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# A Cross Domain Next Generation Network IPTV Client for Media Center environments

DIPLOMA THESIS

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# Abstract

Functions, which can be summarized to the keyword Internet Protocol Television (IPTV) describe the transmission of video services to users via Internet Protocol (IP). Accompanying to this new television transmission path Home Theatre PCs (HTPC) running a so called Media Center platform are more and more entering the living rooms as a companion for the popular LCD and Plasma displays. Perfect ease of use and the visual integration on the screen and also into the living room is raising their acceptance. These HTPCs are a central node for multimedia services such as TV, radio and email within the networked household. Thus, there are good preconditions for the use of a HTPC as end device for Telco operator driven IPTV and telecommunication services.

In the context of this diploma thesis possibilities for the provisioning of IPTV and Next Generation Network (NGN) services on a converged multimedia home entertainment platform for the living room will be investigated, especially Vista Media Center platforms. For this reason, standardization activities will be investigated, which deal with the integration of IPTV and telecommunication services into NGN. The validation of the results will be achieved by the design and implementation of a Vista Media Center Add-In, which can be integrated as an IP Multimedia Subsystem (IMS) based User Agent (UA) in ETSI TISPAN Release 2 IPTV infrastructures. Additionally, a Cross Domain messaging service for IMS based UA is created, which enables a cross-network communication between users.

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## Abbreviations

| | |
|---|---|
| AAA | Authentication, Authorization and Accounting |
| ADSL | Asymmetrical Digital Subscriber Line |
| AJAX | Asynchronous JavaScript and XML |
| API | Application Programming Interface |
| AS | Application Server |
| ASP | Active Server Pages |
| BCG | Broadband Content Guide |

| | |
|---|---|
| CAB | Composite UI Application Block |
| CATV | Cable Television |
| CS | Call Server |
| CSCF | Call Session Control Function |
| DCT | Discrete Cosine Transformation |
| DLNA | Digital Living Network Alliance |
| DOCSIS | Data Over Cable Service Interface Specification |
| DSL | Digital Subscriber Line |
| DSLAM | Digital Subscriber Line Access Multiplexer |
| DVB | Digital Video Broadcasting |
| DVD | Digital Versatile Disc |
| DWT | Discrete Wavelet Transformation |
| EPG | Electronic Program Guide |
| ETSI | European Telecommunication Standards Institute |
| GPL | General Public License |
| GSDZ | Gemeinsame Stelle Digitaler Zugang |
| GSM | Global System for Mobile Communications |
| GUI | Graphical User Interface |
| HDTV | High Definition Television |
| HNED | Home Network End Device |
| HSS | Home Subscriber Server |
| HTML | Hypertext Markup Language |
| HTPC | Home Theatre Personal Computer |
| HTTP | Hypertext Transfer Protocol |
| I-CSCF | Interrogating Call Session Control Function |
| IGMP | Internet Group Management Protocol |

| | |
|---|---|
| IM | Instant Messenger |
| IMS | IP Multimedia Subsystem |
| IP | Internet Protocol |
| IPTV | Internet Protocol Television |
| ISDN | Integrated Services Digital Network |
| ISO | International Organization for Standardization |
| ITU | International Telecommunication Union |
| ITU-T | International Telecommunication Union – Telecommunication Standardization Sector |
| JPEG | Joint Photographic Experts Group |
| JVT | Joint Video Team |
| LAN | Local Area Network |
| LINQ | Language Integrated Query |
| MAC | Media Access Control |
| MCML | Media Center Markup Language |
| MGCF | Media Gateway Control Function |
| MGW | Media Gateway |
| MHP | Multimedia Home Platform |
| MILAB | Media Interoperability Lab |
| MMS | Microsoft Media Server Protocol |
| MPEG | Moving Picture Expert Group |
| MRFC | Media Resource Function Controller |
| MRFP | Media Resource Function Processor |
| MSNP | Microsoft Notification Protocol |
| MSRP | Message Session Relay Protocol |
| NGN | Next Generation Network |

| | |
|---|---|
| NPVR | Network Personal Video Recorder |
| NTBA | Network Termination for ISDN Basic rate Access |
| OSI | Open Systems Interconnection Model |
| P-CSCF | Proxy Call Session Control Function |
| POTS | Plain old telephony service |
| QoE | Quality of Experience |
| QoS | Quality of Service |
| RFC | Request for Comment |
| RTCP | Real Time Control Protocol |
| RTP | Real Time Transport Protocol |
| RTSP | Real Time Streaming Protocol |
| S-CSCF | Serving Call Session Control Function |
| SCTP | Stream Control Transmission Protocol |
| SDK | Software Development Kit |
| SDNS | Service Discovery and Selection |
| SDO | Standard Development Organization |
| SDP | Session Description Protocol |
| SGW | Signalling Gateway |
| SIP | Session Initiation Protocol |
| STB | Set Top Box |
| TCP | Transmission Control Protocol |
| TISPAN | Telecommunication and Internet converged Services and Protocols for Advanced Networking |
| TLS | Transport Layer Security |
| UA | User Agent |
| UAC | User Agent Client |

| | |
|---|---|
| UAS | User Agent Server |
| UDP | User Datagram Protocol |
| UE | User Equipment |
| UGC | User Generated Content |
| UHF | Ultra High Frequency |
| UI | User Interface |
| UMTS | Universal Mobile Telecommunication System |
| UPnP | Universal Plug and Play |
| UPSF | User Profile Server Function |
| VDSL | Very High Speed Digital Subscriber Line |
| VLC | Video LAN Client |
| VMC | Vista Media Center |
| VoD | Video on Demand |
| VoIP | Voice over Internet Protocol |
| VS08 | Visual Studio 2008 Professional |
| WCF | Windows Communication Foundation |
| WF | Windows Workflow Foundation |
| WLAN | Wireless Local Area Network |
| WMCPL | Windows Media Center Presentation Layer |
| WMS | Windows Media Service |
| WMV | Windows Media Video |
| WPF | Windows Presentation Foundation |
| WWW | World Wide Web |
| XAML | Extensible Application Markup Language |
| XCAP | Extensible Markup Language Configuration Access Protocol |
| XML | Extensible Markup Language |

# 1 Introduction

## 1.1 Motivation

Until now television has been a unidirectional experience. The user receives and consumes media content, without any interaction. The next generation of television breaks with this tradition and provides new possibilities for users.

The transmission of television content via the Internet Protocol[1] (IP), the so called Internet Protocol Television (IPTV), provides crucial advantages in contrast to the conventional transmission paths (satellite, cable and terrestrial). Via the available back channel, user feedback and information can be exchanged. In contrast to the capabilities of traditional broadcast technology, IPTV enables enhanced multimedia services by the distribution of additional video, audio, text, pictures or data. All this capabilities allows an interaction with the user and drive the development of corresponding new interactive value-added services. Leading telecommunication companies already offer IPTV, which contain interactive services like Video on Demand[2] (VoD), an Electronic Program Guide[3] (EPG) or Time-Shifting[4].

Recent Personal Computers are evolving more and more towards home entertainment solutions. These computers represent the evolution of legacy PCs into digital media hubs that bring together the advantages of cheap PC platforms, multimedia entertainment and digital television services. With so called extender solutions it is possible to distribute media content in the networked household, e.g. with a game console to the children room. Thus, all digital media content can be accessed with one remote control in multiple rooms of the networked household. A next evolutionary step seems to be a merger between Set-Top-Boxes (STB) and more powerful PC hardware. These so called Home Theatre

[1] Internet Protocol: is a popular network protocol for interconnected systems of packet oriented computer communication networks. It is defined in RFC 791 [109] and located in layer three of the OSI model.

[2] Video on Demand: describes the possibility to receive digital media content at a desired time of the user. The content will be transmitted as a video stream.

[3] Electronic Program Guide: provides information about the current and future television shows in an electronic style. Usually on television screen. [89]

[4] Time-Shifting: the user consumes a recorded stream while the original broadcast signal will be recorded in the background. This enables time-displaced consume of content to the original broadcast signal [89].

PCs (HTPC) running a Media Center platform[1] are more and more entering the living rooms as a companion for the popular LCD and Plasma displays. Perfect ease of use and the visual integration on the screen as well as into the living room is raising their acceptance. Thus, they might be used as end devices for Telco operator driven IPTV services, which enables a new Quality of Experience[2] (QoE) for the user and also a seamless integration of IPTV and Telecommunication services into the entire networked household. This integration includes all media player enabled devices and all mobile end devices. Figure 1.1 depicts an example of a Media Center based HTPC system.


Figure 1.1: Example of a Media Center based HTPC system

To enable this vision, Next Generation Networks[3] (NGN) have evolved towards a platform for the transmission of multimedia content. These NGNs provide the required level of quality, security and reliability to ensure a smooth playback of media content. For this reason, large parts of the telecommunication industry and Standard Development Organizations (SDO) are currently working on the development of IPTV systems and open standards. The main developers of these open standards are international and european standardization organisations, e.g.:

- International Telecommunication Union – Telecommunication Standardization Sector[4] (ITU-T)

[1] Platform: describes an execution environment for applications.

[2] Quality of Experience: is a subjective measure of a customer's experience with an application or hardware equipment.

[3] Next Generation Network: describes a network in telecommunication infrastructures which replaces conventional line oriented infrastructures to packet oriented infrastructures [7].

[4] International Telecommunication Union: is the leading United Nations agency for information and communication technologies. They are working on three core sectors: radio communication, standardization and development [96].

- European Telecommunications Standards Institute[1] (ETSI) - Telecommunications and Internet converged Services and Protocols for Advanced Networking[2] (TISPAN)
- the Digital Video Broadcasting[3] (DVB) Project
- the Open IPTV Forum[4]

These organizations develop new standards for appropriate scenarios, network and software architectures and also signal and transport protocols for the transmission and control of multimedia content. To support seamless access for the user to these new services, the integration of existing services should not be ignored. This refers particular to existing Web 2.0[5] services or Instant Messaging[6] (IM) communication.

## 1.2 Aims of this diploma thesis

The aim of this diploma thesis is the design and implementation of an IPTV client Add-In[7] for a homogenous, interactive and expandable Vista Media Center (VMC) platform.

Current standards, of international and european standardization committees, which define the integration of IPTV in NGN and the IP Multimedia Subsystem[8] (IMS) will be analyzed and explained.

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[1] European Telecommunications Standards Institute: is one of the three major standardization organizations in Europe which produces globally-applicable standards for information and communications technologies [87].

[2] Telecommunications and Internet converged Services and Protocols for Advanced Networking: is a sub organization of ETSI which defines Next Generation Network specifications [113].

[3] Digital Video Broadcasting Project: is an industry-led consortium of broadcasters, manufacturers, network operators, software developers and regulatory bodies. This project designs open interoperable standards for the global delivery of digital media services [86].

[4] Open IPTV Forum: is a consortium of telecommunication companies and research institutes to develop specifications and standards for IPTV [97].

[5] Web 2.0: describes a concept for new interactive technologies and services in the World Wide Web.

[6] Instant Messaging: describes the possibility to send text-based messages between two or more users [58].

[7] Add-In: is an optional module, which extends existing hard- or software.

[8] IP Multimedia Subsystem: is a cross-network service platform, which provides mechanism for a standardized access to services from different telecommunication networks. It is for an All-IP network like NGN [7].

The IPTV Vista Media Center Add-In will unite different IPTV[1] and telecommunication services in one application and show its interaction on the basis of IMS and the Session Initiation Protocol[2] (SIP).

Finally, the developed IPTV Vista Media Center client will be integrated into the test bed environment of the Media Interoperability Lab[3] (MILAB) at Fraunhofer FOKUS[4], to demonstrate the possibilities of IPTV and innovative interactive rich media applications in combination with the Vista Media Center platform and NGN. Figure 1.2 depicts the MILAB architecture and visualizes on the left side in red colour the implementation part of this diploma thesis. The components of the architecture will be explained in chapter three.

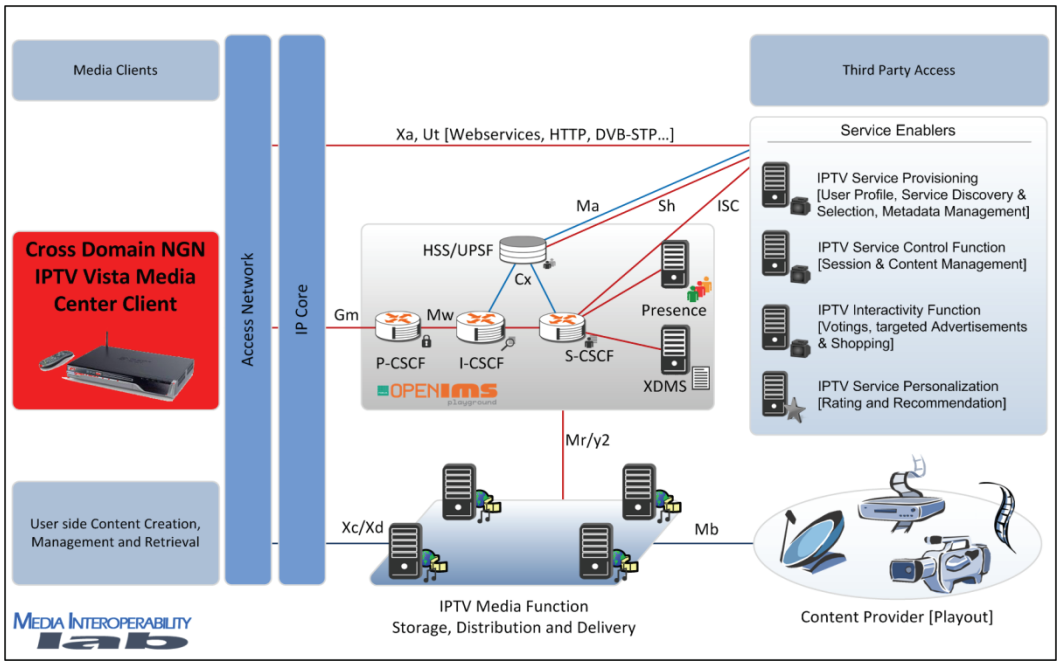


Figure 1.2: Integration of IPTV VMC client in MILAB environment

## 1.3 Chapter overview

Chapter two contains the basics of IPTV. These include the requirements for the transmission network and the home network, the encoding of video content

[1] IPTV services: e.g. IPTV Live TV or VoD. See chapter 4.2.2 for further information.

[2] Session Initiation Protocol: is a protocol for controlling sessions between two or more users [13]. See chapter 3.5 for further information.

[3] Media Interoperability Lab: a competence centre of Fraunhofer FOKUS for IPTV [117]. See chapter 3.6 for further information.

[4] Fraunhofer Institute for Open Communication Systems: is an institute, which research and develops solutions for industry, research field and state agencies, e.g. communication technologies and services and their interoperability [116].

as well as required transport and control protocols[1]. Furthermore the IPTV transmission path will be compared with conventional transmission paths.

An overview of NGN and IMS is provided in Chapter three. The chapter contains current results of standardization committees and the explanation of SIP, which is used as signal protocol in IMS.

Chapter four contains the development of a requirement catalogue for an NGN IPTV Media Center client. Based on these results, the implementation of the IPTV client is described in detail.

Chapter five contains an analysis of IM in an IMS environment via SIP and the implementation of a cross domain messaging service for IM via Internet. Based on a requirement catalogue, the implementation of this service is described in detail.

Chapter six summarizes the results of this diploma thesis and contains an outlook of the topic IPTV and NGN.

[1] Protocol: is the definition of a procedure of a connection between two or more partners.

# 2 IPTV

## 2.1 IPTV - Web-TV

In public, different terms and abbreviations are known for services, which describe the transmission of media content over an IP based network. For this reason, it is necessary to explain the concepts of these terms to avoid confusion.

Keywords such as IPTV or Web-TV are generally used within public. They are often regarded as similar, because both transmit media content, as streaming video or Live TV, via IP.

With the increase of data transmission rates with broadband Internet[1] accesses and new video data compression algorithms it is possible to distribute media contents over the open Internet. This form is called Web-TV and is presented on video portals[2] like YouTube, Clipfish or the ZDF Mediathek [1]. Web-TV is very popular. A third of German households already have access to television offers via the open broadband Internet [2]. The media content is mostly free available and only a few requirements are necessary for consumption of this television content: a PC system with appropriate software and a broadband Internet access. This can be a standard non professional PC system in a household or a mobile end device on the go. However, a large disadvantage of this transmission path is that it cannot assure any warranties for quality, security and/or availability. This is due to the openness of the Internet. Each person can store a self created video, e.g. with a mobile camera, at a video portal like YouTube. The quality is quite often unacceptable and there is no comparison to the quality of standard television. The reasons for that lie in the lower resolution[3] and bit rate[4] in contrast to standard television.

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[1] Internet: describes a global system of interconnected computer networks for public, private, academic, business and government uses. A popular Internet service is the World Wide Web.

[2] Video portal: is a website which offers video content often in combination with community services, e.g. YouTube [124]. With video content, which is created by the user, will be spoken of User Generated Content (UGC).

[3] Resolution: describes the amount of pixels in horizontal and vertical way of a picture, video or display.

[4] Bit rate: is the ratio between time and a volume of data. The measure will be denoted in bit per second or bit/s. A bit is a unit of computer science.

In contrast to Web-TV, IPTV is distributed over a managed package orientated network via IP. With this transmission path it is possible to keep a certain level of Quality of Service[1] (QoS) and availability. However, for the transmission of the media content advanced distribution technologies are used (see chapter 2.7). For this reason, specific receivers are necessary, e.g. a Set Top Box[2] (STB), which receives the data stream and present the media content on an end device. Such an end device is usually a TV Set. As a result IPTV can be consumed like conventional television, which has great advantages for the consumer. There is no need for any special knowledge. The Hardware can be controlled by simple operating a remote control.

## 2.2 Definition of IPTV

The ITU-T – Focus Group on IPTV (FGIPTV) had defined IPTV as follows:

“IPTV is defined as multimedia services such as television, video, audio, text, graphics, data delivered over IP based networks managed to provide the required level of QoS, QoE, security, interactivity and reliability.” [3]

This definition describes the transmission of multimedia content, e.g. moving picture content as streaming video, over a managed IP based network, which keeps a certain QoS, security and reliability. In the context of this diploma thesis the term IPTV relies on this definition.

The distribution of IPTV requires a strong network infrastructure, which implements the necessary QoS, security and reliability. This would be possible with the interaction of service-, content- and access providers and the use of NGN in combination with IMS. In Chapter three of this diploma thesis such an infrastructure is described in detail.

## 2.3 Comparison with conventional transmission paths

Media content can be distributed via different transmission paths. The conventional methods are the transmission via satellite, cable or terrestrial networks. Within a total of 37.277 million German TV households the transmission via ca-

[1] Quality of Service: is an acronym for mechanism, which ensures the quality of transmission for real-time data [13].

[2] Set Top Box: is an equipment item, which provides additional functionality for other entertainment equipment, e.g. for end devices like television.

ble is the largest with 52.5 percent, followed by the transmission via satellite with 42 percent and via terrestrial transmission with 11.1 percent [2]. The sum is over 100 percent, because some households own more than one TV Set and receive their television content via different transmission paths.

With IPTV arises a fourth transmission path. Such a path is usually offered by local telecommunication companies in form of broadband connections. The IPTV package often consists of a Triple Play offer, meaning that the consumer has the benefit of using only one company for their telephone, television and Internet.

Another advantage of IPTV is the interactivity. By the IP based network a back channel is provided, which can send information and data back to service providers. On this basis different services can be developed, which provides the user an added value, e.g.:

- E-Commerce[1]
- Content Recommendation
- Personalization

A recommendation service reacts to the desire and activities of the user. Users have the choice to get their consuming behaviour analysed and to obtain new offers that possibly suit their interests. Such value-added services are not possible with the conventional transmission paths, due to the lack of a missing back channel.

Another approach for developing such value-added services for the conventional transmission paths is the usage of a hybrid[2] STB. These STBs combine the receiving of media content via conventional transmission path with a back channel, e.g. via the Internet. Such a concept was realized by the company TechnoTrend. The hybrid STB receives television content with an attached DVB-S[3] Signal and supplements the content with VoD offers and EPG data,

[1] E-Commerce: describes a virtual shopping transaction via data connection.

[2] Hybrid: combines two different technologies in one system.

[3] DVB-S: distribution of a digital signal (DVB) via geostationary satellite [13]. Defined in standard ETSI EN 300 421 [83].

which can demand via a Digital Subscriber Line[1] (DSL) broadband connection. This hybrid box was presented to the public at the “Internationale Funkausstellung” 2008 in cooperation with the public sector broadcasters ARD [4] and ZDF [5] (see Figure 2.1).

The Multimedia Home Platform (MHP) of the DVB project is a precursor of interactive television presented on STBs. MHP is a standard for transmission and presentation of interactive content. The applications for MHP are based on Java[2] or the Hypertext Markup Language[3] (HTML). The actual version of the standard is 1.2. For further information see [6].

