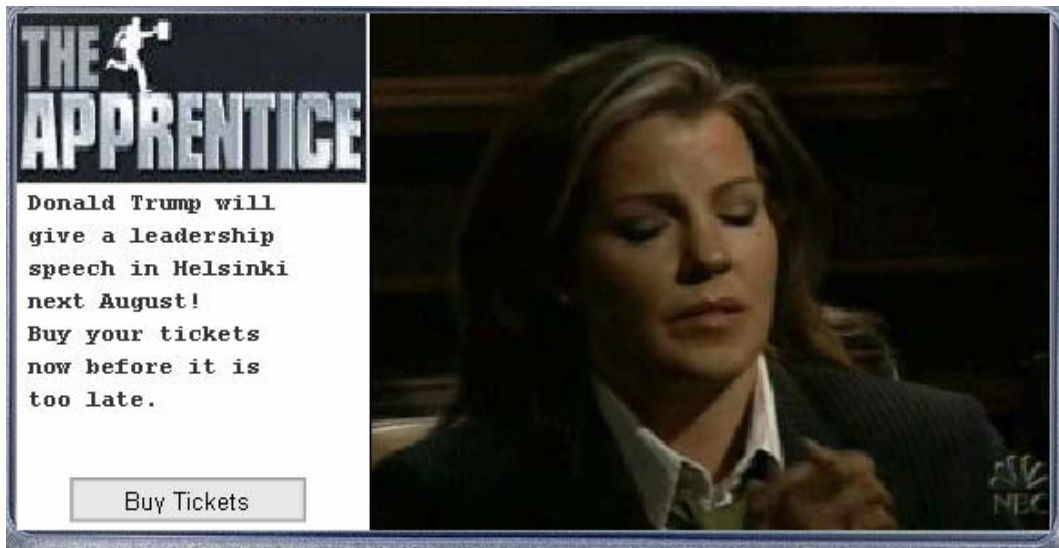
**An Overriding Banner-** This banner is a special case in which it overrides the priority of the other banners. These banners are intended to be used in case of an emergency or a situation where particular news needs to be broadcasted to the general public. These banners will be displayed even though they might not be related to the service in use or the user preferences. See Figure 26.



**Figure 27: A Live Poll**

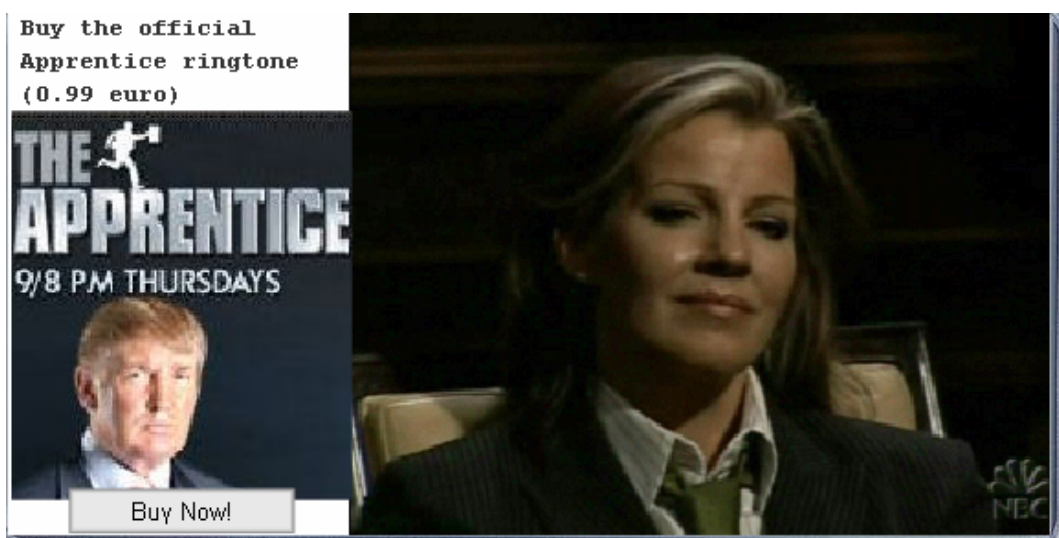
**A Live Poll-** Banners can be used to encourage users to participate in live polls. The user casts its vote by clicking on the banner. The vote itself can have an additional

fee, as in the case of reality shows like “Big Brother”. Therefore, votes are likely to be based on Premium SMS. See Figure 27.