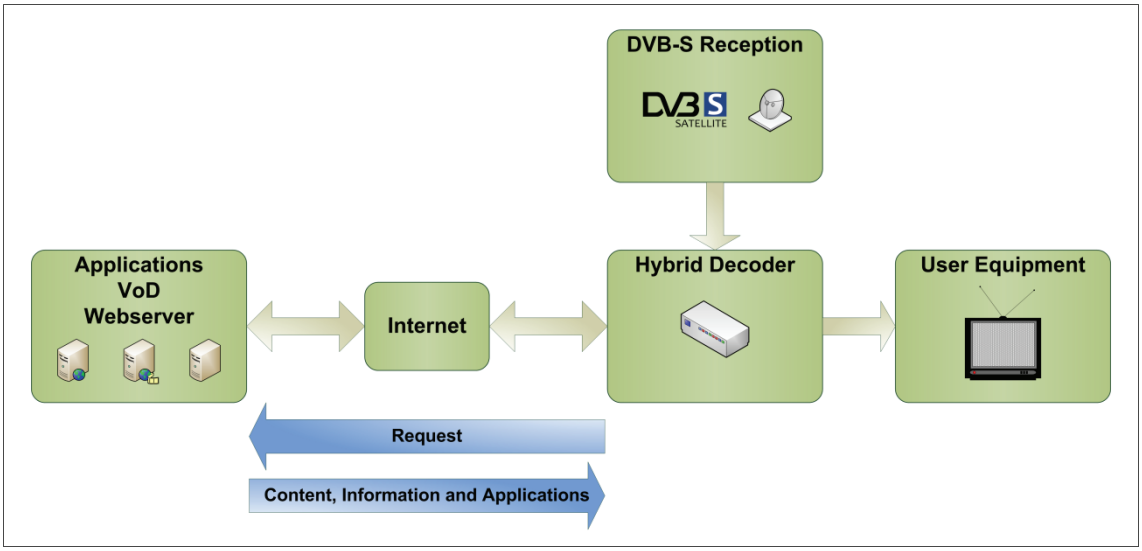


Figure 2.1: IRT Hybrid box concept

The STBs can be addressed uniquely by the usage of IP and the Media Access Control[4] (MAC) address. This offers an approach for the billing of consumed VoD content, because a content provider can simply assign a user to an account.

[1] Digital Subscriber Line: is a collection of transmission standards for high speed data transmissions via a copper wire. Transfer rates up to 200 MBit/s are possible [12].

[2] Java: is an object oriented programming language developed by the company SUN. The applications will be executed by an interpreter, known as the Java Virtual Machine [82].

[3] Hypertext Markup Language: is a text based markup language, which provides for the presentation of websites. It is located in layer seven of the OSI model and specified for version 4.01 [93] by the World Wide Web Consortium [123].

[4] Media Access Control address: is the hardware address of a network adapter. This provides for a uniquely identification of a terminal or end device in a computer network. The MAC address is settled in layer two of the OSI model. An example of an MAC address is: 00:0A:E4:3F:54:C2

All the mentioned facts above occupy that IPTV offers new possibilities for users and service-, access- and content-providers.

## 2.4 Requirements for receiving IPTV

IPTV uses a new transmission path. For this reason, it is necessary to clarify the requirements for the receiving and consumption of media content.

For the usage of IPTV, surfing in the Internet and maybe voice services on a common data line it is necessary that the user has access to a package oriented network with a large bandwidth and QoS. These connections are usually offered by local telecommunication companies with Triple Play and NGN, e.g. a broadband DSL access or a connection via a cable television network[1] (CATV).

DSL exists in different standards. The basic principle describes the transmission of data over a telephone network. For this reason, an extended spectrum of the frequency band is used. Figure 2.2 depicts the spectrum of a conventional telephone line, which is connected to a telephone network with a copper wire.

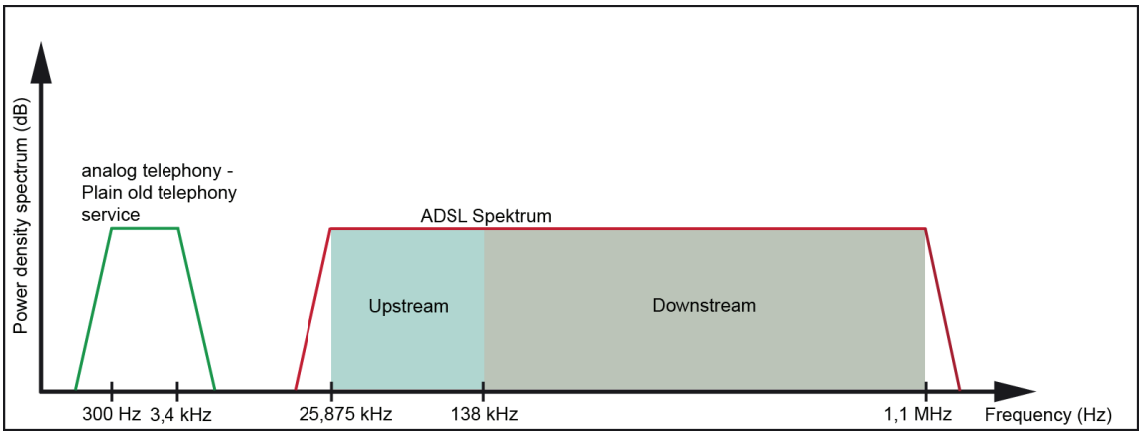


Figure 2.2: Spectrum of an ADSL connection

A voice service (like telephony) get multiplexed with a data service in a hardware component (Splitter) and is transmitted via a copper wire. This signal is sent to a local exchange place. In the local exchange place the signal becomes demultiplexed, the voice service is passed into the telephone network and the data service into the Internet [7]. With Triple Play offers it is possible to remove

[1] Cable television network (CATV): is a cable distribution network for different usage, e.g. transmission of analog and/or digital television content or access to a broadband packet based network [13].

the Splitter, because the voice service is also realized over the package oriented network with Voice over IP[1] (VoIP).

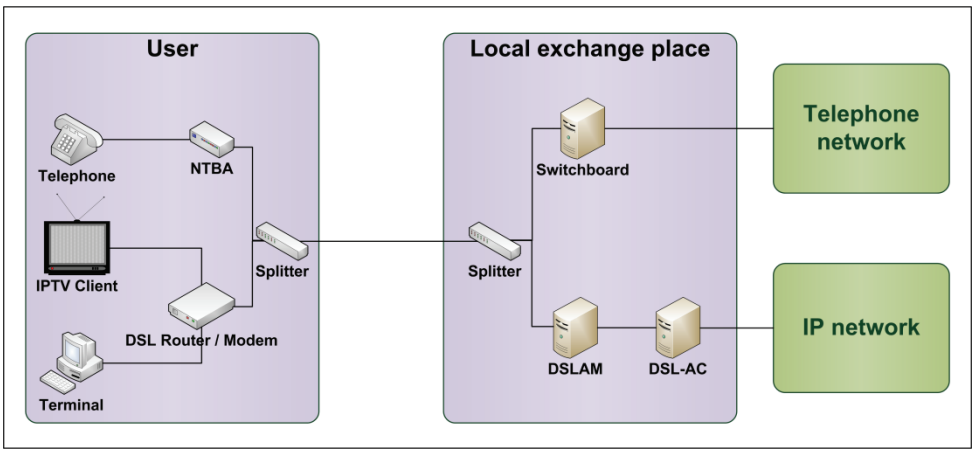


Figure 2.3: Illustration of a DSL connection

Figure 2.2 depicts that the lower frequency range is used by the voice service and the extended upper range is used by the data service. The data service is once again divided asymmetrical. This separation provides a higher speed rate in the downstream[2] than in the upstream. Different bandwidths are possible and depend on the used standard.

| | Frequency band | Data transmission rate |
|---|---|---|
| ADSL | Up to 1,1 MHz | 6 MBit/s downstream |
| ADSL2 | Up to 1,1 MHz | 8 MBit/s downstream |
| ADSL2+ | Up to 2,2 MHz | 16 MBit/s downstream |
| VDSL | Up to 12 MHz | 50 MBit/s downstream |
| VDSL2 | Up to 30 MHz | 200 MBit/s as sum in up and downstream |
| All listed rates are in combination with Plain old telephony service[3] (POTS). See [8], [9], [10], [11], [12] and [13]. | | |

Table 2.1: Overview of DSL technologies

[1] Voice over IP: is a synonym for telephone calls, which are transmitted via IP.
[2] Downstream: describes the data flow from a server to a client. Opposite from upstream.
[3] Plain old telephony service: is an analog telephony technology transmitted via copper wire.

Another possibility to get access to a package oriented network is via CATV. These connections can use a larger frequency spectrum than DSL [14]. Originally cable systems only provide the reception of television content. They are unidirectional, i.e. they have no capabilities for a back channel. However, this is necessary for a data service, e.g. send a request for subscribing to an IPTV Live TV channel. To realize an upstream the cable network operators have renewed their infrastructures. The back channel is now in the range between 5 and 65 MHz. The television channels which were at this range beforehand were moved into an unused lower part of the Ultra High Frequency[1] (UHF) band. With the implementation of the Data Over Cable Service Interface Specification[2] (DOCSIS) version 3.0 data rates up to 160 MBit/s in the downstream [15] are possible.

The explained technologies provide only for the transmission of data packets. For the processing of data packets and presentation of media content further devices are required.

## 2.5 Home Network End Devices

In order to consume media content on a television screen the user needs a Home Network End Device (HNED). This HNED is usually a STB, which is connected with television equipment and which presents the media content on the screen.

The user should be able to reuse his STB when he changes his IPTV provider. In order to ensure this interoperability of STBs within various IPTV platforms standardized solutions should be applied, e.g. usage of standardized signal and transport mechanism by the IPTV providers or usage of standardized basic requirements of the STB hardware platform by the manufacturers. This ensures that the basic functions ,of each STB, are supported, e.g. channel selection, decoding[3] and presentation of media content.

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[1] Ultra High Frequency: is a frequency range for micro waves, which have a wave length between one and ten decimetre. This is a frequency range from 0.3 to three GHz [13].

[2] Data Over Cable Service Interface Specification: is a standard, which defines the interface requirements for cable modems in a broadband cable television network for high speed data transmissions [15].

[3] Decoding: recovery of information, e.g. to reconstruct a picture [73].

Another approach for the interoperability of STB could be the usage of profiles[1], which subdivide the required functionality, e.g. basic profile, basic plus profile or interactive profile (see [16]).

In the implementation part of this diploma thesis standards for signal and transport mechanism of ETSI TISPAN are applied. For this reason, any IPTV provider, which uses the standards of ETSI TISPAN, can ensure the functionality and interoperability of the Media Center STB.

In addition all HNEDs should comply with specifications from the Digital Living Network Alliance[2] (DLNA) or Universal Plug and Play[3] (UPnP). With the DLNA Networked Device Interoperability Guidelines increases the user experience. An end device which is developed upon these specifications is able to connect easily to each DLNA compliant end device in a networked household to share media content via a transmission network. Therefore a home network is required, which link all HNEDs and provide them access to the managed IP network. The specifications are based on open standards and widely available industry specifications.

## 2.6 IPTV and the Home network

The IP access network connection is usually used by several end devices in the household for different services, e.g. STB for IPTV or a PC for the World Wide Web[4]. For this reason, a private home network is necessary, which provides a possibility to use several end devices with the same access network connection.

This home network should fit with the QoS and speed rate of the access network connection.

[1] Profile: defines what requirements are necessary to ensure a specified functionality.

[2] Digital Living Network Alliance: is an association which defines standards for end devices in the home area [91].

[3] Universal Plug and Play: is a set of computer protocols to allow a seamless connection of end devices in the home area [118].

[4] World Wide Web: is a popular Internet service. This service presents media content on web pages to the user.

This could be technologies like:

- Ethernet
- Wireless Local Area Network[1] (WLAN)
- Power Local Area Network (Power LAN)

Ethernet is a technology for the transmission of data within local wired networks, which is defined in the standard IEEE[2] 802.3 [17]. Therefore, it is necessary to lay cable from the IP access network connection to each end device. A disadvantage is obvious. With several end devices in a multi-level household a lot of cables have to be laid out. This could end in high costs for the user. The Ethernet technology specified several data transmission rates. A data transmission rate at least of 100 MBit/s is recommended. This already covers future increases of broadband connections on the market place.

WLAN is a technology for the transmission of data over air. The main advantage here is that it is not necessary to lay any cables to the equipment in the household. However, there is also a large disadvantage. The signal strength could vary by the absorption of electronic waves by air, wrong alignment of antennas, different built volumes of walls and other radio networks, which are placed on the same frequency channel as the own. An encryption for the network is urgently recommended, because the range of the network could reach over the borders of the household. This provides a safety risk to break into the network, because other users outside of the household can also receive the signal. Thus, they can access to the private home network. The actual standard of WLAN is IEEE 802.11g and has a gross data rate of 54 MBit/s [18]. This rate sinks through obstacles, absorption and disturbance to a lower net data rate. However, by the different factors no statement can be given to the obtained net data rate.

Power LAN is a good alternative in comparison to other connection possibilities. The end devices will be connected with the already existing electricity infrastructure of the private household and there is no necessity for modifications. Data

[1] Local Area Network (LAN): is a computer network, which is usually extended for a limited area, e.g. a few rooms or a building.

[2] IEEE: Institute of Electrical and Electronics Engineers, Inc.: is a worldwide professional organisation of Engineers [94].

rates up to 200 MBit/s are possible [19]. An advantage of this system is that mostly an electric socket already exists in the near of an end device like the STB. For this reason, no cables need to be laid in the household. The barrier is the electric meter. The transmission can be encrypted, if another user has access to the same electrical infrastructure.

In a household, which would like to use IPTV the following conditions should be fulfilled:

- Broadband access to a managed IP network
- Set Top Box
- Private home network for the simultaneous usage of several end devices at the managed IP access network connection

For the implementation part of this diploma thesis a 1 GBit/s Ethernet network and a PC STB with integrated Hard Disk (see Figure 1.1) will be used.

## 2.7 Requirements to the Managed IP network

During the transmission of digital media content, e.g. audio or video, a large amount of data will transferred over the managed IP network.

With the increase of user numbers the load capacity of the IP network rises too. For this reason, approaches for load reduction should be investigated.

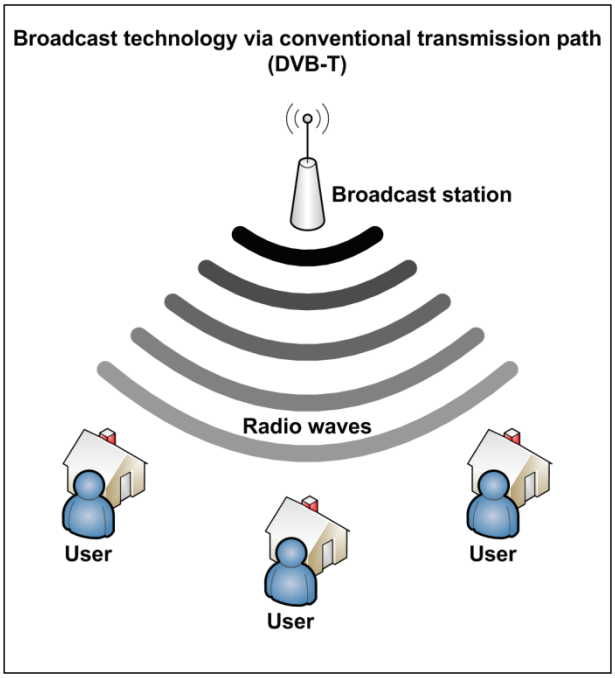


Figure 2.4: Broadcast via DVB-T

Figure 2.4 depicts a conventional broadcast for multiple users from one broadcaster via DVB-T[1]. A distribution like this conventional broadcast transmission cannot be realized in a managed IP network, because IPTV requires other transmission mechanisms. Thus, the transmission of media content via a package oriented network differs to this conventional broadcast technology. Each user receives the data packets, which contain the media content, exclusively. This technology is called Unicast and represents a point-to-point connection. It will be used for Internet services like the WWW.

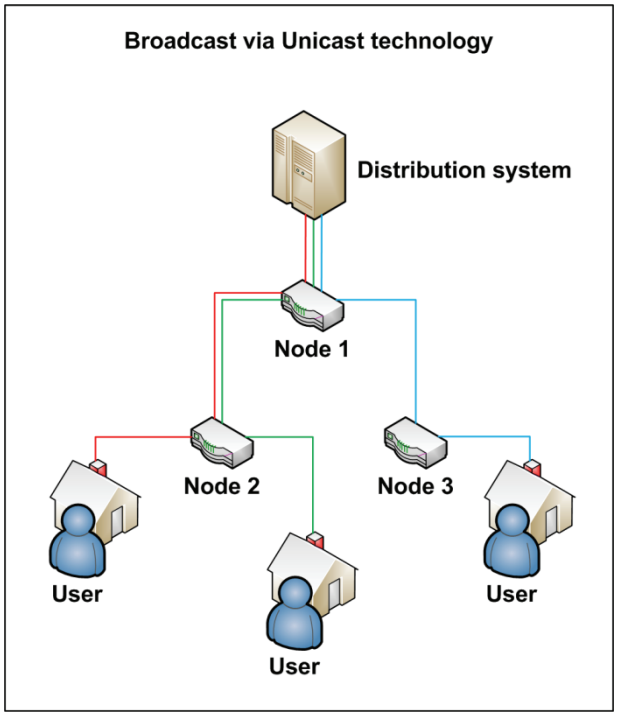


Figure 2.5: Unicast technology

Figure 2.5 depicts the Unicast technology and the proportionally rising of required bandwidth in association with the rising of users, because each user is supplied with an individual data stream. The rising load capacity is also noticeable in the nodes. Node two has a double data-flow rate, because it must supply two users. Node one has the highest load of all. The Node holds three connections to users. This means it has to supply the three-fold amount of data. The following condition can be stated with x users:

*Required bandwidth of the distribution network = x * bandwidth of one stream*

[1] DVB-T: distribution of a digital signal (DVB) via a terrestrial network [13]. Defined in standard ETSI EN 300 744 [85].

The Unicast technology is not advisable for the distribution of IPTV Live TV content, because with the increasing amount of users in the network or nodes could occur errors. Another approach for the distribution of media content over a package oriented network is the usage of the Multicast technology. Figure 2.6 depicts that on the feeder link towards a Multicast enabled node each IPTV Live TV channel of the offered bouquet[1] needs to be transported at least once. If there is at least one user viewing the channel and served by that node, it needs to be transported exactly once on the feeder link. That is because that node can duplicate a flow it receives to as many destinations as have subscribed to that channel. The channel does not need to be transported at all over the feeder link, if there are no users served by that node that are viewing the particular channel. This technique saves considerable transport capacity on those feeder links [20]. Thus, the Multicast technology is comparable with the conventional broadcast technology, because it is a point-to-multipoint connection. Not the entire managed IP network will be flooded with data packets by using the Multicast technology. The data packets will be sent to a logical group, the Multicast group. A group could be the subscriber of a IPTV Live TV channel. For this reason, it is necessary that an end device registers at nodes to be able to receive Multicast data packets.

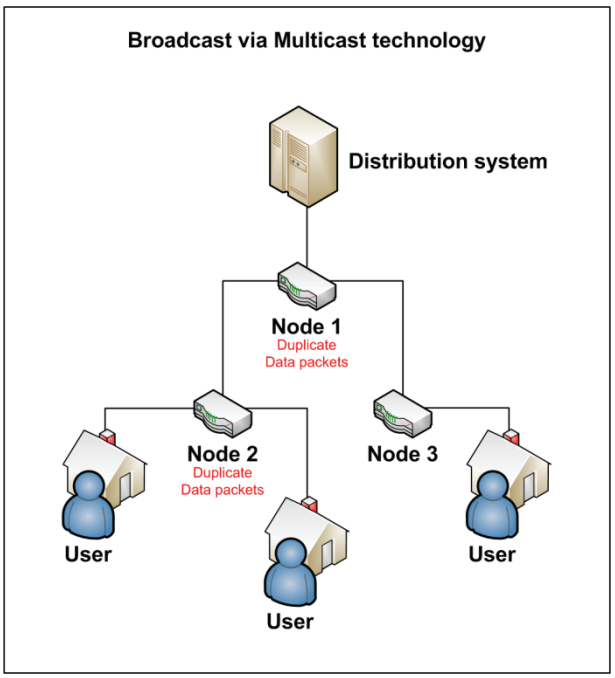


Figure 2.6: Multicast technology

[1] Bouquet: A set of several program stations

The Internet Group Management Protocol (IGMP) was developed for the administration of Multicast groups. It is defined in Request for Comment[1] (RFC) 3376 [21] for version three (IGMPv3). IGMP is located on Layer three of the Open Systems Interconnection[2] (OSI) Model. By using the IGMP message "Membership Report" an end device can join a Multicast group and leave it with IGMP message "Leave Group". A Multicast group is an IP address, e.g. 239.255.255.230. Each end device, which is registered at this Multicast group receives data packets, which are addressed to this group. For IP Multicasting with IPv4 the address range from 224.0.0.0 to 239.255.255.255 (see [22]) is reserved.

If an Ethernet Switch[3] is used in the private home network for distribution of the data packets it should be a managed Switch, which implements IGMP snooping according to RFC 4541 [23]. In the implementation part of this diploma thesis the Multicast technology will be used. However, this technology describes only the mechanism for the transmission of the data packets. Transport and control protocols are necessary for transport and flow control of the data packets.

## 2.8 Transport and control protocols

In order to send real-time[4] media content, e.g. video or audio, to the user via a package oriented network transport and control protocols are necessary.

A transport protocol is for example:

- Real-time Transport Protocol (RTP)
- User Datagram Protocol[5] (UDP)
- Transport Layer Security[6] (TLS)

[1] Request for Comment: A library of Internet standards, e.g. protocols

[2] Open Systems Interconnection Model: is a reference model for data communication [13]. The Model contains seven logical layers and is defined in ISO 7498 [95] of the International Organization for Standardization (ISO) [92].

[3] Switch: is a network component, which connects several LAN segments [13].

[4] Real-time: a term in computer science for the shortest possible duration of a process, e.g. audio transmission like VoIP.

[5] User Datagram Protocol: is a protocol for data transmission between hosts in a packet oriented network. It does not implement mechanism for a safe transmission like acknowledgement. It is defined in RFC 768 [108] and located in layer three of the OSI model.

[6] Transport Layer Security: is a protocol for the encryption of a data communication between a client and a server. It is defined in RFC 4346 for version 1.1 [106] and is located above layer four of the OSI model.

The transport protocols provide a standard for the transmission of data packets. However, they do not implement possibilities for the control of data streams. For this reason, control protocols are necessary.