**Figure 28: A Purchase Banner (Tickets)**

**A Purchase Banner (tickets)-** Banners can also be used to sell or reserve items such as tickets. The tickets could be provided in several ways depending on the provider and price of the tickets. If the tickets are low priced, it is possible to sell them through Premium SMS. However, Premium SMS purchases have a price limit. Therefore, if the tickets are expensive enough, they might need to be sold through other payment method, such as credit card or mobile cash. See Figure 28.



**Figure 29: A Purchase Banner (Ringtone)**

**A Purchase Banner (ringtone)-** Ringtones and wallpapers are items that are purchased commonly by mobile users. Normally, the ringtones are purchased by using Premium SMS. However, these items can also be provided through file downloads using GPRS or W-CDMA data connections. See Figure 29.

### 6.1.2. User and Services Related Banners

The following example describes a scenario where the banners are displayed according not only to the TV show, but also according to the user preferences. The TV show is a sports show called “NBA Action”. In this case, the user has defined in his preferences that its favorite basketball team is the Houston Rockets. Therefore, the application filters the banners using the user’s favorite team as a parameter. The following banners are mostly related to the Houston Rockets team and Houston Rockets players. By doing so, the banners are displayed to potential customers since they are more likely to attract the user.



**Figure 30: Purchase Banner (wallpaper)**

**A Purchase Banner (wallpaper)-** This purchase banner offers a wallpaper featuring the Houston Rockets most popular player, Yao Ming. Wallpapers are usually purchased in the same way as ringtones. See Figure 30.



**Figure 31: A Web Banner (Online Poll)**

**A Web Banner (online poll)-** Web banners can also be used to provide poll services. The use of web based polls provides different features than live polls. For example, a web poll is not dependant on the schedule of the TV show and can be shown at any time. Furthermore, it is based on weblink hits, and for that reason the results of the poll can be displayed to the user immediately after the banner has been clicked. Moreover, web polls are very easy to implement and manage. See Figure 31.



**Figure 32: Third-Party Shopping Channel**

**Third-party shopping channel-** Banners can also be used to offer items from third-party shopping channels. In this example, the third-party is an auction organization that sells sports memorabilia. See Figure 32.

Basketball Betting		
NBA Basketball		
Sun 5/8 Games		
Sun 5/8 Supersonics		
05:05PM Spurs		
Sun 5/8 Wizards		
12:35PM Heat		
Spread	Money Line	
+8.5-106	+430	
-8.5-104	+510	
+10.5+100	+600	
-10.5-110	-730	
<input type="button" value="Bet"/>		