A control protocol is for example:

- Real Time Control Protocol (RTCP)
- Session Initiation Protocol
- Real Time Streaming Protocol[1] (RTSP)

In an IP network data packets can get lost. A transport protocol like the Transmission Control Protocol[2] (TCP) implements mechanism for a safe transmission of data packets. Each correctly received data packet is acknowledged by the receiver, e.g. computer terminal. The sender observes the acknowledgement with a timer. If a data packet is lost, it will be sent again by the sender. However, the playback element, which renders the media content, cannot wait for the arrival of missed data packets, because a smooth playback must be ensured. Waiting for missed data packets could lead to an interrupted playback. For this reason, it does not make sense to request lost data packets again. Thus the usage of UDP is recommended, which does not implement methods for the repeated sending of lost data packets. UDP realizes the transmission of real-time data via a package oriented network in combination with Multicast technology.

In an IP based network it is also possible that data packets can overtake each other by different node ways (see Figure 2.7). UDP is well suited for real-time data like media content, but by this overtake effect it is possible that data packets arrive at different time at the end device.

[1] Real Time Streaming Protocol: is a protocol for control real-time media content. It is defined in RFC 2326 [75] and located in layer four of the OSI model [13].

[2] Transmission Control Protocol: is a host-to-host protocol between hosts in a packet oriented computer network. It is described in RFC 793 [110] and located in layer four of the OSI model.

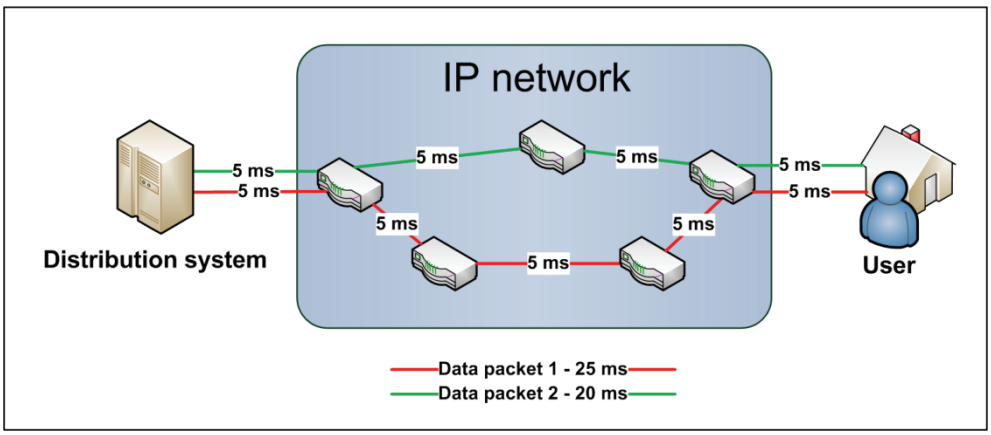


Figure 2.7: Overtake effect of data packets in IP network

UDP does not implement sequence numbers in the header (see Figure 2.8). For this reason the end device cannot correctly order the data packets, which arrive with different time. The rendering of media content could be incorrect, e.g. audio is corrupted. A further protocol should be implemented, which is more specific to real-time data.

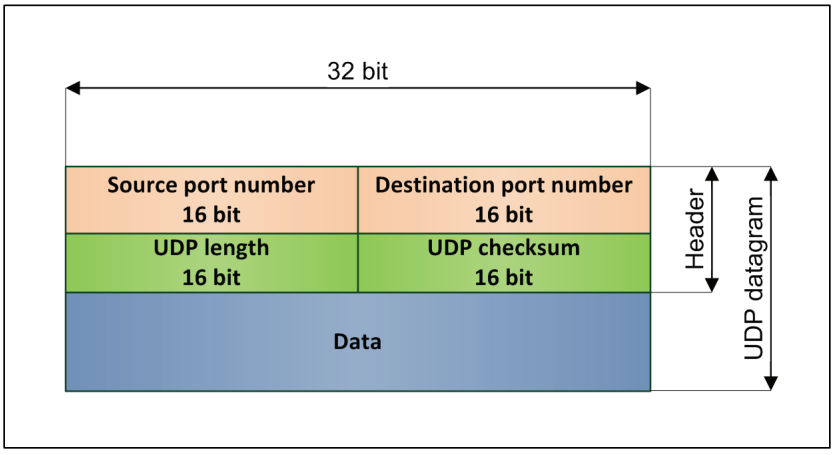


Figure 2.8: UDP datagram

## 2.9 Real Time Transport Protocol

RTP was developed for the transmission of real-time data. It is defined in RFC 3550 [24] and located in layer four of the OSI model. RTP has properties like:

- Sequence numbers
- Timestamp

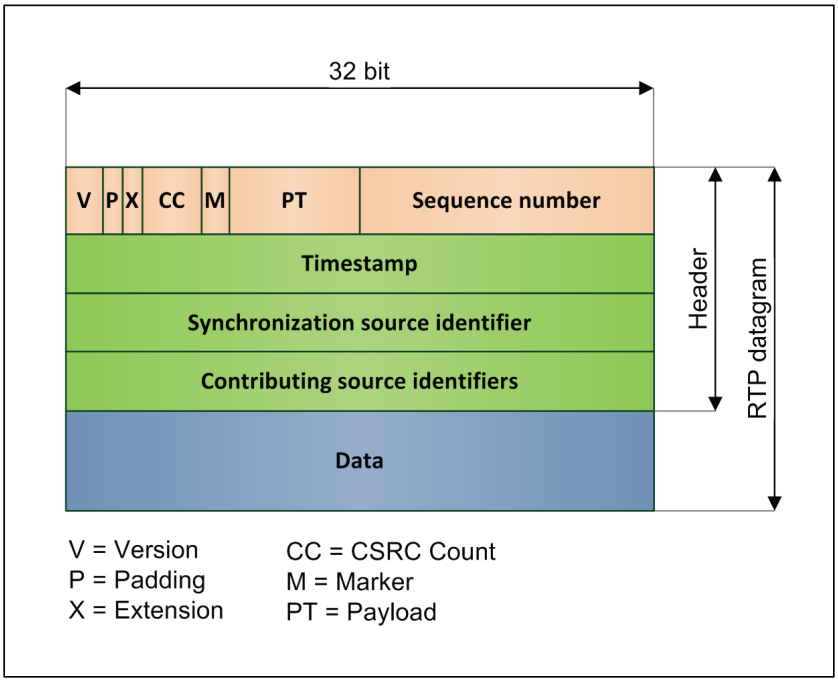


Figure 2.9: RTP datagram

RTP in combination with the Multicast technology is excellently suited for the transmission of real-time media content in a managed IP network, because the sequence numbers provide a correct order of the received data packets at the end device. The timestamp represents the scanning time for the first data byte. This value will be increased. With sequence numbers and the time stamp the end device can playback the media content correctly. The transmission of RTP data packets is unidirectional. In order to keep QoS, which was defined by ITU-T, a protocol should be implemented, which enables the exchange of information between sender and end device. It should exchange information like:

- Latency[1]
- Jitter[2]
- Data packet loss rate
- Data throughput

This information is implemented with RTCP, which is used to monitor the connection quality. RTCP is also defined in RFC 3550 [24] and occurs only in com-

[1] Latency: is the time between an action and the occurrence of a reaction.
[2] Jitter: is the variance of the transmission time of data packets [7].

bination with RTP. It is located in layer four of the OSI Model. For each unidirectional RTP session a bidirectional RTCP session can exist.

The RTP transmitter sends a Sender Report in periodic distances with a timestamp and a sender packet count. The end device sends an RTCP Receiver Report with information of latency, a jitter value and the data packet loss rate. This information comes up by comparisons between the Sender and Receiver Report.

If the QoS parameters are inacceptable, i.e. too many data packets get lost or the latency is too large due overloading of the IP network, the sender could change the parameter of transmission speed or picture encoding to reduce the required bandwidth.

## 2.10 Data compression of media content

By the high amount of data with the creation of digital media content high bandwidth requirements to the managed IP network arise. For this reason, it is necessary to reduce the volume of the data.

Video content results in a sequence of pictures. To capture the picture sequence devices are used, which scan the reflected light of the environment with special hardware components. The light will be divided by a prism into the parts red, green and blue (RGB) and converted into a digital binary signal. In europe usually 25 pictures per second are used for one second of video content.

The volume of data depends on different parameters like resolution, colour depth[1] and frame rate[2]. A full scanning of each picture with a resolution for standard television (720x576 pixel), a colour depth of eight bit per colour for RGB and a frame rate of 25 pictures per second would have as result a bit rate of:

$$\frac{720 \times 576}{Picture} \times 24\,Bit \times 25\frac{Pictures}{s} = 248.832.000\frac{Bit}{s}$$

This bit rate refers to one second of uncompressed digital video content and includes no audio data, which would increase the bit rate. This bit rate requires

[1] Colour depth: describes the amount of states for a pixel, e.g. 8 bit = $2^8$ = 256 states. A state stands for an index of a colour table.

[2] Frame rate: describes the amount of pictures per second for video content.

a high bandwidth for a video data stream to the user. However, such a bandwidth cannot be realized to the end device of a user. Therefore, the high bit rate must be reduced. This will happen at the side of the sender, e.g. IPTV content provider or broadcast station, by using source encoding. They are based on redundancy and irrelevance reduction. The redundancy reduction remove information in the source, e.g. a picture, which is several times present. The removed information can be added in the receiver end device without quality loss. Some of these redundancy reduction compressions are:

- Run Length Coding[1]
- Huffman Code[2]
- Lempel-Ziv codes[3]

The irrelevance reduction implies a loss of quality, because information of the source will be removed, which cannot noticed by humans through biological characteristics. This means the information is irrelevant for the consumption of media content by the user. For example: the human eye takes less notice of difference in colour than in brightness. To remove such irrelevant information compression algorithms are used, which are based on mathematical transformations. Some of these transformations are:

- Discrete Cosine Transformation[4] (DCT)
- Discrete Wavelet Transformation[5] (DWT)

The combination of the irrelevancy and redundancy reduction leads to a decrease of the data mass. With the help of a further technology, e.g. picture sequence compression, the bit rate drops to 4 MBit/s in average for standard tele-

[1] Run Length Coding: is an algorithm, which replaces a sequence of the same source character by a special character [7].

[2] Huffman Code: is an algorithm for the construction of minimum redundancy codes [13].

[3] Lempel-Ziv codes: are universal algorithms for sequential data compression developed by Abraham Lempel and Jacob Ziv. They developed the LZ77 and LZ88 algorithm.

[4] Discrete Cosine Transformation: is a mathematical transform, which is used for lossy compression [73], e.g. in JPEG standard for encoding pictures. JPEG stands for Joint Photographic Experts Group (JPEG) [73]. This group is a committee of picture coding experts from ISO and ITU-T [111].

[5] Discrete Wavelet Transformation: is a mathematical transform, which is used for lossy compression [73], e.g. in JPEG2000 standard for encoding pictures. JPEG2000 has more efficiency than JPEG through the DWT and is developed by the Joint Photographic Experts Group [73].

vision with Digital Versatile Disc[1] (DVD) quality. For the transmission of High Definition Television[2] (HDTV) content a bandwidth of 6-16 MBit/s [25] is necessary.

## 2.11 Overview of video file formats for picture sequence compression

The picture sequence compression technology uses the fact that the content is changing only a little between two following pictures. That offers approaches for the usage of prediction coding. That means a picture is used as reference and for a certain sequence length only the changes will be encoded. Some video encoding standards, which use redundancy, irrelevance and picture compression technology, are:

- MPEG 2[3]
- Windows Media Video[4] (WMV)
- H.264[5]
- QuickTime[6]

In the implementation part of this diploma thesis the MPEG 2 codec[7] for IPTV Live TV content and Windows Media Video for VoD content will be used. The characteristics of WMV are explained in chapter 4.3.5.

[1] Digital Versatile Disc: is a high capacity digital storage device. Several capacities are possible, i.e. up to 17 GByte.

[2] HDTV describes a range of television standards. HDTV has an increased horizontal and vertical resolution for brighter pictures.

[3] MPEG 2: is a standard of the Moving Picture Expert Group to encode moving picture content [101]. It is used for DVD and DVB content.

[4] Windows Media Video: is a proprietary video codec of Microsoft [53].

[5] H.264: is a standard for video encoding developed by the Joint Video Team (JVT). The JVT is a group of video coding experts from ITU-T and MPEG [99]. The codec can be used for HDTV content. In comparison to MPEG 2 is required only one third of storage capacity.

[6] QuickTime: is a proprietary video codec developed by the company Apple [103].

[7] Codec: is an algorithm to compress or decompress audio or picture content

# 3 Integration of IPTV in Next Generation Networks

## 3.1 Definition of Next Generation Networks

According to the definition of ITU-T for IPTV a managed IP network is required, which implements mechanism for QoS, security and reliability. This means the deployment of new network architectures. The most important innovations can be summarized under the keyword Next Generation Networks.

The working Group TISPAN of ETSI defines NGN as follows:

“A Next Generation Network is a packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.”

The NGN is characterized by the following fundamental aspects:

- Packet-based transfer
- Separation of control functions among bearer capabilities, call/session, and application/service
- Decoupling of service provision from network, and provision of open interfaces
- Support for a wide range of services, applications and mechanisms based on service building blocks (including real time, streaming, non-real time and multi-media services)
- Broadband capabilities with end-to-end QoS and transparency
- Interworking with legacy networks via open interfaces
- Independence of service-related functions from underlying transport technologies

[26]

This definition is based on the NGN definition of the ITU-T [27].

## 3.2 High level overview of a Next Generation Network

Figure 3.1 depicts the architecture of a NGN. The important components are:

- Call Server (CS)
  - Management of connections and services
  - Routing
  - Authentication, Authorisation and Accounting (AAA)
- Media Gateways (MGW) and Signalling Gateways (SGW)
  - Integration of existing legacy networks like Global System for Mobile Communications[1] (GSM), Universal Mobile Telecommunication System[2] (UMTS), POTS and Integrated Services Digital Network[3] (ISDN)
  - Conversion of codec's, signalling and protocols into the IP network

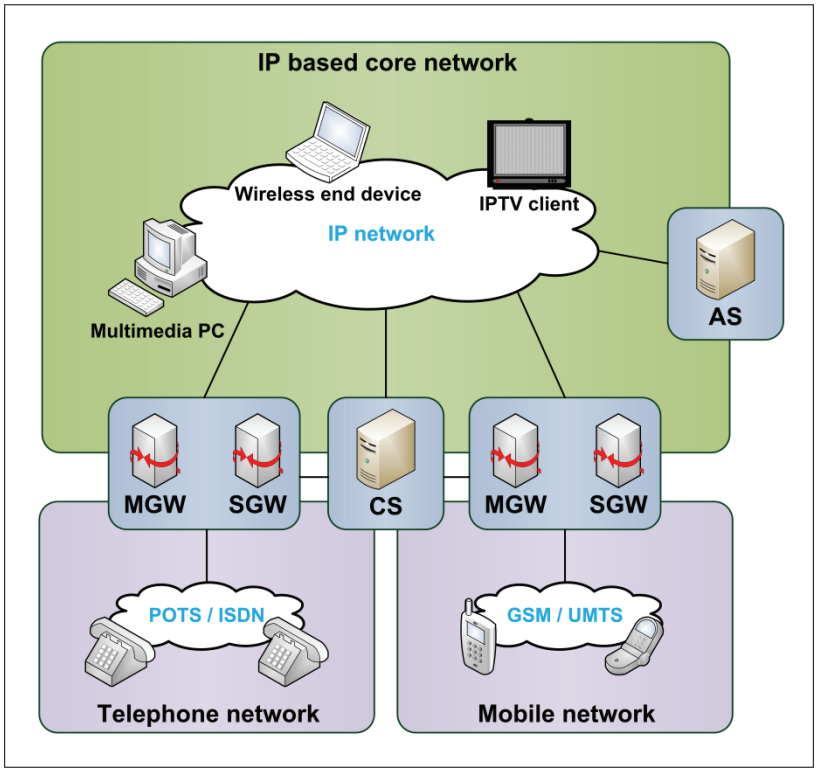


Figure 3.1: High level overview of a NGN

[1] Global System for Mobile Communications: is a network for mobile communication of the second generation [13].

[2] Universal Mobile Telecommunications System: is a network for mobile communication of the third generation [13].

[3] Integrated Services Digital Network: is a digital telephone network for voice and data services [13].

The use of a NGN implies for a telecommunication company large cost savings, because in the core network exists only an IP network instead of a separate network for data and voice services. This means less network elements, homogenous technology and a standardization of the network management. New multimedia services can be easier implemented as in the past [7] by using Application Server[1] (AS).

This new variety of multimedia information and communication applications requires a service platform, which offers secure access to the demanded services independent of the underlying IP network architecture.

## 3.3 IP Multimedia Subsystem

For the management of multimedia sessions in NGN a service platform is required, which implements mechanism for session control, QoS and AAA independent of the underlying IP network architecture.

IMS fulfils all these Requirements. Originally developed by the Third Generation Partnership Project[2] (3GPP) for UMTS Release five [7]. ETSI TISPAN picked up the approach with the aim to make IMS also available for fixed networks and convergent[3] networks [28]. Thus ETSI TISPAN published the standard NGN Release one [29], which implements only an IMS core in contrast to the 3GPP IMS. It presents a subset of the 3GPP IMS and is limited to session control functionality. The IMS core orients consequently at the NGN approach of the separation from data, communication control and value-added services. The NGN Release one of ETSI TISPAN also defines IPTV functions supported by IMS and possibilities to integrate an IPTV subsystem into IMS (see [7], [29], [30] and [31]). The main functions of IMS are:

- Handling and controlling of multimedia session
- Trigger services at Application Servers
- Providing network specific information for the realization of QoS to the IMS application

[1] Application Server: is a Server in a computer network, which provides applications or functionality. They host and execute services [7].

[2] Third Generation Partnership Project: is an association of SDOs for creating technical Specifications and reports for mobile networks [76].

[3] Convergence: describes the merging of different services or sections.

- Providing standardized interfaces for the usage of network functionality and services, e.g. Roaming, Accounting or Security

## 3.4 High level overview of ETSI TISPAN IMS architecture

Figure 3.2 depicts the basic ETSI TISPAN IMS architecture. It has to be noticed that the IMS is divided into three layers:

- Transport layer
  - Connects the different networks
- Call control layer
  - Manages the sessions and provides interfaces for transport and application layer
- Application layer
  - Contains AS which provides value-added services

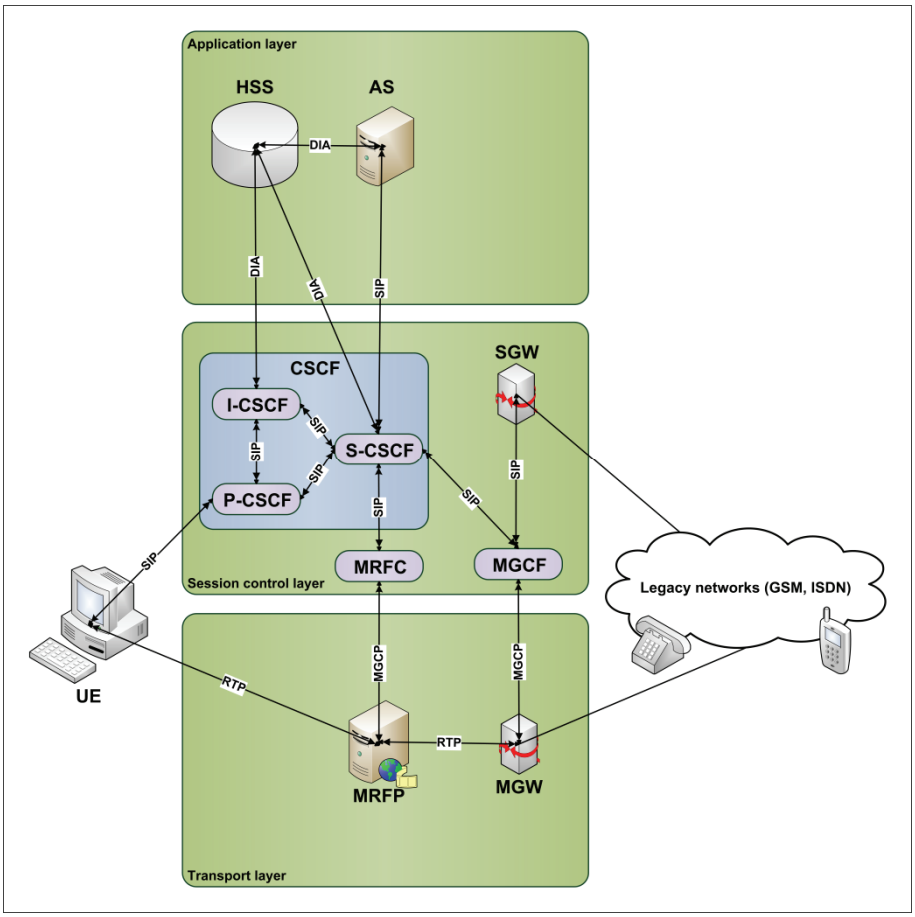


Figure 3.2: High level overview of ETSI TISPAN IMS architecture

In the following the functionality of the components will be explained:

- User Equipment (UE)

  The User Equipment is an end device like the IPTV Vista Media Center client.

- Call Session Control Functions (CSCF)

  Call Session Control Functions are the most important components of IMS. They establish, monitor, support, and release multimedia sessions and manage the users service interactions. They appear as Proxy-CSCF, Serving-CSCF or Interrogating-CSCF.

- Proxy Call Session Control Function (P-CSCF)

  The P-CSCF works as a SIP Proxy[1] and is the point of entrance for an IMS client. Each client registers with the P-CSCF at the IMS core. The SIP MESSAGE will be passed internally to Interrogating-CSCF or Serving-CSCF. The P-CSCF may include a Policy Decision Function (PDF) that manages the QoS over the transport layer. The PDF can be integrated in the P-CSCF or implemented as a separate entity. The P-CSCF supports the compression and decompression of SIP messages.