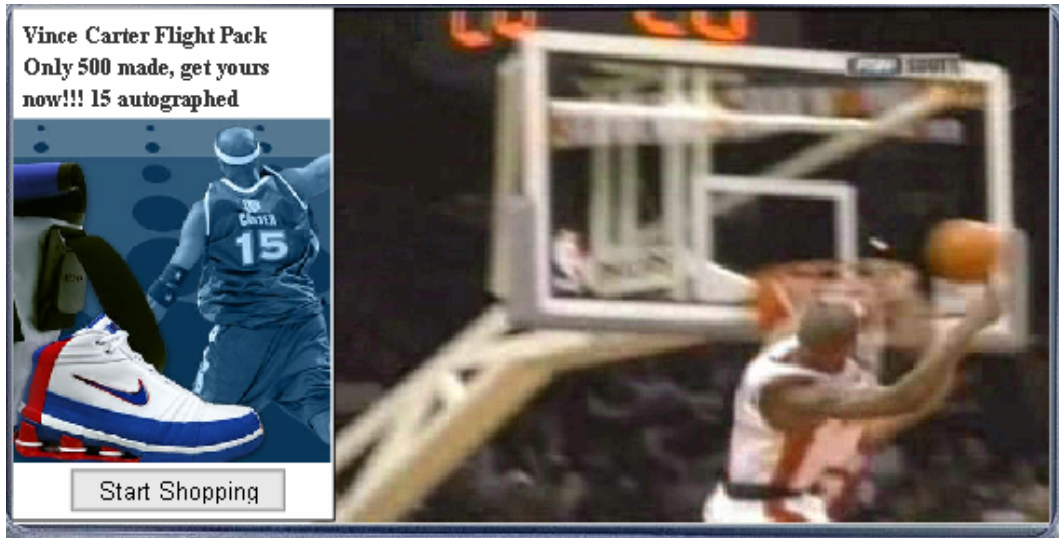
**Figure 33: Gambling**

**Gambling-** Gambling and betting on sports events is common among sports fans. Therefore, banners can be used to advertise sports betting. Depending on the organization running the gambling service, clicking the banner could generate a bet immediately, open a website, or contact a third-party shopping channel. See Figure 33.

Yao Ming		
11		
2004-2005		
Statistics		
PPG	18.3	
RPG	8.40	
APG	.8	
EFF	+20.60	
Position:	C	
Born:	09/12/80	
Height:	7-6/2.29	
Weight:	310lb/140.6kg	

**Figure 34: An Informative Banner**

**Informative Banner-** Informative banners are banners that are static and do not provide any interactivity. However, they offer an interesting way of providing and added value service to the user by displaying useful information. In this example, the banner displays player statistics from the Houston Rockets roster. See Figure 34.



**Figure 35: Local Advertisements**

**Local Advertisements-** Banners can be used to display local advertisements to the user. This example depicts a web banner advertising Vince Carter's new tennis shoes, there were only 500 made. When the user clicks on the banner, it directs the user to the webpage of the store located in the area where the user is. From the webpage, the user can reserve or buy the tennis shoes immediately. See Figure 35.



**Figure 36: A Quiz Banner**

**A Quiz Banner-** Banners can be used to provide limited interactivity. One example is a simple quiz. It is likely that banners have a maximum limit on their file size. However, if the banner does not use images it can contain a significant amount of text. Therefore, the text can be structured in such a way, that a whole quiz is

contained within the same banner. The banner starts by displaying a question to the user and a predefined set of answers. After the user clicks on the banner to answer the question, the next question of the quiz is displayed and so on. The quiz terminates when all the questions have been answered. The banner can inform the user about the correct answers and the number of questions answered correctly. This type of banner can provide interactivity at no price, and does not need to use any communication channel. See Figure 36.

# 7. Analysis

## 7.1. Requirements Analysis

The initial phase of the project consisted in retrieving the service ideas that were the result from the first phase of the INDICA project. This phase also included an extensive literature research and expert opinions.

### *Q1. What kind of services will be offered through IPDC?*

IP datacasting is a technology that provides access to multimedia content to a large amount of users simultaneously. Therefore many of the services that can be offered through IP in a unidirectional way can also be broadcasted.

At the time of this study there was a lack of empirical data regarding the pilots because they were on initial or trial phase. For this reason, the main material for studying the services had to be based on expert's opinions, previous project results as well as literature research. Experts from different organizations agreed with the idea that the services that are to be broadcasted should only be those that should reach everyone. However, there is a discrepancy regarding what is exactly the data that should reach everyone.

Some of the preliminary studies that were developed stated that "anything" that can be used in IP can also be broadcasted through IPDC (RTT, 2004). However, this turns to be untrue in some cases. Services that need a return channel on a permanent basis as well as connection acknowledgements are not well suited for IPDC. Therefore, not all IP content is suitable for broadcasting, such as TCP services.

However, there are many other services based on UDP that can be used. Furthermore, it was implied several times that IPDC would provide up to 50 services at the same time. This is unlikely to happen in some scenarios. Unless a DVB-H dedicated network is deployed, the IPDC stream will share the spectrum used by digital television. Therefore, the amount of services provided through IPDC could be restricted due to the limited amount of spectrum. In this sense, regardless of the possibilities that IPDC provides for broadcasting different services, they might be limited to a few types.

In the current pilots, only the real time TV channels and the electronic service guide are broadcasted. However, the electronic service guide contains too much information and it takes very long to update. This issue resulted in new ideas such as dividing the content broadcasted. For example, for updating the electronic service guide, the update of the guide could also be broadcasted. That is, a separate file that will only contain the data needed to update the old ESG. Then, the terminal would only need to stream the update instead of the whole guide all over again. Additionally, items such as banners, which can contain images and have a significant file size, should not be broadcasted entirely. The banners can be split in a way that only the base description of the banner is broadcasted. The description can be XML based and contain just the general information of the banner and links. This description is included within the ESG. Afterwards, the mobile TV application would refer to that description to request the rest of the banner, for example the logo or picture through a communication channel. By doing so, more spectrum can be allocated for services that have more demand.

An additional possibility is to send sets of webpages that have related information. For example, a set containing information about the World Cup, or traffic jams. Then, the set can be cached by the terminal, and the terminal will have quick access to them. The terminal may save only those that are related to the user. For example, if the user is subscribed to a bundle of sports services, sets related to sports would be cached. It is unclear how hard will it be to manage these sets of webpages. However, it is highly probable that at least some sets will be broadcasted like in the case of major sport events such as the World Cup or the Olympics.

*A1. The main services to be broadcasted are likely to be video streams, the electronic service guide, electronic service guide updates and sets of webpages related to the same service.*

***Q2. What kind of services will be offered through other communication channels?***

By taking into consideration *Q1*, it appears that many of the services that researchers thought would be broadcasted will still be offered through other communication channels. This is not necessarily bad because 3G networks might be used extensively by the time IPDC is commercially available. Even though the use of 3G networks is expensive, they would not be used to download very large files. Instead they can be used to receive content and services that are not popular enough, do not follow a schedule, need a return channel, or just do not fit in the broadcast spectrum. The services could range from ringtones, wallpapers, web pages, chat, community services, video clips and music files.

*A2. The services to be offered through other communication channels are likely to be multimedia messages, and Internet services, and file downloads for smaller files than those that are broadcasted.*

***Q3. What are the high-level goals of a mobile TV application that provides interactive services?***

The mobile TV application is not a competitor of the normal TV set. Instead, it should provide an added-value to the user. Specially, the mobile TV should provide the user a different experience. Therefore, the mobile TV should be considered an application that is personal and that has to adapt to the user behavior and needs. Furthermore, it should give the user the opportunity to interact with other people that share the same interests. The ideas of how the user can interact with others are complex and in many cases are dependent on law regulations and hardware manufacturers. For example, being able to record a video clip from TV and send it to ones friends involves a complex copyright scheme. Structured chat systems that integrate communities of users that share common interests are not so easy to develop and require good planning. Also capabilities that extend the TV set, such as adding remote control functions to the terminals depend on terminal manufacturers. However, simple interactive services can be developed based on more basic high level goals that are not

so complex. For example, chat can be provided in a simple form without a complex structure to manage communities and users.

*A3. The high level goals of a mobile TV application that provides interactive services are:*

- a) File download capabilities*
- b) User sensitive advertisements*
- c) One-click purchase functionality*
- d) Recommend keyword and content related searches*
- e) Chat*
- f) Electronic service guide filtering*

## 7.2. Software Design

In this phase, all the information gathered was structured and summarized. As a result, a full set of software specifications that match the high-level goals was proposed. Most of the high-level customer requirements used for this document were results from the INDICA project. The software design phase provided the architecture and a broad view of how the software should work.