- Interrogating Call Session Control Function (I-CSCF)

  The I-CSCF is a SIP Proxy and works as gateway to other domains. It assigns a Serving-CSCF to each user at registration and passes SIP messages of other networks to this assigned Serving-CSCF. For this reason the I-CSCF acts with the Home Subscriber Server (HSS) to query user information.

- Serving Call Session Control Function (S-CSCF)

  The S-CSCF is the proxy server controlling the communication sessions. It invokes the AS related to the requested services and is the central network element in the session control layer. Each SIP MESSAGE which will be send or received by the UE passes the assigned S-CSCF.

[1] Proxy: is a component in a computer network, which works as a mediator. The Proxy receives requests of a client and forwards the request to another client with his own address.

- Home Subscriber Server (HSS)

  The HSS is the master database for a given user. It is the entity containing the subscription-related information to support the network entities actually handling sessions, e.g. user identity, authorization information or subscribed services. There can be several entities of the HSS and it is also called as User Profile Server Function (UPSF).

- Media Gateway Control Function (MGCF)

  The MGCF enables the cooperation of the packet oriented IMS network with the legacy networks like POTS, GSM or ISDN. It contains a MGW, which converts the codec's, and a SGW, which converts the transport and signalling protocols for interacting with the legacy networks.

- Media Resource Function Controller (MRFC)

  The MRFC is the connection from the IMS core to the Media Resource Function Processor (MRFP). It interprets information coming from an AS and S-CSCF (e.g. session identifier) and control the MRFP.

- Media Resource Function Processor (MRFP)

  The MRFP provides a streaming server for multimedia applications and is the central element for media processing, e.g. providing resources to be controlled by the MRFC, mixes incoming media streams or processes media streams (e.g. transcode audio, media analysis).

- Application Server (AS)

  An Application Server offers value-added services and could be placed in a third party location, e.g. another network. It is an SIP entity and can be a SIP Proxy, SIP User Agent Client (UAC) or SIP User Agent Server (UAS).

(See [32], [7] and [33])

IMS uses different protocols. SIP and the Diameter protocol are the main protocols within IMS. The Diameter protocol is used for Authentication, Authorization and Accounting and is defined in RFC 3588 [34]. SIP is used for controlling services within the IMS core and supports session control.

## 3.5 Session Initiation Protocol

In order to control multimedia sessions within NGN a protocol is required, which provides mechanism for setting up a session for a communication connection between two or more participants. SIP fulfils these requirements. This protocol will be explained in the following.

A communication connection can be:

- A telephone call
- A multimedia session

SIP provides a standard for signal and service flow control and is applied in NGN since UMTS Release five [7]. It is defined in RFC 3261 [35] and located in layer seven of the OSI model. SIP will be transmitted via TCP, UDP or the Stream Control Transmission Protocol[1] (SCTP). While SIP as a session protocol implements itself secure transport mechanism, e.g. a handshake, repeated sending and timeout procedure, the use of UDP is sufficient.

At a secure transmission SIP will be transmitted at port 5061 via TLS and at port 5060 without a secure transmission. SIP is a text based protocol and the structure and communication procedure is similar to Hypertext Transfer Protocol[2] (HTTP).

With SIP it is possible for the end devices to connect directly or via a Proxy server. The entities are called User Agents (UA) and have to be differentiated between:

- User Agent Client
    - Initiate a session
- User Agent Server
    - Contra-part of UAC
    - Answers the requests of the UAC

[1] Stream Control Transmission Protocol: is a transport protocol for packed oriented networks and is located in layer four of the OSI model. It is defined in RFC 2960 [105].

[2] Hypertext Transfer Protocol: is a protocol for the transmission of data via network. It is mainly used to load websites of the World Wide Web. Version 1.1 of HTTP is defined in RFC 2616 [104]. It is located in layer seven of the OSI model.

A Proxy server can unite client and server functionality in itself. It is placed between the communication partners and fulfils the tasks of routing of SIP messages. The Proxy server receives a SIP message and forwards it to the SIP contact address, which is provided by the SIP message.

SIP addresses are similar to email addresses. They are equipped with a “sip:” prefix. Table 3.1 contains some examples of SIP addresses:

| SIP-Address | Example |
|---|---|
| sip:user@domain | sip:alice@atlanta.com |
| sip:user@ip_adress | sip:alice@10.147.67.181 |
| sip:phonenumber@domain | sip:030123456@gateway.com |

Table 3.1: Example of SIP addresses

SIP supports, similar to HTTP, the message types Request and Response. SIP messages consist of a Header and a Body and are presented in text form. The Header contains parameters for the connection and the body any content, e.g. Session Description Protocol[1] (SDP) parameters like the used codec of the RTP transmission for an IPTV Live TV channel.

Following basic requests are defined in RFC 3261:

- INVITE
    - Set up an connection oriented SIP session between two end devices, e.g. telephone call or IPTV Live TV channel request
- BYE
    - Causes the terminating of an existing session, e.g. end telephone call or end transmission of an IPTV Live TV channel
- OPTIONS
    - Requests properties of an end device without setting up an SIP session

[1] Session Description Protocol: is a protocol for negotiating properties of multimedia data streams [7] and is defined in RFC 4566 [107]. It is located in layer seven of the OSI model.

- CANCEL
    - Terminates the treatment of SIP transactions, e.g. setting up an SIP session, during the establishment
- ACK
    - Stands for acknowledgement
    - Is a positive confirmation for the receiving of a final status information, e.g. confirmation of telephone call
- REGISTER
    - Transmitted status information (IP address) of the user and is transmitted to the core network as initial message

(See [35] and [7])

Each request is acknowledged with one or more status information to the UAC, which is likewise answered by the content of the response. The response message is not defined like the request by method names, e.g. INVITE. They contain a three-figure decimal number, the status code. Each status code is assigned a meaning in word form. Table 3.2 shows the basic types of the responses:

| Basic type | Meaning |
|---|---|
| 1xx | Provisional Responses<br>Request is received an will processed |
| 2xx | Successful<br>The action was successful received, understood and accepted |
| 3xx | Redirection<br>Further actions are necessary to process the Request |
| 4xx | Request failure<br>The Request contains errors or could not processed by the UAS |

| | |
|---|---|
| 5xx | Server failure<br>Request could not be processed due a server side error |
| 6xx | Global failure<br>The Request could not be processed due a general error by the UAS |

Table 3.2: Basic types of SIP responses

## 3.6 IMS Infrastructure at Fraunhofer FOKUS

The Fraunhofer Institute for Open Communication Systems realized with the Open IMS Playground [36] an own development of an IMS infrastructure. The Open IMS Playground contains all fundamentally IMS components and protocols. The main component is the open source[1] IMS core, which implements the CSCFs and HSS functionality. This IMS core is freely available as open source project [37].

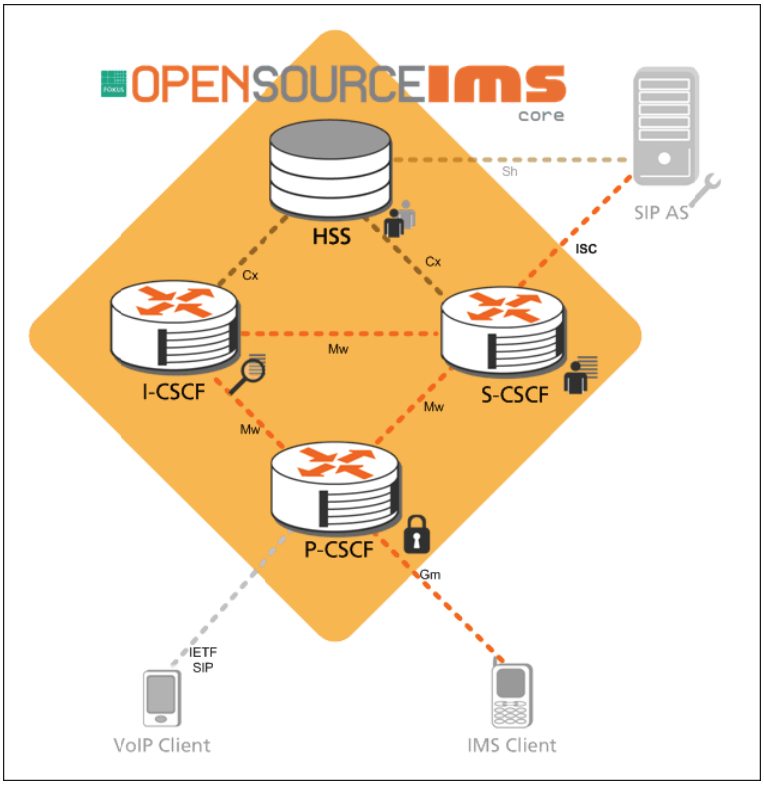


Figure 3.3: Fraunhofer FOKUS open source IMS core

[1] Open source: a method for developing software. The definition describes the redistribution, access to source code and additional topics.

Based on the open source IMS core project Fraunhofer FOKUS provides a test bed, so called MILAB. The MILAB is a test bed for IMS based IPTV architectures. Figure 1.2 depicts the test bed environment of MILAB. Different AS are already implemented for enabling IPTV services, e.g.:

- IPTV Service Control Function, which controls broadcast and VoD sessions via SIP.
- IPTV Interactivity Function, which provides interactive service, e.g. Voting, Shopping, Targeted Advertisement.
- IPTV Service Personalization, which contains a Recommendation web service for rating of VoD content.

In the context of the implementation part of this diploma thesis, the test bed environment of MILAB is used. This environment provides all necessary components of IMS for developing IMS based IPTV clients and services.

# 4 Next Generation Network IPTV Media Center client

With the new possibilities of NGN a new experience can be offered to the users. The IMS network ensures QoS and provides mechanism for the distribution of IPTV media content. With the integration of AS in the IMS network, value-added services can be combined with IPTV. For this reason, an interactive IPTV client will be developed in the context of this diploma thesis, which presents these new possibilities to the user on a suitable platform.

## 4.1 IPTV Playout Center

In order to present media content with an IPTV client, e.g. IPTV Live TV or VoD, a fundamental component is required for the provisioning of media content. This component is called IPTV Playout Center[1]. Such a Playout Center contains several components. It integrates one or more Head-Ends[2] to distribute IPTV Live TV content and also one or more streaming servers to distribute VoD content. Head-Ends for IPTV Systems are also called digital turnarounds, because they provide IP data from a digital TV signal. Each broadcasted channel from a bouquet will be mapped onto a Multicast address. This means a Head-End receives media content (e.g. via DVB-S), demultiplex[3] and encodes the input and forwards the data to the distribution network. A Head-End could be a hardware component, which is connected to a DVB-S, DVB-C[4] or DVB-T signal and configurable via a web interface to administrate the bouquets and the Multicast IP addresses. The easiest way to set up a small scale non-professional Playout Center can be realized by using standard PC hardware, a DVB PCI-card and an open source software solution like the Video LAN Client (VLC - see chapter 4.3.5 for further information of VLC). Professional equipment is provided by different companies. For this diploma thesis solutions from ETAS and Appear TV are used. The ETAS DVB-Gate Q-306 and the Appear TV SC2000 are the

[1] Playout center: Contains the equipment for encoding, storage and multiplexing for all video, audio and data of a bouquet [89].

[2] Head-End: The Site in a network where the distribution network starts. Content is usually received from other signals, e.g. DVB-S, DVB-C or DVB-T [90].

[3] Multiplexing: Combined transfer of several communication signals over one physical or logical channel. Demultiplexing is the reversing: dismantling of the communication signals from the physical or logical channel [13].

[4] DVB-C: distribution of a digital signal (DVB) via a cable network [13]. Defined in standard ETSI EN 300 429 [84].

Head-Ends at MILAB. As 19 inch racks they are easy to integrate into a server cabinet. This equipment realizes the distribution of IPTV Live TV content (which is attached with a DVB-S signal) over an IP based network via Multicast data streams. In the context of the implementation part of this diploma thesis an address range from 239.255.255.230 to 239.255.255.235 for testing the Multicast data streams is used.

As previously mentioned a further component, the VoD streaming server, is necessary. The VoD streaming server stores all VoD content in a video file format which must be streamable. This means that the video file format must have the ability to already present the media content while it is still receiving data packets. This will be reached by using a streamable video file format, e.g. WMV, in combination with an appropriate protocol, e.g. RTP, and client-side buffer[1] mechanism. Thus, the media content on the end device can be received and rendered while following frames are still transmitted by the sender. In chapter 4.3.5 the selection of the video file format will be explained in detail. For the implementation part of this diploma thesis a Windows Server 2008 with the Windows Media Service (WMS) platform is used. The WMS represents a platform, which makes media content accessible in a network [38] via the Microsoft Media Server[2] (MMS) protocol. Figure 4.1 depicts an overview of the IPTV Playout Center at Fraunhofer FOKUS MILAB. On the left side is an attached DVB-S signal with a bouquet of program stations. In the Head-Ends the DVB-S signal will be demultiplexed and the single stations will be mapped onto individual Multicast data streams, which will be sent to the subscribed STBs of users. Each program station obtains its own Multicast data stream. On the lower edge the VoD streaming server is visualized, which distribute VoD content via the MMS protocol.

[1] Buffering: data will be stored temporarily to compensate a difference of flow of data in a stream.

[2] Microsoft Media Server protocol: is a proprietary protocol of Microsoft. The MMS protocol streams multimedia content from Windows Media Services to a suitable client via TCP or UDP [80].

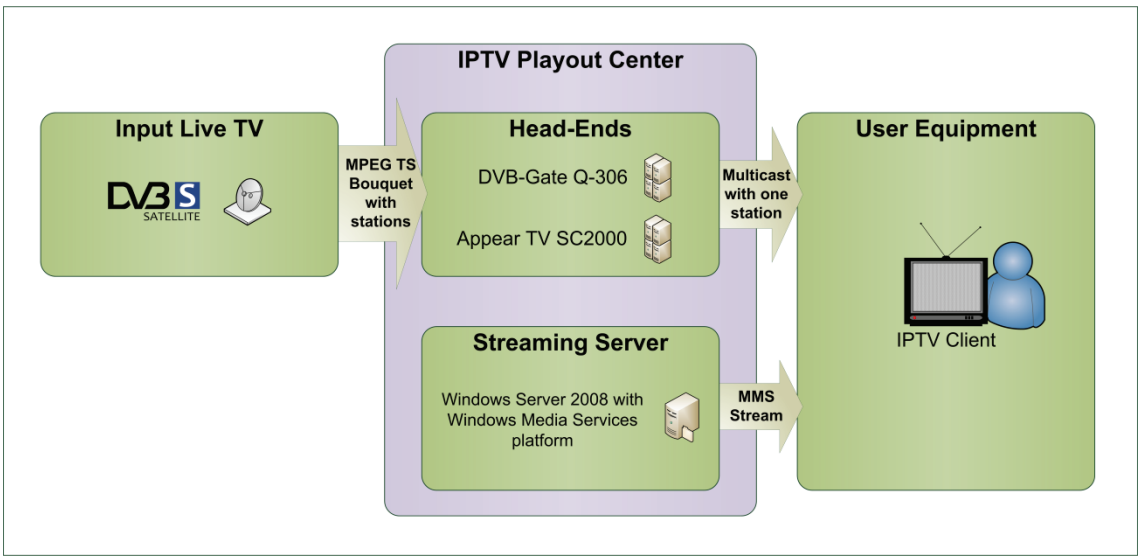


Figure 4.1: Fraunhofer FOKUS IPTV Playout Center

To demonstrate the possibilities of NGN and IMS in combination with IP based television a practical demo will be developed in the context of this diploma thesis, which implements NGN and IPTV services. This is done as an IPTV Media Center client.

## 4.2 Requirements to the IPTV Media Center client

The implementation part of this diploma thesis requires an analysis of the technical requirements. A catalogue will be created, which defines the requirements to the design and implementation of the IPTV Media Center client.

### 4.2.1 NGN Services

Basic NGN services are for example:

- Presence
- Instant Messaging (see chapter 5.1 for more information)
- Telephony via VoIP

To use NGN services the implementation part of this diploma thesis must communicate with IMS, which represents a fundamental component. Each client must register at the IMS core. This is a basic condition for the control and administration of communication connections. The communication between a UA and the IMS core is based on SIP. For this reason, the implementation part of this diploma thesis must implement a SIP software stack.

One service of NGN is providing information about the current status of users. Similar services are well-known from IM tools, which implement a service to present the online[1] status to other users. Such a service is called Presence and defined in RFC 2778 [39]. This RFC document defines an abstract model for a Presence service. But to publish the Presence information of a user a basis to present Presence information is required. This required basis is specified in RFC 3863 [40]. This RFC document defines the representation of Presence information in an Extensible Markup Language[2] (XML) format. Additionally, it is an advantage to provide additional information like the current consumed content of a user. For this Rich Presence service an extension to RFC 3863 is necessary, which is defined in RFC 4480 [41]. Rich Presence information in an IPTV client can be used to link to content, which is currently consumed by the user. Thus, a buddy[3] could demand easily and uncomplicated the same content.

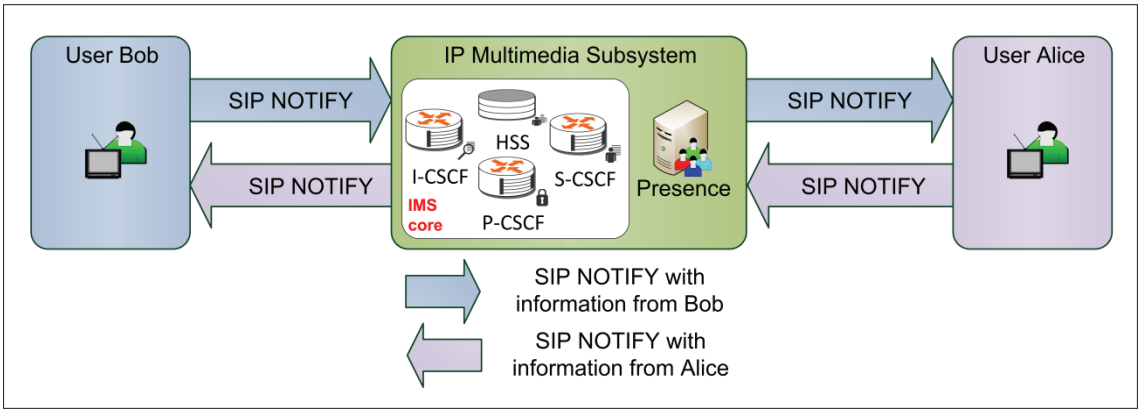


Figure 4.2: Presence service

Presence information will be provided by an AS within IMS. After successful registration at the IMS core the user subscribes to the Presence information of other users from his contact list by using the SIP SUBSCRIBE method. When the status of a subscribed buddy is changing, the user will be informed via SIP NOTIFY message. In return the user notifies the presence server of its own status changes (see Figure 4.2). The SUBSCRIBE and the NOTIFY methods are extensions of SIP specified in RFC 3265 [42].

[1] Online: describes the active connection of an object (e.g. computer system) with a network like the Internet.

[2] XML: Extensible Markup Language is a simple text format to present hierarchical structured data [88]

[3] Buddy: a friend or partner

The analysis showed that the implementation part of this diploma thesis must fulfil the following requirements:

- Communication via SIP
- IMS conform registration and session control to set up communication connections
- Service for Rich Presence information as defined in RFC 4480

### 4.2.2 IPTV Services

In order to be able to consume media content several services are needed, which enable the receiving and rendering of media content.

An IPTV service is for example:

- Live TV
- VoD
- Time-Shifting
- Trick functions[1]
- Network Personal Video Recorder[2] (NPVR)
- Broadband Content Guide[3] (BCG)

Live TV is the description of linear television. The content is selected by broadcast stations. IPTV Live TV will be received from a signal and sent via Multicast data stream to several IPTV clients. For this reason, particular attention should be paid to the support of the Multicast technology in the implementation part of this diploma thesis. Some Media Center platforms support the recording of Live TV content. Thus, a service could be developed, which implements Time-Shifting. However, the implementation of such a Time-Shifting service is not an aim of this diploma thesis.

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[1] Trick functions: The ITU-T terms Trick functions as: “A consumer will want to pause live incoming content on their receiving device so that they can "resume" later and continue to watch the content in Time-Shift mode.” [102]

[2] Network Personal Video Recorder: is a digital video recorder. The recorded content is stored in a network based storage system. The user can consume the recorded content at a later time as it was broadcasted.

[3] Broadband Content Guide: a content guide, which is delivered over an always on bi-directional IP network

VoD describes the possibility to receive digital video content at a desired time. Thus, the user can select the starting time of content. The basic principle is well-known by DVD's, where the user can watch videos at any time he wants. VoD content is stored on a VoD streaming server in a video file format, which is streamable. Nowadays, various streaming formats are widely available, e.g. Apple QuickTime or Microsoft WMV. For this reason, the implementation part of this diploma thesis must support various video file formats and decoding of these. The distribution of VoD content does not represent a form of Live TV. Each user is delivered by an own data stream. For this reason, attention at the implementation part of this diploma thesis should be paid to the support of the Unicast technology, which is used by VoD streams.

For selecting a preferred IPTV Live TV content a TV-Guide is necessary, e.g. a printed magazine. In such a TV-Guide a user has the possibility to get a long-term overview of the IPTV Live TV offer, which is editorially evaluated. Another solution is an EPG. The result of a first evaluation of a study for EPG by the "Gemeinsame Stelle Digitaler Zugang der Landesmedienanstalten" (GSDZ) shows that the EPG is used as a short-term information possibility by all asked participants [2]. For this reason, it is a large advantage to implement an EPG into the implementation part of this diploma thesis. An approach for this topic may be a Broadband Content Guide, which is defined in ETSI TS 102 539 [43]. This document describes the implementation of a BCG with the TV-Anytime[1] metadata standard. With a BCG it is possible to generate EPG data.