### ***Q4. How can the services provide interactivity to the user?***

Interactivity in mobile TV applications should be simple. Mobile terminals and particularly handsets have considerably small screens. For that reason, interactivity should require as few user input as possible. Banners are an easy way to reach the user by displaying information or advertisements without requiring any user input. However, banners can be developed in such a way that they provide some level of interactivity when clicked. If a generic framework for banners is designed, different banner functionalities can be implemented. Banners can serve several purposes such as displaying news, additional information about a TV show, advertisements, live polls and quizzes. The area in which the banners are displayed is an integrated web browser. Therefore, in this area other information can be displayed, for example a chat interface. For a detailed study about banner possibilities refer to Chapter 6.

*A4. Interactivity is provided mostly through the use of banners. Depending on how they are implemented, they can provide different functionality.*

***Q5. What are the requirements for providing interactivity and user sensitive customization in mobile TV applications?***

Mobile terminals are considered personal items. For that reason the mobile TV application should provide a personalized experience to the user. Personalization can be achieved by implementing a user profile and a search engine. The user profile is a record that contains the user information, billing information, user preferences, and user behavior. The user behavior refers to services that user has consumed, previous votes, etc. This information is used to filter the service lists. The filtering scheme can be used for several purposes. For example, when the electronic service guide is displayed, it can be structured according to these preferences. Thus, offer the services that the user is likely to be attracted to will be displayed first. If a user is kin with sports, then sports services will be displayed first. Moreover, if the user has showed a preference in a particular team or sport, the search can be filtered further. Likewise, the banners that are to be displayed can be selected based on the preferences and the service in use as well. By doing so, the banners are likely to reach a potential customer and provide an added-value service. Additionally, this information can be used to recommend services to the user, and provide search for services based on keywords or categories.

To provide interactivity, the Mobile application shall have access to the different communication interfaces. The communication channel as well as the payment method choices can be predefined in the user profile. Therefore, when the user clicks on a banner for example, the communication channel and payment method could be selected without requiring additional user input.

*A5. A user profile, a record of user actions and behavior, as well as a search engine and access to the communication interfaces are required to provide interactivity and user customization. The mobile TV application can offer user-sensitive banners, access a communication channel, and services all according to the user preferences and behavior*

### 7.3. Software Implementation

The software implementation phase was initiated after the software design was completed. This phase would result in a software prototype that provided limited functionality. The main objective of the software prototype was to test if the functionality regarding the connection interfaces to the different communication channels was possible as specified in the software design phase.

#### *Q6. What technology is required to develop such application?*

IPDC applications that provide interactivity in mobile TV applications require interfaces to different networks. First, the mobile terminal needs an air interface to receive the IPDC stream. At the moment of this study the receiver that was being used for the pilots was referred as “Nokia SU-22 streamer”. However, Texas Instruments also plans to release a digital TV receiver on a chip code-named “Hollywood” for DVB-H and ISDB-T (TI, 2005b). In addition to the IPDC air interface, an interface to the cellular networks is required. If the terminal has access to different cellular networks, the options for the user increase as well as the quality of service. The Nokia 7710 terminal does not have an interface to 3G networks. Therefore, it only provides interfaces to GSM/GPRS/EDGE and not W-CDMA.

The Nokia 7710 terminal uses the Symbian operating system. This terminal is the only IPDC terminal commercially available. However, the commercial version does not include an IPDC receiver. Siemens has expressed interest in developing IPDC terminals too. However, it is unknown what operating system their terminal will use. For that reason, the application has to be developed in Symbian programming language.

If the application is aimed for the Nokia 7710 terminal, the 7710 SDK programming platform has to be used. IPDC programming libraries are needed to develop an application that has access to the IPDC air interface. Unfortunately, these libraries are not included with the 7710 SDK programming platform. However, Nokia has recently stated that the interface specifications will be available for mobile operators and service providers (Nokia, 2005). Therefore, it is possible that these libraries will eventually be included in the SDK. With an open DVB-H air interface, service operators and content providers are encouraged to test the technologies and start developing their own applications. Furthermore, multimedia terminals similar to

the 7710 but with 3G capabilities will eventually be released. The amount of services that can be provided will increase because 3G provides the means for very fast data connections. Therefore, it will be important to develop business concepts and test them with users to measure the user acceptance of 3G services combined with IPDC. With more terminals available, it will be easier to attract new customers and therefore the demand for DVB-H applications will increase.

*A6. The technology required to develop an IPDC application are:*

- a) IPDC terminal such as the Nokia 7710*
- b) IPDC air interface receiver*
- c) cellular channel interface*
- d) Symbian programming environment*
- e) 7710 SDK programming platform*
- f) IPDC programming libraries.*

***Q7. Is it feasible to develop such an application with the current technologies?***

It is possible to develop IPDC applications with the current technologies. However, as mentioned in *Q6*, access to hardware and software that is not commercially available is required. Furthermore, for testing purposes, access to the broadcasting network is required too. Regardless of the closeness of the technologies, an IPDC application can be developed with adequate support from organizations that have access to those technologies.

An application that provides access to different communication channels as specified in this Thesis is possible. The prototype demonstrated that the connectivity principles in Symbian make possible to develop an application that can set up connections with different parameters according to the service to be consumed. Furthermore, the connections can take in mind preferences from the User Profile as described in the software design. In these preferences, parameters such as preferred payment method, and user information are included. In this way additional parameters are considered for every connection. Therefore, by setting up the connections dynamically transparent interactivity can be achieved. Users will not be aware of the technology in use and purchasing services will be simple. Additionally, the User Profile is also used for filtering services and banners. It is possible to use these parameters to filter the electronic service guide in a way that it displays information

that is relevant to the user. Also, the banners displayed are also relevant to the user and the service. The features all together result in a personalized user experience.

The feasibility of IPDC applications is not tied only to hardware and software constraints, it also relies on standardization. An IPDC application as described in this Thesis will need an electronic service guide that is robust enough. The ESG shall provide the means to describe the services in much detail. Otherwise, filtering will not be specific enough and the user will not be able to customize the application in the way it was described in this Thesis. The same conflict would result with the banners. If the banners are not described in detail in the ESG, they will not be properly filtered in the searches. Therefore, the banners would not reach the potential users. Furthermore, as it was described in previously in this Thesis, DVB-H is subtle to decisions between countries and organizations regarding spectrum allocation. The spectrum allocation plays a very decisive factor since the decision made will define the bandwidths allocated for DVB-H services.

Finally, IPDC applications might require additional mobile only content. The conditions in which users consume the services can be very different from those from normal TV. For example, short periods of time such as commuting or waiting for an appointment. Therefore, the user should be able to select services that match these needs. Short updates on sports, news, or soap operas could be an example. However, until the results from the pilots are published, it will be unclear how important is the role for mobile only content.

*Q7. It seems feasible to develop mobile TV applications that provide interactivity. However, the feasibility relies heavily on standardization decisions such as a robust electronic service guide and spectrum allocation. Additionally, mobile only content is needed.*

### 7.3.1. Problems Encountered

During the implementation phase, several problems were encountered. Especially problems regarding the 7710 emulator contained in the 7710 SDK version available at the time of the study. Firstly, the 7710 emulator had several major problems. The most crucial problem for the development of this application was the fact that the 7710 emulator has serious problems concerning connecting to the Ethernet.

Connection to the Ethernet is needed to test applications in the emulator. This problem was common among the scarce amount of 7710 developers without a clear solution to the problem. However, this problem is likely to be solved in future versions of the emulator.

Secondly, the documentation is not extensive enough yet. The 7710 SDK has many differences with the Series 60 SDK. Series 60 is the most commonly used platform which is aimed for terminals with considerably smaller screen sizes and no touch screen capabilities. That means interaction in Series 60 is performed with the use of keys. Likewise, Series 60 has more documentation and examples available, which are crucial for Symbian development. The Symbian programming language is not easy to grasp, has considerable programming differences with standard C++ and is not extensively documented. Therefore, most of the problems encountered by programmers have to be solved by gathering source code examples of software that has similar functionality. In this sense, the information available for Series 60 can sometimes be useful. However, porting software code from Series 60 to 7710 is not straight forward and requires expertise in Symbian C++ programming. This lack of documentation lead to many hours of testing and trying to discover if solutions used in Series 60 also applied for the 7710, as well as trying to come up with completely new solutions. In many cases, the problems encountered were not tied to the software source code but to environment settings, faulty documentation or plain bugs in the 7710 SDK.