It is possible that several people live in a standard household. For the registration at the IMS core and for the communication with buddies a user profile is necessary, which contain several information and allows that the implementation part of this diploma thesis can be used by several users. For this reason, user profiles as defined in ETSI TS 182 028 [31] should be integrated. A user profile contains basic user or service specific information, e.g. subscription, bookmarks or parental control.

The analysis showed that the implementation part of this diploma thesis must fulfil the following requirements:

- Support of Unicast and Multicast technology

[1] TV-Anytime: is a set of specifications for providing and describing multimedia data. [114]

- Support of different video file formats and decoding of these
- Integration of EPG data
- Integration of user profiles

### 4.2.3 Media Center platform

In order to present NGN and IPTV services (which are provided by the IPTV ecosystem) to the user, a multimedia platform on the end device is required to manage and integrate these services. This platform should be controllable simple and intuitive and also integrate a possibility for the user to consume media content such as photos, music or videos. This must happen in a uniform representation and handling for a high usability[1].

Because IPTV is moving picture content, the user should have a possibility to control the provided application of this diploma thesis with a remote control (like traditional TV). The Media Center platform must support network connections, because the media content will be received via an IP network. In order to integrate the implementation part of this diploma thesis the Media Center platform must have possibilities to integrate third party applications. Additionally, a Software Development Kit[2] (SDK) or Application Programming Interface[3] (API) for a simpler development should be provided. This supports the development of a NGN based IPTV client for a homogeneous[4] Media Center environment.

The analysis showed that the Media Center platform must fulfil the following requirements:

- Simple, uniform and intuitive control
- Integration of photo, music or video libraries
- Controllable by remote control
- Establish network connections
- Integration of third party applications

[1] Usability: denotes the experience at time of usage of a application by the user.

[2] Software Development Kit: a set of documentations and tools, which are helpful or necessary for programming applications.

[3] Application Programming Interface: a documented software-interface. Thus, an application can use the functions of another program.

[4] Homogeneous: denotes the equality of a property

## 4.3 Design and implementation of the Next Generation Network IPTV client

### 4.3.1 Selection of the Media Center platform

There are several possibilities for the realization of the implementation part of this diploma thesis on a Media Center system. On the one hand an implementation on a Linux[1] based system, e.g. Kubuntu[2], with an open source solution called LinuxMCE[3] and on the other hand an implementation on a Microsoft Windows Vista based system. The Linux based solution has the advantage that it is very economical, because there are no costs for the user for the purchase of the operating system or the Media Center platform. However, the disadvantages of this solution are obvious. In the implementation part of this diploma thesis, frameworks[4] will be used, which are based on the .NET framework (.NET will be more explained in chapter 4.3.2). The Mono-Project is a possibility to run .NET applications on a Linux based system [44]. But the effort of time to port and maintain to Mono is too large. As a result of this, there will be no implementation on a Linux based system with LinuxMCE in the implementation part of this diploma thesis.

There will be two further possibilities for Media Center platforms on Microsoft Windows Vista based systems. On the one hand the open source solution MediaPortal[5] and on the other hand the Vista Media Center.

Both Media Center platforms have the advantages that they have a clean, simple and intuitive user interface with integrated libraries for consuming media content like photos, music or videos (see Figure 4.3). They are easy to control with up, down, left and right keys by using a remote control. They have also the possibility to connect to a network for receiving media content or information, e.g. email.

[1] Linux: is an open source operating system
[2] Kubuntu: is a Linux based operating system, which can be used for free [79].
[3] LinuxMCE: is a free open source add-on for Kubuntu [78].
[4] Framework: is a structure for programming applications, e.g. a collection of objects or methods
[5] MediaPortal: is an open source Media Center platform [77].

IPTV Live TV and VoD content can be presented on both platforms, because the corresponding codec's are already installed by default in Microsoft Windows Vista. Thus, the decoding of different video file formats is ensured.

MediaPortal as well as VMC provides the possibility to develop applications for the respective platform by using SDKs. VMC allows the integration of third party applications by using the Windows Media Center Presentation Layer (WMCPL). Thus, it is possible to access the VMC rendering technology to create rich media applications and services with the same richness and quality of the user interface (UI) within VMC. These third party applications are provided to the user as Add-Ins, which are easy to integrate into VMC via an executable installation program.

VMC is integrated in the editions of Microsoft Windows Vista Home Premium and Ultimate. This has the advantage in contrast to MediaPortal that there exists no necessity for the installation of the Media Center platform on the computer system, because on two of three sold Windows Vista PCs the Home Premium edition is already installed [45].

On the basis of the mentioned advantages and disadvantages, the decision for the realization of the implementation part of this diploma thesis fell for Microsoft Windows Vista Media Center.

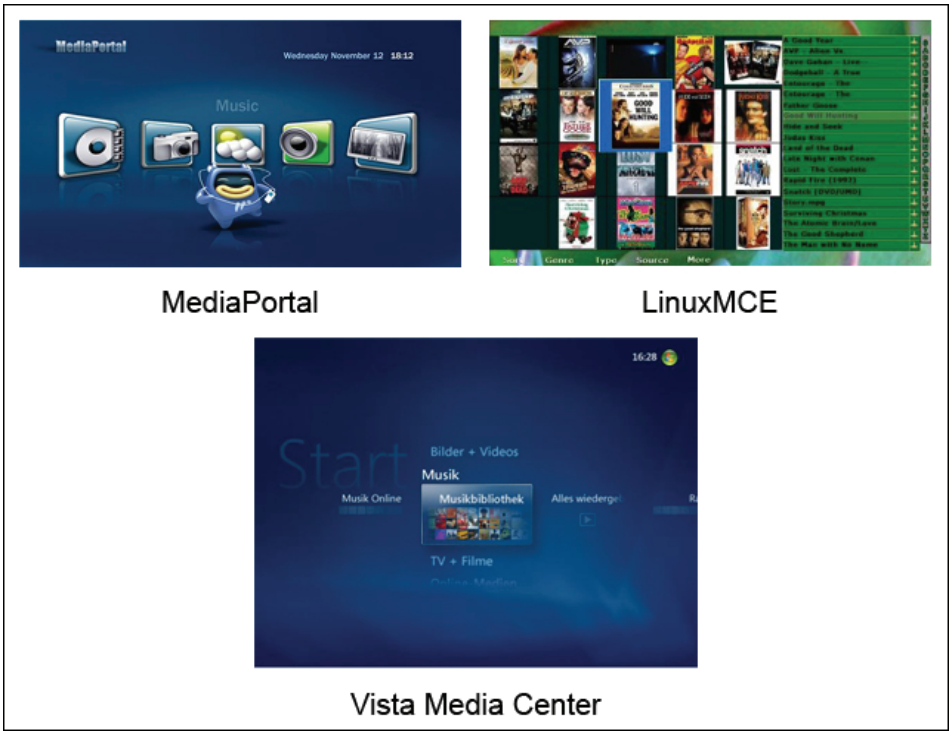


Figure 4.3: Screenshots of Media Center platforms

### 4.3.2 Architecture and programming platform

The implementation part of this diploma thesis was realized with the .NET framework. .NET is a development platform of Microsoft. In this role it unites many advantages, e.g. language independence, object orientation and memory management. For developing .NET applications different programming language concepts can be used, e.g. Visual Basic.NET or C#.NET (pronounced c sharp). It does not play a role what .NET programming language for an application component or class is used, because .NET implements the Common Language Infrastructure (CLI) standard. So Visual Basic.NET classes can also instantiated under C# [46].

Microsoft Windows Vista is delivered by default with the .NET framework 3.0 [47], which extend the components of the .NET framework 2.0 with new technologies.

These technologies are:

- Windows Presentation Foundation[1] (WPF)
- Windows Communications Foundation[2] (WCF)
- Windows Workflow Foundation[3] (WF)
- Windows CardSpace[4]

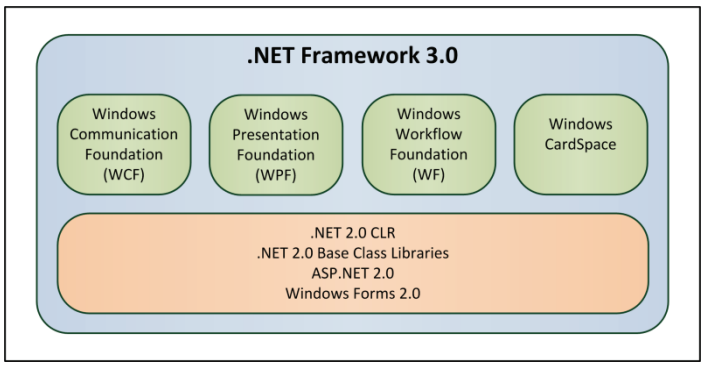


Figure 4.4: .NET framework 3.0 stack

[1] WPF: is a Microsoft technology for developing desktop or web applications. The presentation of the graphical user interface is based on the Extensible Application Markup Language, so the logic is separated from the view. WPF supports hardware acceleration, so high performance graphical user interfaces can be created [121].

[2] WCF: is a Microsoft technology for developing service orientated applications like web services [120].

[3] WF: is a Microsoft technology for defining, executing and managing workflows [122].

[4] Windows CardSpace: is a Microsoft technology for managing identities and can be used for the authentication on websites of a user [119].

Figure 4.4 depicts the .NET framework 3.0 stack, which includes:

- .NET 2.0 Common Language Runtime (CLR – see chapter 4.3.2 for more information)
- .NET 2.0 Base Class Libraries
- ASP.NET 2.0
- Windows Forms 2.0

Thus, an application, which is based on the .NET framework 2.0, can be also executed with the .NET framework 3.0 [48], because the .NET 2.0 CLR is included.

The high-level language C# as programming language for the implementation part of this diploma thesis was used. The frameworks, which will be presented in the next chapters, are also written in C#. Likewise the equality is retained by this decision. C# was developed by Microsoft for the .NET framework. It is an object-oriented language. It has evolved to one of the most important programming languages for the Windows platform, because there is a large offer for designer tools. These designer tools allow a fast and cost effective development of software.

Figure 4.5 depicts the compiling process. The source code, which is written in C#, will be compiled into the Common Intermediate Language (CIL). However, this code is not executable. An interpreter is needed, which interprets the intermediate code. This interpreter is the CLR, which is a runtime layer and serves as a manager. For this reason, with executed .NET application code will be spoken of managed code [49]. One advantage of .NET managed code is the Garbage Collector, which recognizes unused objects and removes them automatically from the memory.

As basis for the application logic[1] of the implementation part of this diploma thesis the Composite UI Application Block (CAB) of Microsoft was used. CAB is an addition to the .NET framework and will be more described in chapter 4.3.6.

[1] Logic: is an expression, which means the functional logic. This will be implemented with a programming language.

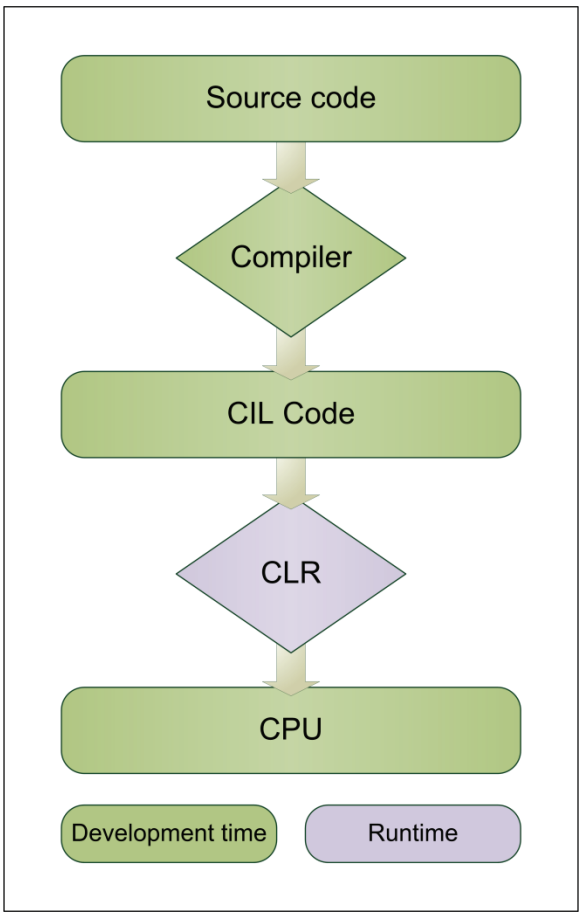


Figure 4.5: Architecture of .NET

Microsoft Visual Studio 2008 Professional (VS08) as development environment was used, which has many helpful tools. Like a code editor with auto completion, a visual editor, syntax highlighting or a project explorer. VS08 is the latest version of the development environment of Microsoft. Important innovations to Visual Studio 2005 are:

- Class designer support for Visual C++ code
  - In earlier versions only managed programming languages were supported (Visual Basic or C#)
- Integration of web based projects
  - Support of Active Server Pages[1] (ASP.NET) and Asynchronous JavaScript and XML[2] (AJAX) development

[1] ASP.NET: is a Microsoft technology for websites with dynamic content [98].

[2] AJAX: is a concept for asynchronous data transfer between a server and a web browser. A request to a web server can be invoked within a website without the need for a complete reload of the website [81].

- Integration of a WPF designer
    - With the WPF designer it is possible to create graphical User Interfaces, which are based on Extensible Application Markup Language[1] (XAML)
- Integration of Language Integrated Query[2] (LINQ)

For further information see [50].

### 4.3.3 Application functionality

In order to use NGN and IPTV services in the implementation part of this diploma thesis the Add-In must provide functionalities for selection and interaction. This will be presented as a Storyboard.

Figure 4.6 depicts the basic concept of the application functionality, which is explained in detail in the following chapter.

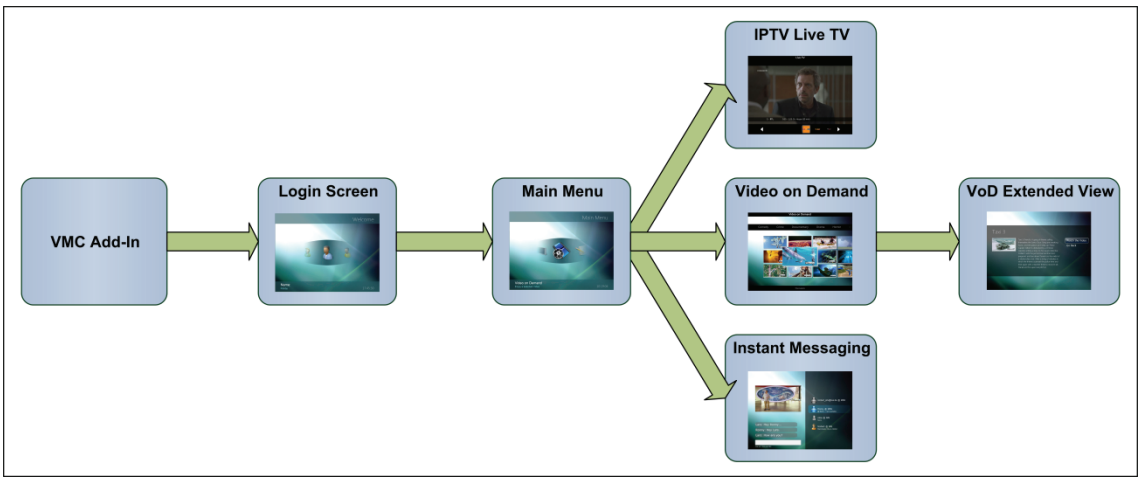


Figure 4.6: Basic concept of application functionality

The GUI of the Add-In is divided into five different sections.

- Login
- Main Menu
- IPTV Live TV

[1] XAML: is a markup language, based on XML, for creating high performance graphical user interfaces of WPF applications [115].

[2] LINQ: a component of the .NET framework, which provides for a query of databases with programming code like C#. Because it is implemented as object instead of a string the compiler can validate the query and display errors if anything is wrong [112].

- Video on Demand Portal
- Instant Messaging

The Login screen is the central entry point into the Add-In. Figure 4.7 depicts the GUI, which provides a selection of profiles. With such a profile a user can be registered at the IMS core. Those profiles are the realization of the user profile approach, which was described in chapter 4.2.2. The individual profiles are read from an XML settings file, which is stored local on the PC system with the Add-In.

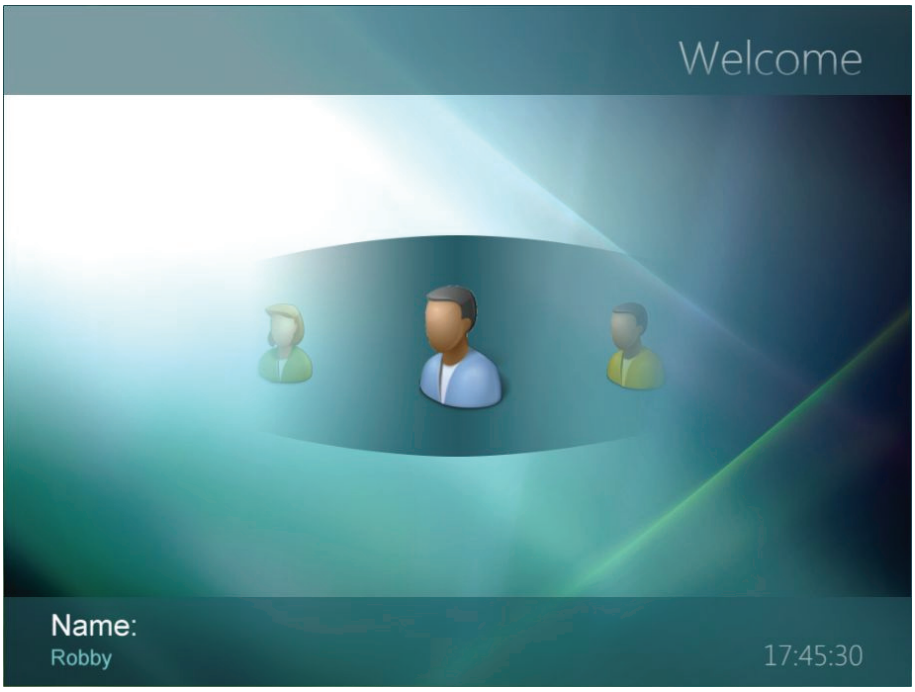


Figure 4.7: Login screen with profiles

After the selection of the login profile and successful registration at the IMS core the user arrives at the main menu. Here he can decide between different IPTV and NGN services like IPTV Live TV, VoD or IM. The main menu is also integrated in all other sections and can be called at any time via remote control or Hotkey F12.

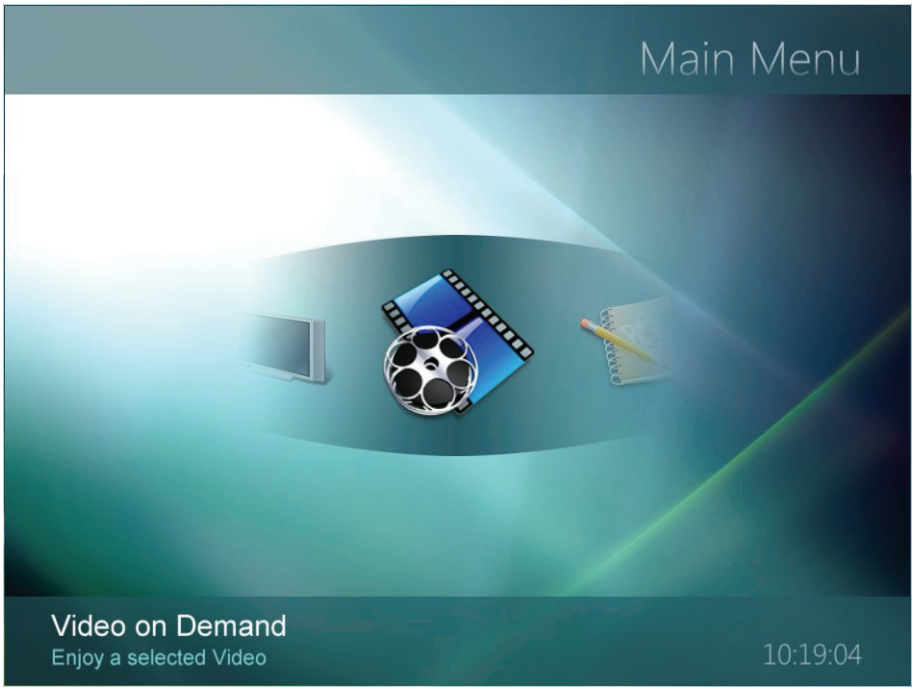


Figure 4.8: Main Menu of the VMC IPTV Add-In

If the user decides for IPTV Live TV, he will be redirected to the next screen (see Figure 4.9). Here he has the possibility to select and watch an IPTV Live TV channel from a provided program bouquet. During selection time more information about the channel and current stream will be presented to the user. This information is from an EPG, which is based on the TV-Anytime Metadata standard. The EPG data is provided by a BCG service from another framework, which will be explained in chapter 4.3.7. After successful selection of an IPTV Live TV channel the screen switches to full screen mode. The user has the possibility to track back to the program bouquet via remote control or via Hotkey F1. In full screen mode the user can call further extended information about the current stream via remote control or via hotkey E. This information is also based on the TV-Anytime Metadata standard. At the upper edge of the screen the name of the current section is displayed. These feature also can be found at the VoD portal and IM.