Even though Symbian is a hard language to program with, the amount of developers and support is increasing. Additionally, some universities have started giving courses related to Symbian programming. Therefore, it is probable that more examples linked to the 7710 platform and new books will be published. The problems with the 7710 SDK and the emulator are also likely to be fixed. The 7710 SDK was released just a few months before the software implementation of this Thesis took place. Probably many of the problems and bugs of the first release will have been fixed in newer versions of the SDK.

Finally, discussion boards are a normally a very good source for ideas and solutions. Particularly Forum Nokia discussion boards have a large number of developers which write actively. Unfortunately, the amount of people working with 7710 was very limited and most of the questions posted in the board regarding 7710 issues and problems never had any feedback. However, multimedia terminals such as

the 7710 are still a new concept. Therefore, when this kind of terminals becomes popular among users there will be more demand for applications, resulting in an increase in the number of programmers. Furthermore, there are some speculations foreseeing that the 7710 and Series 80 platforms will eventually merge with Series 60. If this is to happen, it is likely that programming in Symbian will be a much simpler task.

## 7.4. Evaluation

This phase summarized the service ideas and created interactive service concepts based on the understanding of the technology acquired in the previous phases.

### ***Q8. What will the interactive services look like?***

Since the Nokia 7710 terminal was the only IPDC terminal available, the service concepts provided in this Thesis focus on that terminal. The service concepts take into account the terminal capabilities as well as interface. During the previous phase an understanding on how Symbian interfaces work in the 7710 was acquired. This knowledge was used to create concepts that adapt to those necessities.

The 7710 has a screen size that is considerably wider than its height. For that reason it is possible to display video in full screen and still have a considerable amount of usable space. This unused space is large enough to display a considerable amount of information. The service concepts of this Thesis use that space for the interactive services and banners. For more information on the interactive service concepts of this Thesis refer to Chapter 6.

*A8. It is unknown exactly how will the interactive services look like. However, in terminals with a wide screen, it is possible that a lateral section of the screen is used for the interactive services and banners.*

### ***Q9. What are the major challenges the interactive services face?***

The interactive services are based on banners. Even though implementing interactive banners is not a big problem, TV shows and popular content are expensive to use. For that reason creating banners that are related to the content could be expensive for organizations different from the content provider of the TV show. For

example, paying the royalties needed to use logos, TV show information and names could be too expensive. This problem could be tackled up to some point by using third-party shopping channels.

The most pragmatic scenario is one in which cooperation exists between the several organizations that play a role in the IPDC value chain. The cooperation between service operators and content providers is of much importance. Content providers have all the rights to the content and it is likely that they will also have the rights for the most popular services. However, content providers directly need the service operator to reach users. Service operators on the other hand will get revenue mostly from the use of the cellular networks. The service operators already have the subscribers and much knowledge about them. This knowledge is of great importance to reach potential customers. Furthermore, it is possible that they will have control over the software application that the mobile TV terminals will use. However, to take advantage of these networks they need to provide appealing services. For these reasons, both content providers and service operators have to reach an agreement. Service operators should be able to afford paying for TV show royalties to provide interactive and content related services. In return, the service operator will provide the content provider the means to reach its base of potential customers.

*A9. Agreement between organizations involved in the value chain is the major challenge for interactive services. Royalties for TV show related content should be affordable for service operators. In return, content providers should be able to reach the service operator's customers.*

## 7.5. Limitations

The use of interactive services in IPDC applications has not been tested. The technology is not available and it will continue this way for some time. The IPDC business opportunities of the value chain are still under study. This Thesis helps understand how these new business models can be applied in IPDC.

In the case of Finland, it is hard to produce mobile only content due to the scarce population. Creating mobile only content is expensive and might not get enough revenues. Therefore, the amount of mobile only content created will differ from country to country. Additionally, if foreign programs are used, they need either to be

translated or use subtitles. In Finland, subtitles are normally used with foreign programs. However, reading subtitles in a considerably smaller screen might be hard or annoying for users. Creating new services is a challenge and making them appealing for consumers is difficult. Thus, the decision of what kind of mobile only content will be created should be taken carefully.

Moreover, the spectrum constraints are still unresolved and the pilots developed have not tested all the functionality of IPDC and DVB-H. For example, the pilots are still using compression methods inherited from DVB-T. To be specific, H263 is used instead of H.264. Furthermore, MPE-FEC had not been tested in the pilots that had concluded at the time of this study. Additionally, some of the preliminary results from the pilots have shown that indoor coverage requires the use of many gap-fillers. Finally, it is still unclear whether consumers will like the technology and if transparent interactivity will be appealing enough.

## 8. Conclusions

DVB-H is a standard that makes it possible to deliver live broadcast television through the use of IP datacasting to a mass audience. However, interactivity in mobile TV applications is a new concept and has not been tested. The objective of this thesis was to test the feasibility of providing transparent interactivity to users through different communication channels such as GPRS or W-CDMA. That is, the users should not be aware of the technology that is being used. Furthermore, mobile terminals are personal items. Therefore, mobile TV applications should provide a personalized experience to the user.

This study started by gathering the high-level goals of such an application and designing a software application that would provide transparent interactivity. Then, a prototype was implemented to test if the design proposed was feasible for providing transparent interactivity. Finally, interactive service concepts were developed and presented. The results of the implementation phase revealed that it is possible to provide transparent interactivity within a mobile TV application. Furthermore, user customization is possible as well. Customization plays an important role to provide the user a personalized service. However, developing the whole application with all the functionality proposed in this thesis is difficult. The application proposed relies heavily on the standardization of the electronic service guide. The electronic service guide needs to be robust enough to describe the services in detail. Otherwise, filtering of services and customization might not be possible as proposed in this thesis. Additionally, a shortcoming of the study is the lack of empirical material regarding mobile broadcast services. Since the mobile broadcast services were still in initial

trial/pilot stage at the time of this study, no real commercial mobile broadcast business systems existed. Moreover, interactive services have not been tested and therefore it is unclear whether the users will find them attractive or not.

Finally, even though the technology to provide mobile TV services exists, key regulatory and business issues still need to be resolved. Countries and organizations must reach assent to decide the frequency spectrum to be allocated for DVB-H. Furthermore, content providers, service operators and other members of the value chain should consider how mobile TV services may be integrated into their strategy and business models.

## 8.1. Future Work

The next steps to research in IPDC are to carry out tests on users and analyze their response to interactive services and customization. The implementation of the search engine itself is a broad topic. The search engine is a core element for providing a personalized experience. It shall be able to filter the services from the electronic service guide in an intelligent way. Furthermore, it should be able to queue the results and, generate additional searches automatically with more general parameters automatically if the original search provided bad results. Additionally, the different business models, revenue flows and service pricing should be studied further.

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# Appendix A

## Complementary Software

The interactive service concepts were implemented as an animation to provide the look and feel of what the real services would look like. The animation is included as complementary software in this thesis. The software is in the CD that accompanies this thesis.

**Requirements:** The only software required to run the animation are the Flash Player and Shockwave Player plugins. The plugins can be downloaded directly from Macromedia through the following web address:

<http://www.macromedia.com/shockwave/download/alternates/>

**Instructions:** The animation comes in two different versions, high quality and low quality video respectively. In order to play the animation, select and execute the file that corresponds to the quality of your choice

The animation files are also available from the following web addresses:

### **High quality video**

[http://www.andreasarjona.com/thesis/andres\\_arjona\\_thesis\\_anime\\_high.exe](http://www.andreasarjona.com/thesis/andres_arjona_thesis_anime_high.exe)

### **Low quality video**

[http://www.andreasarjona.com/thesis/andres\\_arjona\\_thesis\\_anime\\_low.exe](http://www.andreasarjona.com/thesis/andres_arjona_thesis_anime_low.exe)