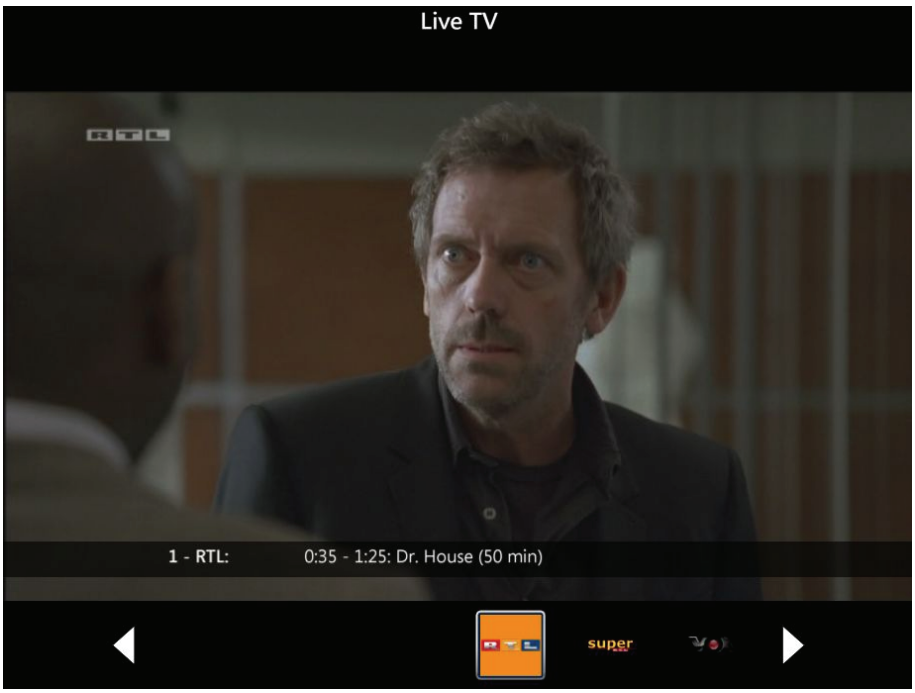


Figure 4.9: IPTV Live TV screen

Within the section VoD the user can browse through different offered VoD content. For a better overview the selection of the content is subdivided into genres[1]. At the lower edge of the screen the name of the current selected video is displayed.

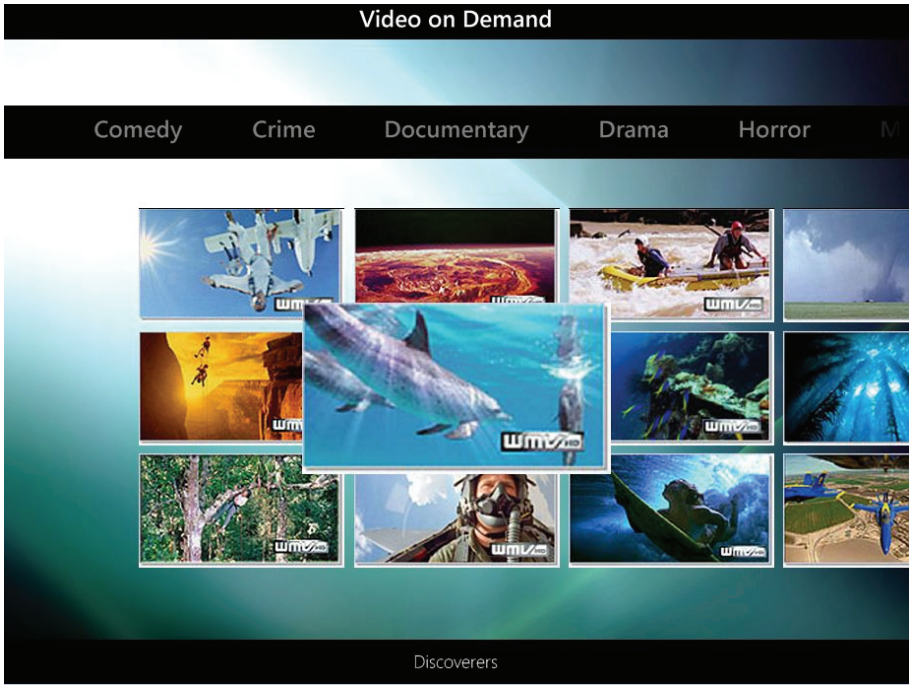


Figure 4.10: Video on Demand portal

[1] Genre: describes a classification by the content. In this case a video, e.g. comedy, action or drama

After the selection of the VoD content another screen with further extended information about the selected video will be displayed. At this point the user has two options:

- Request the video stream, or
- Go back to the selection screen


Figure 4.11: Detailed view of VoD content

If the user decides to request the stream, the screen will be switched to full screen mode. Via remote control or the hotkey F1 the user can switch back to the VoD Portal.

Within the section IM the user has the possibility to chat with other people, which are online. For a better overview the chat partners will be split into IMS and Microsoft Network (MSN) Live Messenger users. A Rich Presence service, which was explained in chapter 4.2.1, can be recognized. The user can see the online status and further information of his buddies, e.g. the consumed content. The application logic for this service is implemented with the IMS framework (see chapter 4.3.6) and the Cross Domain Messaging service (see chapter five).

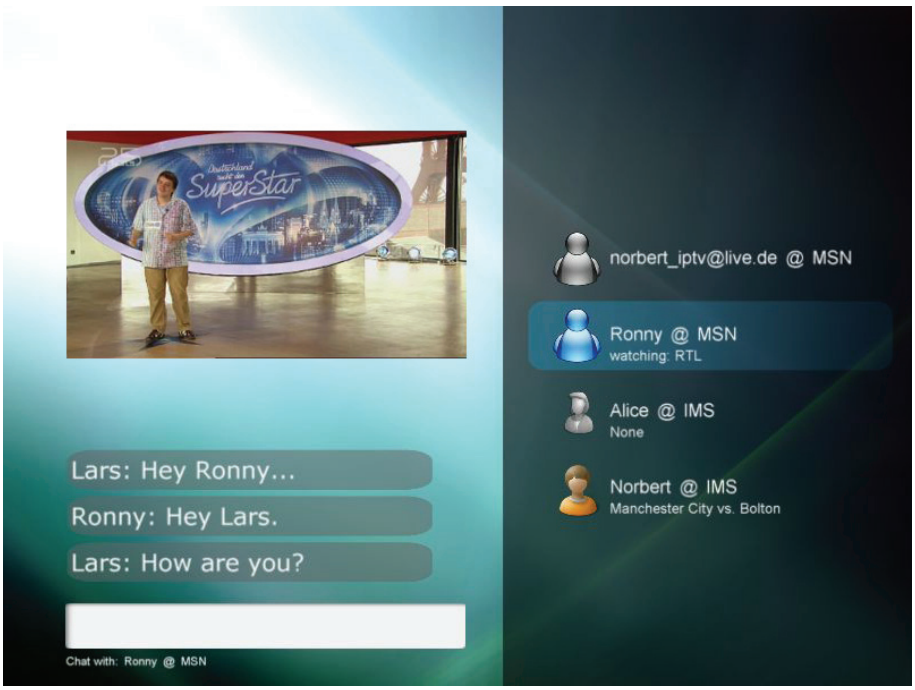


Figure 4.12: Instant Messaging

### 4.3.4 Graphical User Interface

#### 4.3.4.1 Media Center Markup Language

In order to be able to present the user the implementation part of this diploma thesis, a graphical user interface (GUI) is needed. This GUI displays all graphical components like buttons, images and icons, which offers information and interaction to the user. It should support a concept like the Model-View paradigm, to separate the application logic from the view. This has the advantage that programmers and designers could work independently, e.g. a programmer implements the application logic and provides interfaces for a user interface designer. It also reduces the working time for searching errors. The GUI for the implementation part of this diploma thesis is developed with the Media Center Markup Language (MCML), which supports the Model-View paradigm.

Microsoft provides a possibility to develop Add-Ins for the VMC platform through a combination of a .NET programming language (e.g. C#.NET) and MCML. MCML is a type-safe XML declarative language, which provides a few possibilities for creating enhanced interactive applications. This includes dynamic layout capabilities, integrated animation support, rich text and graphics support, automatic keyboard and remote navigation, parameterization, private local storage, conditional-based data binding, and access to managed code assemblies from

markup [51]. Views can be linked to application logic, like .NET framework objects. The XML tags are .NET framework objects and the XML Attributes are .NET framework properties [52].

#### 4.3.4.2 MCML syntax and programming reference

The top-level root tag of MCML is `<Mcml></Mcml>`, followed by one or more `<UI></UI>` tags. A `UI` can be a complete presentation of a User Interface or a single item, e.g. an item of a list.

Within a `UI` tag can be four additional main sections:

- `Properties`
  - Can be used to pass parameters to a `UI`
  - Allow the customization of an existing `UI`
  - Can be any type (built-in MCML type or user defined type)
- `Locals`
  - Local variables, which can be used by the `UI` or passed down to Child `UI`'s
  - Can be any type (built-in MCML type or user defined type)
  - Only one requirement: must be able to be instantiated via a default constructor[1]
- `Rules`
  - Are for simple logic inside of MCML
  - To compare values
  - To bind a local variable or a .NET framework property (to track changes) to another object
- `Content`
  - Contains all objects, which will be presented to the user
  - Can contain Child `UI`'s

MCML has a lot of built-in types, for example:

- `Color`
  - Defines a colour

[1] Constructor: is a procedure, which will be run at time of creation of an object. It is for set up an object into a defined initial state.

- `Graphic`
  - Displays an image
- `KeyHandler`
  - Provides key input behaviour to a UI element
- `Panel`
  - A non-drawing layout container
- `ShortcutHandler`
  - Provides remote control behaviour
- `Text`
  - Defines a text element with different properties like typeface, size or colour

Object paths define the primary form of data binding in MCML. They are used to refer to any .NET framework object with dot notation. The syntax of object paths is `[ObjectName.Member]`, where `ObjectName` is the first part of the path. The `ObjectName` refers every time to a named object within the `UI`. But there are restrictions, depending on which section of the `UI` the object exists.

- Paths in `Properties` section
  - Are not supported
- Paths in `Locals` section
  - Can access to objects in the `Properties` section
- Paths in `Content` section
  - Can access to objects in the `Locals` and `Properties` section
- Paths in `Rules` section
  - Can access to objects in all other sections: `Content`, `Locals` and `Properties` section

Object paths can be used to refer to methods, properties or indexer members of a dictionary. The syntax to access to a dictionary is `[MyDictionary.#Indexvalue]`, where `Indexvalue` stands for a integer number. Object paths support type casting and type conversations.

The syntax is `[Data.Item!cor:String]`, where `Data.Item` is of type object and `cor:String` is of type string. This example is a typecast.

At VMC development, a MCML file represents the view and .NET framework classes the application logic. The existing .NET framework class or self written class can be instantiated by using the example in the `Locals` section below:

```
<Mcml  xmlns="http://schemas.microsoft.com/2006/mcml"
       xmlns:cor="assembly://MSCorLib/System"
       xmlns:myAssembly="assembly://MyAssembly,Culture=Neutral,
       Version=1.0.0.0,PublicKeyToken=4d61efe74a3833fe/MyAssembly.Namespace
       ">
   <UI Name="Default">
      <Locals>

         <!-- Class String from Namespace cor -->
         <cor:String Name="MyString" String="Hello World!"/>

         <!-- Class "MyClass" from Assembly "MyAssembly.dll" -->
         <myAssembly:MyClass Name="myClass"/>

      </Locals>
   </UI>
</Mcml>
```

Figure 4.13: Instantiate a .NET framework class in MCML

#### 4.3.4.3 An "Hello World" Example with MCML

This example gives an introduction to the syntax of MCML. The result is the presentation of the words "Hello World!" on the GUI of the VMC platform. Therewith, the creation of a presentation view for the VMC platform with MCML will be demonstrated.

```
<Mcml xmlns="http://schemas.microsoft.com/2006/mcml"
      xmlns:cor="assembly://MSCorLib/System">

    <UI Name="Default">
        <Properties>
            <Color Name="MyColor" Color="White"/>
        </Properties>
        <Locals>
            <cor:String Name="MyString" String="Hello World!"/>
        </Locals>
        <Rules>
            <Default Target="[MyText.Content]" Value="[MyString]"/>
        </Rules>
        <Content>
            <Text Name="MyText" Color="[MyColor]" Font="Arial,24"/>
        </Content>
    </UI>

</Mcml>
```

Figure 4.14: MCML Example of "Hello World"

Figure 4.14 of the Hello World example depicts the following scenario:

- `Properties`:

  A built-in MCML type called `Color` is instantiated, which gets the name `MyColor` and the value `White`. The colour white is temporarily the standard value. A programmer can do two basics functionalities with this property:

  - Change the value of the colour at runtime with a rule within the `UI` itself, or
  - Instantiate this `UI` with name Default from another `UI` and pass through another Colour with `<me:Default MyColor=”Black”/>`. So the child-`UI` has at time of creation the colour black as default. Enables the reusing of `UI`’s with different properties.

- `Locals`:

  A string object of the .NET class System.String is instantiated, with the name `MyString` and the value `Hello World!`

- `Rules`:

  The value `Hello World!` of the string object `MyString` will be linked to the built-in MCML type `Text` with name `MyText` in the content section

- `Content`:

  A built-in MCML type called `Text` is instantiated with the name `MyText`, typeface `Arial`, size `24` and the colour `[MyColor]`, which calls the value of object `MyColor` (instantiated in the properties section).

### 4.3.5 Video Rendering

In order to present media content on the screen a so called presentation element is required, which is able to render media content. For this reason, the Video Element object of MCML is used. Thus, it is possible to render and present media content, which will be received from a content provider by using the Unicast technology. All video file formats, which are installed on the Vista Media Center PC system, will be supported. The choice for content of VoD fell on Windows Media Video [53]. This video file format offers a high compatibility to Microsoft products, e.g. VMC. Likewise WMV supports the distribution of High Definition content (e.g. HDTV), which was considered with the conception of the VoD Portal.

WMV is also a streamable video file format. This is an important requirement for offering VoD content. In the context of the implementation part of this diploma thesis the VoD content is streamed via the Microsoft Media Service platform. Thus, a good compatibility is achieved by the combination of Microsoft based solutions (Windows Media Video, Vista Media Center and Windows Media Services platform).

Unfortunately, the Video Element object does not support the rendering of media content, which is received via Multicast technology necessary for IPTV Live TV. For this reason, it is necessary to integrate a further component, which can receive and demultiplex Multicast data streams. This component could be the media player VLC, which can be used under General Public License[1] (GPL). It is possible to integrate this media player in projects by using an API. Another

[1] General Public License: is a license for open source software [100].

solution is the use of a proprietary[1] Direct Show filter graph like the Elecard MPEG 2 decoder and Streaming Plug-In. Direct show filter graphs are used for multimedia processing. They make it possible to take up data, work on it or change it and make the processed data available for other components [54]. With the implementation of the Elecard MPEG 2 decoder and Streaming Plug-In the rendering of media content, which is streamed via the Multicast technology, will be enabled. Thus, the use of the Multicast technology within the implementation part of this diploma thesis is possible. The decision fell on the Direct Show filter graph, because with this solution it is possible to use the integrated `Video` element of MCML.

This has the advantage that it is easier to integrate in contrast to VLC. An investigation in the context of the implementation part of this diploma thesis had as result that the integration of VLC in the VMC platform would be very complex and is related with problems.

For playing media content the `PlayMedia` method of the namespace[2] `Microsoft.MediaCenter.Hosting` will be used. A call of this method with the necessary parameters presents media content to the user. A call, e.g. for IPTV Live TV, could look like as following.

```
//original play method
public bool PlayMedia(MediaType mediaType, object media, bool addToQueue);


//example
PlayMedia(MediaType.Video, "elecard://239.255.255.240:1234/udp", false);
```

Figure 4.15: PlayMedia method

`MediaType` defines the type of media content, which will be played. The string object defines the source of the media content. In this case it is a Multicast data stream for IPTV Live TV. The Elecard Direct Show filter graph will be called automatically by using the prefix "`elecard://`". The third parameter is a bool value, which defines whether or not the called media content will be added to a

[1] Proprietary: means the comprehensive reservation of the author for all property rights.
[2] Namespace: describes a definition in computer science to define objects within a context

playlist (which is integrated in VMC). With the combination of the `Video` element of MCML and the proprietary Direct Show filter graph of Elecard it is possible to present streaming media in VMC and it does not matter whether Multicast data stream or WMV Unicast file streaming.

### 4.3.6 IMS framework

For the integration into the IMS Network, the implementation part of this diploma thesis must know a lot of different communication services (services like registration, session management or Presence). They are essential for interaction with the IMS core. One of the used protocols for communication is SIP. For developing the implementation part of this diploma thesis it is recommended to use a framework, which provides these communication services. Such a framework was developed in another diploma thesis at Fraunhofer Fokus, the IMS framework [55]. Thus, it is possible that the implementation part of this diploma thesis implements the required NGN service:

- Communication via SIP
- IMS conform registration
- Rich Presence

This framework is developed with the .NET framework and the programming language C#.NET. The IMS framework is based on CAB. CAB is an addition to the .NET Framework and provides the ability to develop modular applications with high complexity by loosely coupled components. It also provides for a better service oriented programming architecture within the application logic. CAB by itself has a high complexity, and it is not the aim of this diploma thesis to explain CAB. For further information see [56]. An example to create an CAB module[1] will be explained in chapter 5.3.2.

### 4.3.7 Media Client framework

The IMS framework only settles the basic communication between the IMS core and the implementation part of this diploma thesis (registering, session management, Presence or contact data). In order to use the full functionality of in-

[1] Module: is an independent component for programming applications

teractive NGN IPTV applications, a further framework is needed, which implements additional services. For example: request IPTV Live TV channels, VoD content or EPG data. Such a framework was developed in another diploma thesis at Fraunhofer Fokus [57]. This Media Client framework uses the IMS framework and is likewise implemented with C# and CAB. Figure 4.16 depicts an overview, which shows the cooperation of the Fraunhofer FOKUS frameworks and other used frameworks.

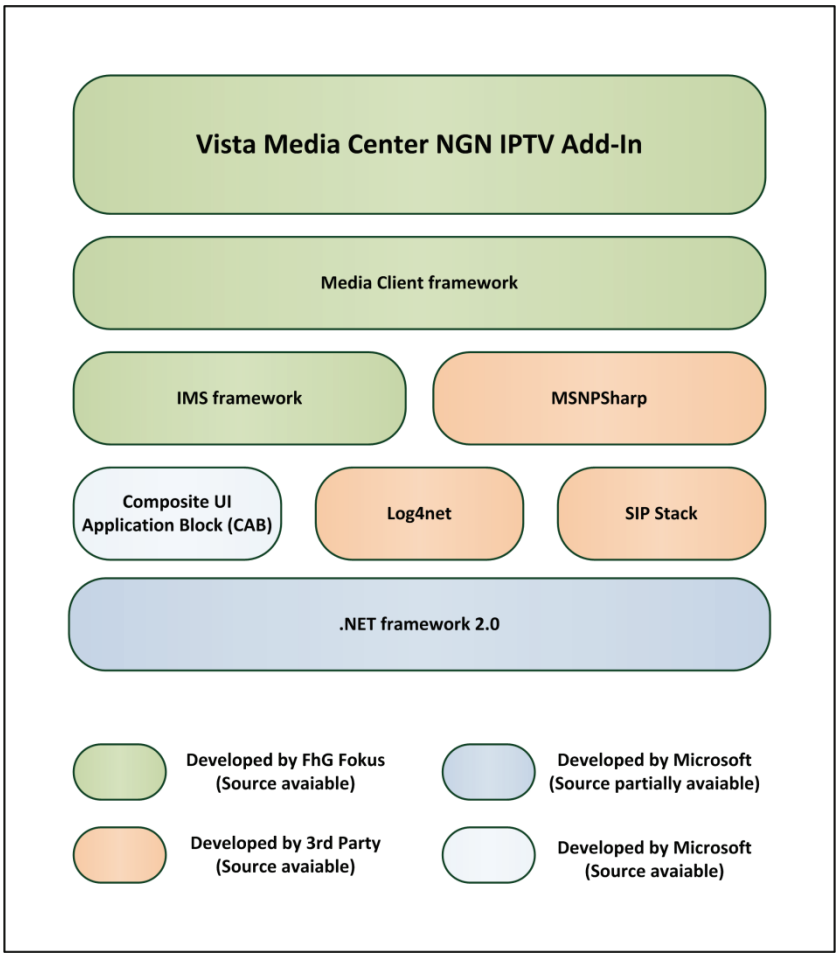


Figure 4.16: Components of VMC Add-In

# 5 Implementation of a Cross Domain Service

The implementation part of this diploma thesis unites services and functions of NGN. For example a IM service in a SIP based network like IMS, which is described in the document ETSI TR 181 007 [58]. This IM service is based on SIP and acts within a domain[1]. SIP is the standard for IM in an IMS environment. However, the user has a disadvantage, if he wants to send text-messages outside of this domain. He would act with the IPTV VMC client within the IMS domain and with a second application in another domain, e.g. the Internet. Thus, a clear separation of the domains is available.

The implementation part of this diploma thesis is primarily used with a television screen and presented on a VMC platform, which is usually executed in a full screen mode. It has a large disadvantage to control a second application beside the IPTV VMC application. A simple, uniform and intuitive control is a requirement to the implementation part of this diploma thesis. For this reason, it is beneficial to create a convergence between the IMS world and the Internet world for IM within the implementation part of this diploma thesis.

This Cross Domain approach could be realized with an implementation of an IM Service for the Internet. In the following chapter SIP based IM will be more explained and a service will be created for a converged communication. This service combines the IPTV VMC client (Figure 5.1 – Domain A) with Internet IM (Figure 5.1 – Domain B). This approach could accelerate the deployment of NGN on the market place, because that is a use case, which could be requested by users.

[1] Domain: describes a definable field in a network architecture

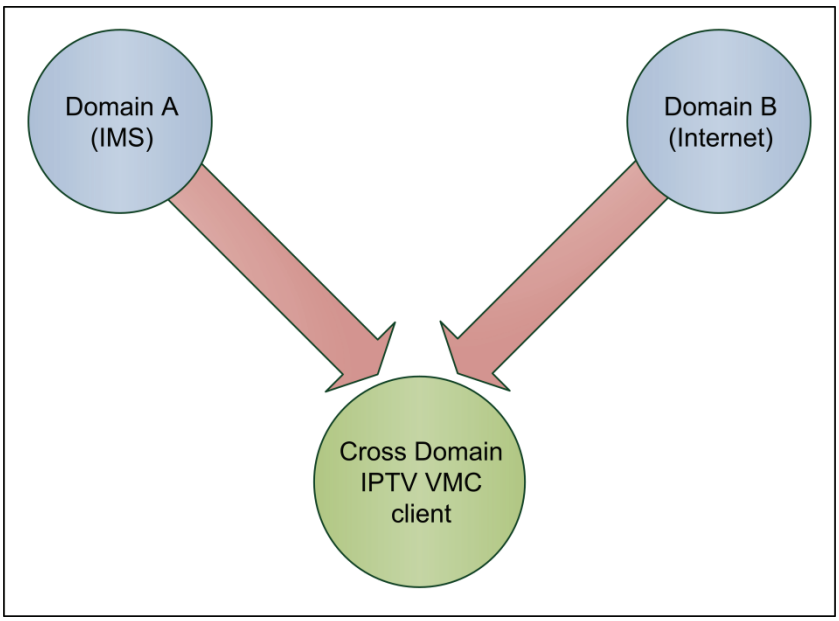


Figure 5.1: Cross Domain approach

## 5.1 SIP Instant Messaging within IMS

To communicate with other users within IMS a SIP based IM service is needed. IM describes the possibility to send text-messages between two or more users [58]. This happens with the help of different protocols like Extensible Messaging and Presence Protocol (XMPP), ICQ, Skype, Microsoft Notification Protocol (MSNP) or Yahoo Messenger. A lot of IM programs exist on the market place, which implement such an IM protocol. These tools also support the transfer of video or audio streams beyond messaging.

SIP is already an elementary part for registration and session management of end devices in the IMS world and can be extended for the usage of IM. The extension is specified in RFC 3428 [59]. The document describes the implementation of the SIP MESSAGE method to send text messages. The SIP MESSAGE method only supports conversations without a session. Text messages (via the SIP MESSAGE method) without session act like a pager[1]. A user can send a text-message to another user and each text-message stands for itself alone. A session (like a conversation) exists only in the user interface of the client. To create a real conversation with a session it is necessary to implement a mechanism, which is specified in RFC 4975 [60]. This RFC document describes the implementation of a Message Session Relay Protocol (MSRP), which is located

[1] Pager: equipment which receives short messages, e.g. “Call me back…”.

at layer seven of the OSI model. It can be used to send text messages in a conversation mode, if a session with SIP is created. The SIP MESSAGE method from RFC 3428 [59] is implemented with the IMS framework in the implementation part of this diploma thesis for the usage of IM.

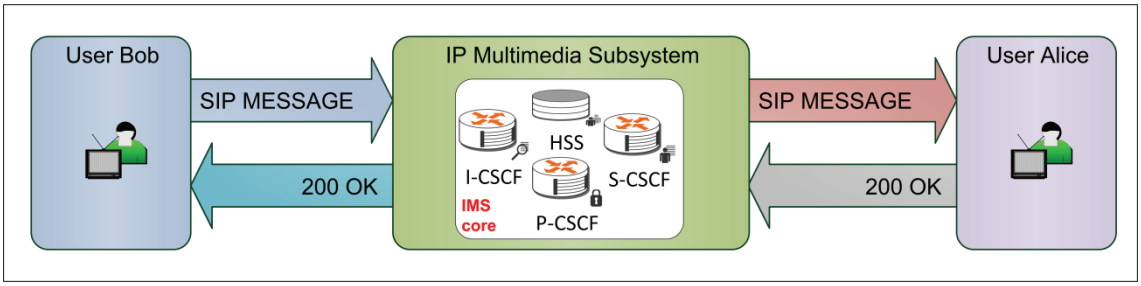


Figure 5.2: SIP based Instant Messaging

Figure 5.2 depicts the flow of an IM by using the SIP MESSAGE method according to RFC 3428 [59] in IMS. A text-message will be send from user “Bob” to user “Alice”. If the presence status of user “Alice” is online, the user “Alice” will receive the message with the text. If the presence status is offline, the message and also the text will be discarded.

User “Bob” sends a text-message with content “Hey Alice. How are you?” to user “Alice” via the SIP MESSAGE method. The SIP proxy, in this case the P-CSCF, receives the SIP MESSAGE (see Annex A:) and forwards it to the S-CSCF (see Annex B:). The S-CSCF looks up user “Alice” in the database (HSS) and finds a binding to user “Alice”. Thus, the SIP MESSAGE will be passed back to the P-CSCF (see Annex C:) and forwarded by the P-CSCF to user “Alice” (see Annex D:). The SIP MESSAGE will be received by user “Alice” and the text-message will be displayed on the screen. After receiving of this SIP MESSAGE an answer will be created. The answer will be routed to all entities which were passed by the SIP MESSAGE beforehand. Therefore, the entity, which forwards the answer, removes the top VIA and forwards it to the next VIA. The Answer with status 200, which stands for OK, will be send to the P-CSCF by user “Alice” (see Annex E:). The P-CSCF forwards it to the S-CSCF (see Annex F:) and back to the P-CSCF (see Annex G:). Finally, the answer is forwarded by the P-CSCF to user “Bob” (see Annex H:).

In the context of the implementation part of this diploma thesis an IM service for the Internet will be created.

## 5.2 Requirements to the Cross Domain IM service

Before the beginning of the implementation, a requirement catalogue is needed. These define the requirements to the design and implementation of a Cross Domain IM service.

Because of the circumstance that on the market place a lot of IM clients already exists, an IM protocol should be selected, which is popular and offers a lot of interfaces for further features. This guaranteed a connection to a large IM network, whereby many users can be reached. Thereby functions like registering at the system, send and receive IM and Rich Presence should be supported. This provides for a seamless integration into the implementation part of this diploma thesis, which also implements registering, Rich Presence and IM services. Thus, a uniform convergence will be achieved. In contrast to the non-conversation method of the implemented SIP MESSAGE method the used protocol should support conversations with a session mode. This has the advantage that several received IM can be better assigned to a conversation session of users.

An SDK or API should also be offered for the selected protocol. This enables a simple implementation and usage of functions like contact lists or event handler.

Conclusion for the design of the client:

The service should support the following functions:

- Implementation of a protocol to reach a large number of IM users
- Registering
- Send and receive of text messages
- Rich Presence
- SDK or API Support

## 5.3 Design and implementation of the Cross Domain Messaging Service

### 5.3.1 Selection of the Internet IM protocol

In the following an overview of popular IM protocols on the market place can be found. All of these IM protocols are located in layer seven of the OSI model.

| Name | Registration ID |
|---|---|
| IRC | Nickname!Username@hostname |
| MSNP | Email address |
| OSCAR | Username or clear ID[1] |
| QQ | Clear ID |
| Skype | Username |
| XMPP (Jabber) | Jabber ID |
| Yahoo Messenger | Username |

Table 5.1: Overview of popular Instant Messaging protocols

Because there is no official user statistics it is not possible to recognize which IM service is used mostly. This could be responsible by decentralized server structures with XMPP or IRC. IRC and XMPP have the advantage of open standards, which are defined in RFC 3921 [61] (IRC) and RFC 1459 [62] (XMPP). XMPP is used, among other services, by Google Talk, which is an IM service of the company Google. The IM service can be used with a Google email account over a web interface or a desktop application [63]. By opening the Google Talk network for other XMPP networks in 2006 (see [64]), an increasing of the user numbers is expected. However there are no actual user statistics for this IM protocol. Thus, the XMPP protocol will not be used in the implementation part of this diploma thesis.

[1] ID: abbreviation for Identification. For example: john.smith@internet.com

QQ is a very popular IM service and mostly used in China. The focus for Skype is primarily on VoIP services. The Skype protocol was developed for VoIP services. Later it was extended with a IM service. OSCAR is the protocol for the ICQ IM service. This service appeared after the IRC service in 1996. Many users have several accounts for the ICQ IM service. Therefore, it is not possible to do a statement on the spreading of the ICQ IM service.

On NETSPLIT [65] an overview for the usage of over 800 international IRC servers can be found. This overview contains the most popular IRC servers. The ranking shows over 860.000 active users during rush hours. However, this is only a small number of users in comparison to the user numbers of Windows Live Messenger. Microsoft presents user numbers for Windows Live Messenger with over 300 million to the public [66]. One reason for this high user number could be the integration of the Windows Live Messenger into Windows XP by default. Windows XP is one of the most popular operating systems. This statement resulted by a survey of an Internet consulting company [67]. However, the Windows Live Messenger service also with other operating systems can be used.

Windows Live Messenger implements MSNP. For the usage of MSNP a Windows Live ID for registering at the IM network is required. The Windows Live ID could be an existing email address or an email address, which is offered by Microsoft. With a Windows Live ID also other Internet services like Hotmail, SkyDrive or Mesh can be used. Thus the usage of MSNP in combination with the Windows Live ID has a large advantage for the user, i.e. one Windows Live ID for several services. All these Internet services could be implemented into the implementation part of this diploma thesis in the future.

The implementation of MSNP has a large time effort, because many conditions must be kept for communication with the messaging network. Thus, the usage of a framework can be helpful. For this reason, two frameworks are offered. These implements the MSNP stack and providing objects and event handler for programming. On the one hand is the framework DotMSN [68]. It fulfils all requirements of the requirement catalogue. However, since 2006 it is not further developed. Test in the context of the implementation resulted in an incompatibility to the current MSNP version. This incompatibility occurs in form of program-

ming exceptions while sending a text-message. On the other hand is the framework MSNPSharp [69]. This framework is based on DotMSN and extends it. The current MSNPSharp version is 2.5.2 (07.01.2009) and is compatible to the actual MSNP version. The MSNPSharp framework is an open source project. The sources are freely available and permission for modification is given by the developers. MSNPSharp supports functions like:

- Registering at the system
- Set up presence status and Rich Presence
- Send and receive text-based messages

These functions are necessary for the implementation of the Cross Domain Messaging service.

Beyond of that it supports further functions such as email inbox status, file transfer and sending IM to users which presence status is offline. Therefore, the Cross Domain Messaging service could be extended with further functions in the future. However, this will not take place in the implementation part of this diploma thesis.

Microsoft and Yahoo decided to connect their messaging networks in 2006 (see [70]). This means that with the usage of MSNP further users of a popular IM network can be reached. The functionality to send IM to Yahoo users is also implemented in the MSNPSharp framework.

On the basis of the mentioned facts the decision fell for an implementation of MSNP with the MSNPSharp framework in the implementation part of this diploma thesis.

### 5.3.2 Implementation of the Cross Domain Messaging service

To implement the Cross Domain Messaging service in the implementation part of this diploma thesis a CAB module is needed. This is a basic condition, because CAB represents a basis for the application logic of the IPTV VMC client. With the implementation of CAB, there only exists one global instance of each service. This ensures that data, functions and event handler only exists as singletons. In order to provide a CAB module an assembly must be created, which implements these three classes:

- `Module`
- `ModuleController`
- `ModuleName`

The static class `ModuleName` contains a static constant string variable `Name`:

```
public static class ModuleName
    {
        public const string Name = "VMC.ConvergedCommunication";
    }
```

Figure 5.3: The ModuleName class

This class represents the identification of the module.

Each Module inherits from the `ModuleInit` class. This class is the entry point of a module and is responsible for loading `WorkItems`. A `WorkItem` serves for managing of objects of a service and represents a class, which encapsulates the logic for a certain use case.

```
public class Module : ModuleInit
    {
        private WorkItem workItem;
        private ModuleController mc;
        public Module([ServiceDependency]WorkItem workItem)
        {
            this.workItem = workItem;
        }
        public override void Load()
        {
            base.Load();
            mc =
            workItem.WorkItems.AddNew<ModuleController>(ModuleName.Name);
            mc.Run();
        }
        public override void Unload()
        {
            mc.Terminate();
            base.Unload();
        }
    }
```

Figure 5.4: The Module class

With the implementation of the `ModuleInit` class a `ModuleController` object will be created. A `ModuleController` serves as controller for the `WorkItem` of a module. The `ModuleController` will be created and executed in the `Load()` method of the `ModuleInit` class.

```
public class ModuleController : WorkItem
    {
        private IMSNService msn;
        protected override void OnRunStarted()
        {
            msn = RootWorkItem.Services.AddNew<MSNService, IMSNService>();
        }
    }
```

Figure 5.5: The ModuleController class

The class `MSNService` (to see in Figure 5.5) represents the implementation of the IM functionality. In the implementation part of this diploma thesis the Cross Domain Messaging service can called simply with:

```
private IMSNService msnService = RootWorkItem.Services.Get<IMSNService>();
```

Figure 5.6: Call of the Cross Domain Messaging service

The Cross Domain Messaging service is represented by the interface `IMSNService`. It implements all properties, methods and event handlers, which are provided to the application. The functionality of the properties, methods and event handlers is implemented in the `MSNService` class. For example the interface provides the method:

```
/// <summary>
/// Disconnect from the MSN Network
/// </summary>
void UnRegister();
```

Figure 5.7: Example of a service method

This Method can be called in the implementation part of this diploma thesis with:

```
msnService.UnRegister()
```

Figure 5.8: Call of a service method

The functionality of the `UnRegister()` method is handled by the `MSNService` class:

```
public void UnRegister()
        {
            if (wrapped.Connected == true)
            {
                wrapped.Disconnect();
            }
        }
```

Figure 5.9: Funcionality of a service method

In the case of the `UnRegister()` method of Figure 5.9 the implementation part of this diploma thesis will be disconnected from the Windows Live Messenger network.

In the implementation part of this diploma thesis the following interface for providing the service was implemented.

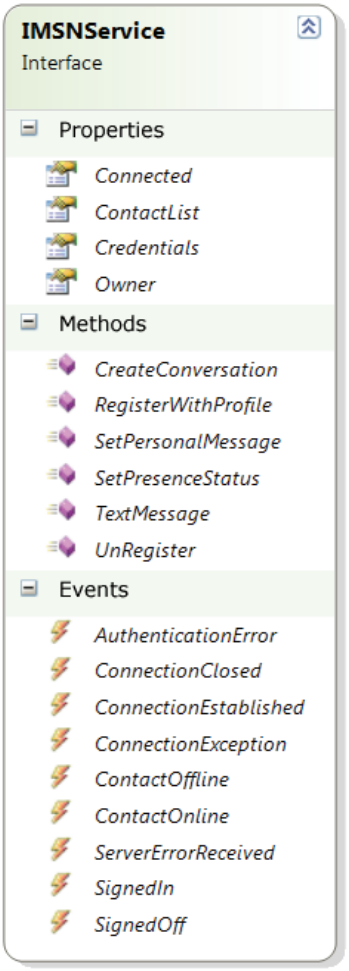


Figure 5.10: Cross Domain Messaging service interface

In order to use the Cross Domain Messaging service module it must be initialized. All modules are handled by a CAB application. A CAB application is the result of the implementation of CAB. It can be differentiated into Windows Forms application and CAB Shell application. Because the implementation part of this diploma thesis does not need Windows Forms, a CAB Shell application will be used. This CAB Shell application represents a Shell. It implements a `RootworkItem`, which hosts all initialized modules (see Figure 5.11). For initializing a module it is necessary to add the Name of the compiled assembly module to the file `ProfileCatalog.Win32.xml`. This file contains all names of modules, which should be initialized at start-up in the implementation part of this diploma thesis (see Figure 5.12).

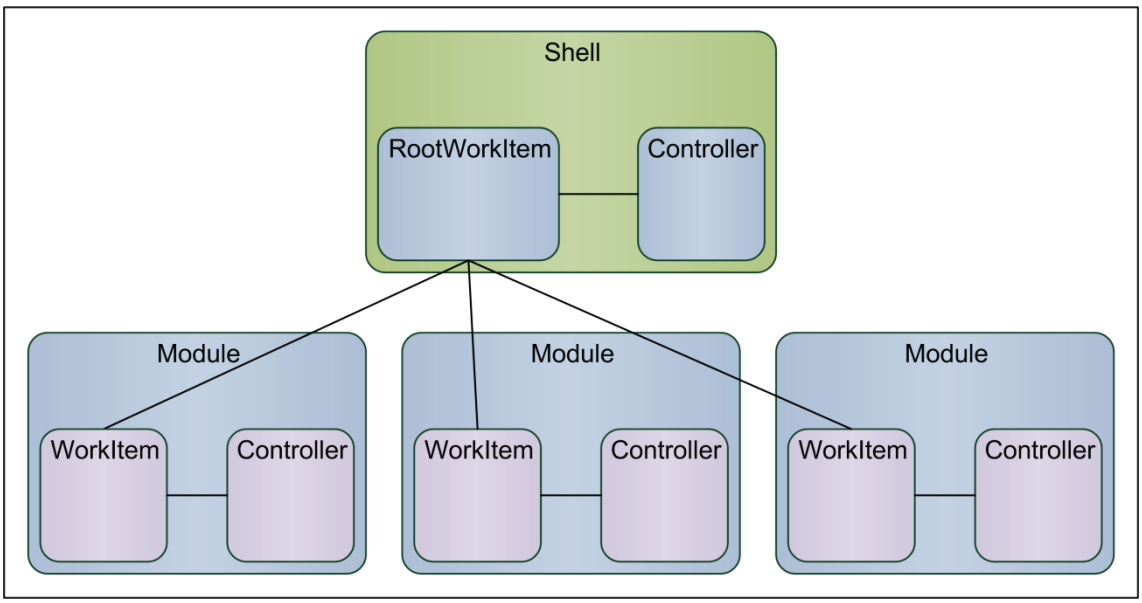


Figure 5.11: Overview of a CAB Shell application

```
<ModuleInfo AssemblyFile="Fokus.SE.IMS.VMC.ConvergedCommunication.dll" />
```

Figure 5.12: Abstract of the file ProfileCatalog.Win32.xml

After call of the `run()` method of the CAB Shell application all modules will be loaded. This means that the `load()` method of the `ModuleInit` class will be called. When no error occurs the services can be called with:

```
IMyService myService = RootWorkItem.Services.Get<IMyService>();
```

Figure 5.13: Example of calling a CAB service

# 6 Summary and outlook

In the context of this diploma thesis a NGN based Cross Domain IPTV Vista Media Center Add-In was designed, implemented and developed. Finally, the IPTV client was integrated in an existing IPTV infrastructure of the Fraunhofer FOKUS MILAB. For this reason, requirements to the transport and home networks, necessary transmission mechanism and current standardization activities of ETSI TISPAN with relation to IPTV were initially examined.

During the investigation it emerged that for the transmission of IPTV Live TV content only a Multicast distribution concept in combination with transport protocols for real-time data should be taken into consideration. Furthermore, it turned out that for the distribution of IPTV a concept of ETSI TISPAN for NGN should be used. This concept contains IMS as a cross network service platform for session control and QoS. With regard to the usage of IMS, requirements for the design and implementation of the IPTV client, particularly for the IMS compliant registration and the usage of NGN and IPTV services, must kept.

In order to present the media content to the user the usage of a Media Center platform, namely Microsoft Windows Vista Media Center is recommended. The VMC platform brings together IPTV and picture, music and video libraries of an entire connected household in a homogenous home entertainment environment.

As the course of this diploma thesis showed, SIP based IM is the default standard for text based communication between users in NGN. To enable with the NGN concept also text-based communication between users via the open Internet, an approach of convergence between Internet and NGN was examined. This approach was realized with the design and implementation of a Cross Domain Messaging service.

In the implementation part of this diploma thesis some problems occurred. The first problem that had to be solved was how the VMC platform in IMS can be integrated. To communicate with IMS and set up multimedia sessions, e.g. subscribe to an IPTV Live TV channel, the VMC IPTV client must implement SIP and several IMS compliant processes. As solution the Fraunhofer FOKUS IMS framework was used, which implements all necessary mechanism for commu-

nication with IMS. The GUI for the VMC IPTV client was difficult to develop, because designer tools are not offered. Some GUI views are based on a basis GUI view. Thus, they could be reused. However, for the development of this basis GUI views more time was required. IPTV Live TV is distributed via the Multicast technology. Because the Multicast data streams are different to the widely used Unicast technology it will not natively in the VMC platform implemented. Thus arose the problem how IPTV Live TV in the VMC platform can be rendered and presented to the user. As solution for this problem a proprietary Direct Show filter graph was used. This filter graph can be called within the VMC platform and serves for rendering a Multicast based IPTV Live TV channel.

The implemented functionality shows the advantages and possibilities of IPTV in combination with NGN and IMS within a Vista Media Center platform. The following set of services is recommended for future enhancements of the VMC Add-In:

- Recommendation System
- Voice over IP
- E-Commerce
- Target Advertisement
- Community TV

In combination with new Media Center features in the next generation of Windows seven, as for instance Multi-Touch support, symbioses between different devices in the home network emerge. That will offer new opportunities for a new user experience in multimedia applications.

In conclusion, the standardization of IPTV absolutely must be pursued, to enable for the providers as well as home users an easy integration of new services into existing IP network architectures. That provides a basis for multimedia services, which work over network boundaries. The basis for IPTV has been laid. But only with the standardization the expected market will open up for IP based television and all other related services.

# Annex

## Annex A: SIP MESSAGE of IM – Bob to P-CSCF

```
Request-Line:MESSAGE sip:alice@milab.fokus.fraunhofer.de SIP/2.0
Message Header
Via: SIP/2.0/UDP 10.147.66.251:55723;branch=z9hG4bK1773364938
Max-Forwards: 70
From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996
To: <sip:alice@milab.fokus.fraunhofer.de>
Call-ID: 1325943710-364642981-743950764
CSeq: 12 MESSAGE
Contact: <sip:bob@10.147.66.251:55723>
Content-Type: text/plain
Content-Length: 23
Message Body
Hey Alice. How are you?
```

## Annex B: SIP MESSAGE of IM – P-CSCF to S-CSCF

```
Request-Line:MESSAGE sip:alice@milab.fokus.fraunhofer.de SIP/2.0
Message Header
Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0
Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938
Max-Forwards: 16
From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996
To: <sip:alice@milab.fokus.fraunhofer.de>
Call-ID: 1325943710-364642981-743950764
CSeq: 12 MESSAGE
Contact: <sip:bob@10.147.66.251:55723>
```

```
Content-Type: text/plain

Content-Length: 23

Message Body

Hey Alice. How are you?
```

## Annex C: SIP MESSAGE of IM – S-CSCF to P-CSCF

```
Request-Line: MESSAGE sip:alice@10.147.175.161:56850 SIP/2.0

Message Header

Via:SIP/2.0/UDP
193.174.152.23:6060;branch=z9hG4bKe91a.bff23b92.0

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

Max-Forwards: 14

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>

Call-ID: 1325943710-364642981-743950764

CSeq: 12 MESSAGE

Contact: <sip:bob@10.147.66.251:55723>

Content-Type: text/plain

Content-Length: 23

Message Body

Hey Alice. How are you?
```

## Annex D: SIP MESSAGE of IM – P-CSCF to Alice

```
Request-Line: MESSAGE sip:alice@10.147.175.161:56850 SIP/2.0

Message Header

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.4d854e35.0
```

```
Via:SIP/2.0/UDP
193.174.152.23:6060;branch=z9hG4bKe91a.bff23b92.0

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

Max-Forwards: 13

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>

Call-ID: 1325943710-364642981-743950764

CSeq: 12 MESSAGE

Contact: <sip:bob@10.147.66.251:55723>

Content-Type: text/plain

Content-Length: 23

Message Body

Hey Alice. How are you?
```

## Annex E: SIP MESSAGE of IM – 200 OK Alice to P-CSCF

```
Status-Line: SIP/2.0 200 OK

Message Header

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.4d854e35.0

Via:SIP/2.0/UDP
193.174.152.23:6060;branch=z9hG4bKe91a.bff23b92.0

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>;tag=64250445

Call-ID: 1325943710-364642981-743950764
```

```
CSeq: 12 MESSAGE

Contact: <sip:alice@10.147.175.161:56850>

Content-Length: 0
```

## Annex F: SIP MESSAGE of IM – 200 OK P-CSCF to S-CSCF

```
Status-Line: SIP/2.0 200 OK

Message Header

Via:SIP/2.0/UDP
193.174.152.23:6060;branch=z9hG4bKe91a.bff23b92.0

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>;tag=64250445

Call-ID: 1325943710-364642981-743950764

CSeq: 12 MESSAGE

Contact: <sip:alice@10.147.175.161:56850>

Content-Length: 0
```

## Annex G: SIP MESSAGE of IM – 200 OK S-CSCF to P-CSCF

```
Status-Line: SIP/2.0 200 OK

Message Header

Via:SIP/2.0/UDP
193.174.152.23:4060;branch=z9hG4bKe91a.3d854e35.0

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>;tag=64250445

Call-ID: 1325943710-364642981-743950764

CSeq: 12 MESSAGE
```

```
Contact: <sip:alice@10.147.175.161:56850>

Content-Length: 0
```

## Annex H: SIP MESSAGE of IM – 200 OK P-CSCF to Bob

```
Status-Line: SIP/2.0 200 OK

Message Header

Via:SIP/2.0/UDP
10.147.66.251:55723;rport=55723;branch=z9hG4bK1773364938

From: <sip:bob@milab.fokus.fraunhofer.de>;tag=1305339996

To: <sip:alice@milab.fokus.fraunhofer.de>;tag=64250445

Call-ID: 1325943710-364642981-743950764

CSeq: 12 MESSAGE

Contact: <sip:alice@10.147.175.161:56850>

Content-Length: 0
```

## Annex I: List of used framework assemblies

As a result of the interaction of several frameworks a high number of assemblies arise, which should be explained to differentiate them. In the following a list with the used assemblies can be found. Every of them provide special services to interact with CAB, the IMS core or other services.

- the assemblies of CAB
    - Microsoft.Practices.Mobile.CompositeUI.Common.dll
    - Microsoft.Practices.Mobile.CompositeUI.dll
    - Microsoft.Practices.Mobile.CompositeUI.WinForms.dll
    - Microsoft.Practices.Mobile.Configuration.dll
    - Microsoft.Practices.Mobile.ObjectBuilder.dll
- the assembly of the SIP software stack
    - Independentsoft.Sip.dll
        - SIP .NET is a SIP API, written in C# for .NET or .NET Compact framework [71]

- the log4net logging tool
    - log4net.dll
        - a tool to help programmers output log[1] statements with .NET
- the assembly of the MSNP software stack
    - MSNPSharp.dll
        - MSNPSharp is a .NET Library, which provides MSNP interfaces [69]
- the assemblies of the Fraunhofer FOKUS IMS client framework
    - Fokus.NGNI.IMS.Common.dll
        - makes common used classes and methods available, e.g. logging and network tools
    - Fokus.NGNI.IMS.Contact.dll
        - provides an interface for contacts
    - Fokus.NGNI.IMS.Event.dll
        - provides methods for subscribing to events, e.g. presence information of other users
    - Fokus.NGNI.IMS.Media.dll
        - provides information of protocols and audio- and video co-dec's used by the application
    - Fokus.NGNI.IMS.Messaging.dll
        - provides SIP based messaging by using the SIP service, e.g. invoke an action at the user client
    - Fokus.NGNI.IMS.Presence.dll
        - provides functions to manage XML based presence information
        - used by contact service
    - Fokus.NGNI.IMS.Profiles.dll
        - provides user data by using the ProfilData.xml, e.g. user ID, username or password
    - Fokus.NGNI.IMS.Registration.dll
        - handles the registration of the user at the IMS core by using the SIP and the profile service

[1] Log: is a listing of statements, e.g. content of an application variable

- Fokus.NGNI.IMS.SDP.dll
  - implements Session Description Protocol to negotiate session parameters, e.g. properties of a multimedia stream
- Fokus.NGNI.IMS.Session.dll
  - handles session management for SIP signalling
  - set up and termination of sessions
- Fokus.NGNI.IMS.SIP.dll
  - basis for the communication with IMS and other services which are based on SIP, e.g. set up presence information
  - using the SIP .NET API
- Fokus.NGNI.IMS.XContacts.dll
  - using Contact and XDMC service to provide a contact list
- Fokus.NGNI.IMS.XDMC.dll
  - handles user data from a XCAP Server or local file

- the assemblies of the Fraunhofer FOKUS Media Client framework
  - Fokus.SE.IMS.WPF.BCG.dll
    - provides detailed EPG Data by using the TV-Anytime Standard
  - Fokus.SE.IMS.WPF.Channels.dll
    - handles functions for playing content, e.g. payment
  - Fokus.SE.IMS.WPF.Channelselection.dll
    - handles channel session management by using the Fokus.NGNI.IMS.Media service, e.g. request a channel
  - Fokus.SE.IMS.WPF.Common.dll
    - makes common used classes and methods available, e.g. Invoking service
  - Fokus.SE.IMS.WPF.IPTV.dll
    - sets presence information at the presence server, e.g. “I am watching video X”
  - Fokus.SE.IMS.WPF.Live.dll
    - provides information about IPTV Live TV streams, e.g. properties about Multicast addresses

- Fokus.SE.IMS.WPF.Media.dll
  - request channel information of IPTV Live TV and VoD at start of the application
- Fokus.SE.IMS.WPF.Messaging.dll
  - provides SIP based IM with other users
- Fokus.SE.IMS.WPF.ServiceTools.dll
  - parsing XML data, e.g. user settings
- Fokus.SE.IMS.WPF.Video.dll
  - handles trick functions for play, pause and stop
  - provides information about a channel
- Fokus.SE.IMS.WPF.VOD.dll
  - provides information about content within the category Video on Demand

- beside of the framework two additional files are necessary too
  - ProfileData.xml
    - contains user profile information of all users of the application
  - ProfileCatalog.Win32.xml
    - is required for configuration the CAB Application

# Bibliography

[1]. **ZDF.** ZDF Mediathek. [Online] http://www.zdf.de/ZDFmediathek/startseite. January 2009.

[2]. **Gemeinsame Stelle Digitaler Zugang (GSDZ).** *Digitalisierungsbericht 2008.* Berlin : VISTAS Verlag GmbH, 2008. ISBN 978-3-89158-487-3.

[3]. **ITU-T FG IPTV.** *ITU-T FG IPTV-C-0132 - Proposed Definition and Description of IPTV services for IPTV service scenario.* Busan : 2006.

[4]. **ARD.** ARD.de - Homepage. [Online] http://www.ard.de. March 2009.

[5]. **ZDF.** ZDF.de - Startseite. [Online] http://www.zdf.de. March 2009.

[6]. **DVB Project.** *Digital Video Broadcasting (DVB) - Multimedia Home Platform (MHP) Specification 1.2.* Geneva : 2007.

[7]. **Trick, Ulrich und Weber, Frank.** *SIP, TCP/IP und Telekommunikationsnetze.* München : Oldenbourg Wissenschaftsverlag GmbH, 2007. 978-3-486-58228-4.

[8]. **ITU-T.** *G.992.1 - Asymmetric digital subscriber line (ADSL) transceivers.* Geneva : 1999.

[9]. **ITU-T.** *G.992.3 - Asymmetric digital subscriber line transceivers (ADSL2).* Geneva : 2002.

[10]. **ITU-T.** *G.992.5 - Asymmetric Digital Subscriber Line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2+).* Geneva : 2003.

[11]. **ITU-T.** *G.993.1 - Very high speed digital subscriber line transceivers.* Geneva : 2004.

[12]. **ITU-T.** *G.993.2 - Very high speed digital subscriber line transceivers 2 (VDSL2).* Geneva : 2006.

[13]. **Frohberg, Wolfgang, Kolloschie, Horst und Helmut, Löffler.** *Taschenbuch der Nachrichtentechnik.* Leipzig : Carl Hanser Verlag München, 2008. ISBN 978-3-446-41602-4.

[14]. **Elektronik-Kompendium.de.** Kabelmodemtechnik (TV-Kabelnetz). [Online] http://www.elektronik-kompendium.de/sites/kom/0310051.htm. January 2009.

[15]. **CableLabs.** DOCSIS. [Online] http://www.cablemodem.com/primer/. January 2009.

[16]. **Deutsche TV-Plattform e.V.** *IPTV White Paper - Profiles for IPTV Services and Home Devices.* Frankfurt : 2009.

[17]. **Institute of Electrical and Electronics Engineers.** IEEE 802.3 Ethernet Working Group. [Online] http://www.ieee802.org/3. January 2009.

[18]. **IEEE.** *802.11g - Wireless LAN Medium Access Control (MC) and Physical Layer (PHY) specifications.* New York : 2006.

[19]. **devolo.** devolo dLAN 200 AVplus. [Online] http://www.devolo.de/de_DE_cs/produkte/dlan/dlan200avplus.html. January 2009.

[20]. **EurolTV'09.** *Transport Capacity for a Catch-up Television Service.* Leuven : 2008.

[21]. **Internet Engineering Task Force.** RFC 3376 - Internet Group Management Protocol, Version 3. [Online] http://www.ietf.org/rfc/rfc3376.txt. January 2009.

[22]. **Internet Engineering Task Force.** RFC 1700 - Assigned Numbers. [Online] http://www.ietf.org/rfc/rfc1700.txt. January 2009.

[23]. **Internet Engineering Task Force.** RFC 4541 - Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches. [Online] http://www.ietf.org/rfc/rfc4541.txt. January 2009.

[24]. **Internet Engineering Task Force.** RFC 3550 - RTP: A Transport Protocol for Real-Time Applications. [Online] http://www.ietf.org/rfc/rfc3550.txt. January 2009.

[25]. **Ericsson.** IPTV (Television über das Internet Protokol). [Online] http://www.ericsson.com/de/technologien/iptv.shtml. January 2009.

[26]. **ETSI TISPAN.** *ETSI TR 180 000 V1.1.1 - NGN Terminology.* Geneva: 2006.

[27]. **ITU-T .** *ITU-T Y.2001 - General overview of NGN.* Geneva : 2004.

[28]. **ETSI TISPAN.** *ETSI TR 180 001 V1.1.1 - NGN Release 1 - Release definition.* Geneva : 2006.

[29]. **ETSI TISPAN.** *ETSI ES 282 001 V2.0.0 - NGN Functional Architecture.* Geneva : 2008.

[30]. **ETSI TISPAN.** *ETSI TS 182 027 V2.0.0 - IPTV Architecture - IPTV functions supported by the IMS subsystem.* Geneva : 2008.

[31]. **ETSI TISPAN.** *ETSI TS 182 028 V2.0.0 - IPTV Architecture; Dedicated subsystem for IPTV functions.* Geneva : 2008.

[32]. **ETSI .** *ETSI TS 123 002 V8.3.0 - Universal Mobile Telecommunications System (UMTS) - Network architecture.* Geneva : 2008.

[33]. **Bertrand, Gilles.** *The IP Multimedia Subsystem in Next Generation Networks.* Bretagne : 2007.

[34]. **Internet Engineering Task Force.** RFC 3588 - Diameter Base Protocol. [Online] http://www.ietf.org/rfc/rfc3588.txt. February 2009.

[35]. **Internet Engineering Task Force.** RFC 3261 - SIP: Session Initiation Protocol. [Online] http://www.ietf.org/rfc/rfc3261.txt. January 2009.

[36]. **Fraunhofer FOKUS.** What is the "Open IMS Playground"? [Online] http://fokus.fraunhofer.de/en/fokus_testbeds/open_ims_playground/index.html. February 2009.

[37]. **Fraunhofer FOKUS.** The Open IMS Core Project. [Online] http://www.openimscore.org. February 2009.

[38]. **Microsoft.** Windows Media Services. [Online] http://www.microsoft.com/windows/windowsmedia/forpros/server/server.aspx. December 2008.

[39]. **Internet Engineering Task Force.** RFC 2778 - A Model for Presence and Instant Messaging. [Online] http://www.ietf.org/rfc/rfc2778.txt. December 2008.

[40]. **Internet Engineering Task Force.** RFC 3863 - Presence Information Data Format (PIDF). [Online] http://www.ietf.org/rfc/rfc3863.txt. December 2008.

[41]. **Internet Engineering Task Force.** RFC 4480 - Rich Presence Extensions to the Presence Information Data Format (PIDF). [Online] http://www.ietf.org/rfc/rfc4480.txt. December 2008.

[42]. **Internet Engineering Task Force.** RFC 3265 - Session Initiation Protocol (SIP)-Specific Event Notification. [Online] http://www.ietf.org/rfc/rfc3265.txt. December 2008.

[43]. **ETSI .** *ETSI TS 102 539 V1.2.1 - Carriage of Broadband Content Guide (BCG) information over Internet Protocol (IP) V1.2.1.* Geneva : 2008.

[44]. **Novell.** Mono. [Online] http://mono-project.com/Main_Page. December 2008.

[45]. **PCWelt.** Verkauf von PCs mit Vista Home Premium läuft gut an. [Online] http://www.pcwelt.de/start/software_os/vista/news/71462/verkauf_von_pcs_mit_vista_home_premium_laeuft_gut_an/. March 2009.

[46]. **ECMA.** Standard ECMA-335. *Common Language Infrastructure.* June 2006.

[47]. **Schwichtenberg, Dr. Holger.** Vista: Weniger .NET als erwartet. [Online] http://www.computerwoche.de/knowledge_center/software/582722/. December 2008.

[48]. **Microsoft.** Fragen und Antworten zur .NET Framework 3.0 Version und ihrer Bereitstellung. [Online] http://msdn.microsoft.com/de-de/netframework/aa663314.aspx. January 2009.

[49]. **Kühnel, Andreas.** Visual C# 2008. [Online] http://openbook.galileocomputing.de/visual_csharp/. December 2008.

[50]. **Microsoft.** Neues in Visual Studio 2008. [Online] http://msdn.microsoft.com/de-de/library/bb386063.aspx. January 2009.

[51]. **Microsoft.** Working with the Media Center Markup Language. [Online] http://msdn.microsoft.com/en-us/library/bb189823.aspx. February 2009.

[52]. **Microsoft.** Windows Media Center SDK. [Online] http://msdn.microsoft.com/en-us/library/ms818424.aspx. December 2008.

[53]. **Microsoft.** Audio- und Videocodecs der Windows Media 9-Reihe. [Online] http://www.microsoft.com/windows/windowsmedia/de/9series/codecs.aspx. December 2008.

[54]. **Malik, Tanvon.** DirectShow Filters what they are. [Online] http://www.codeproject.com/KB/audio-video/Tanvon_DirectShowFilters.aspx. December 2008.

[55]. **Bachmann, Andreas.** *Design and Implementation of a modular IMS Client Framework based on .NET.* Berlin : 2007.

[56]. **Microsoft.** Smart Client - Composite UI Applicaion Block. [Online] http://msdn.microsoft.com/en-us/library/aa480450.aspx. December 2008.

[57]. **Zachey, Benjamin.** *Personalisierung in Next Generation IPTV - Infrastrukturen - Entwurf und Implementierung eines personalisierten Programmführers.* Berlin : 2008.

[58]. **ETSI TISPAN.** *ETSI TR 181 007 V2.1.1 - Overview of Messaging Services.* Geneva : 2006.

[59]. **Internet Engineering Task Force.** RFC 3428 - Session Initiation Protocol (SIP) Extension for Instant Messaging. [Online]. http://www.ietf.org/rfc/rfc3428.txt. December 2008.

[60]. **Internet Engineering Task Force.** RFC 4975 - The Message Session Relay Protocol (MSRP). [Online] http://www.rfc-editor.org/rfc/rfc4975.txt. December 2008.

[61]. **Internet Engineering Task Force.** RFC 3921 - Extensible Messaging and Presence Protocol (XMPP): Instant Messaging and Presence. [Online] http://www.ietf.org/rfc/rfc3921.txt. December 2008.

[62]. **Internet Engineering Task Force.** RFC 1459 - Internet Relay Chat Protocol. [Online] http://www.ietf.org/rfc/rfc1459.txt. December 2008.

[63]. **Google.** Google Talk. [Online] http://www.google.com/talk/intl/de/. February 2009.

[64]. **Golem.de.** Google Talk öffnet sich für andere Jabber-Netze . [Online] http://www.golem.de/0601/42782.html. December 2008.

[65]. **Gelhausen, Andreas.** Internet Relay Chat. [Online] http://irc.netsplit.de/. January 2009.

[66]. **Microsoft.** Windows Live Messenger. [Online] http://get.live.com/messenger/overview. December 2008.

[67]. **Fittkauf & Maaß Consulting, Internet Consulting and Research Services .** Internet-Nutzer zeigen Windows Vista bisher die kalte Schulter. [Online] http://www.w3b.org/technik/internet-nutzer-zeigen-windows-vista-bisher-die-kalte-schulter.html. December 2008.

[68]. **Xih Solutions.** DotMSN - .NET Messenger Library. [Online] http://www.xihsolutions.net/dotmsn/. December 2008.

[69]. **Geertsema, Bas.** MSNPSharp. [Online] http://code.google.com/p/msnp-sharp. January 2009.

[70]. **Heise online.** MSN und Yahoo schalten Instant-Messaging-Netze zusammen. [Online] http://www.heise.de/newsticker/MSN-und-Yahoo-schalten-Instant-Messaging-Netze-zusammen--/meldung/75414/. December 2008.

[71]. **Independentsoft.** SIP.NET. [Online] http://www.independentsoft.de/sip. December 2008.

[72]. **Apache Software Foundation.** Logging Services. [Online] http://logging.apache.org/log4net/index.html. December 2008

[73]. **Strutz, Tilo.** *Bilddatenkompression.* Wiesbaden : Vieweg Verlag, 2005. ISBN 3-528-23922-0.

[74]. **Golem.de.** Windows Live ID wird zum OpenID-Provider. [Online] http://www.golem.de/0810/63202.html. December 2008.

[75]. **Internet Engineering Task Force.** RFC 2326 - Real Time Streaming Protocol (RTSP). [Online] http://www.ietf.org/rfc/rfc2326.txt. March 2009.

[76]. **3GPP.** 3GPP. [Online] http://www.3gpp.org. March 2009.

[77]. **Team MediaPortal.** [Online] http://www.team-mediaportal.com/. December 2008.

[78]. **LinuxMCE.** [Online] http://www.linuxmce.com/. December 2008.

[79]. **Kubuntu.** [Online] http://www.kubuntu.org/. December 2008.

[80]. **Microsoft.** [MS-MMSP]: Microsoft Media Server (MMS) Protocol Specification. [Online] http://msdn.microsoft.com/en-us/library/cc234711.aspx. February 2009.

[81]. **Mozilla.** AJAX. [Online] https://developer.mozilla.org/de/AJAX. January 2009.

[82]. **SUN Microsystems.** Developer Resources for Java Technology. [Online] http://java.sun.com/. January 2009

[83]. **ETSI .** *ETSI EN 300 421 V1.1.2 - Digital Video Broadcasting (DVB) - Framing structure, channel coding and modulation for 11/12 GHz satellite services.* Geneva : 1997.

[84]. **ETSI.** *ETSI EN 300 429 V1.2.1 - Digital Video Broadcasting (DVB) - Framing structure, channel coding and modulation for cable systems.* Geneva : 1998.

[85]. **ETSI.** *ETSI EN 300 744 V1.6.1 - Digital Video Broadcasting (DVB) - Framing structure, channel coding and modulation for digital terrestrial television.* Geneva : 2009.

[86]. **DVB Project.** Digital Video Broadcasting Project. [Online] http://www.dvb.org/. January 2009.

[87]. **European Telecommunication Standards Institute.** ETSI. [Online] http://www.etsi.org/WebSite/homepage.aspx. January 2009.

[88]. **World Wide Web Consortium.** Extensible Markup Language (XML). [Online] http://www.w3.org/XML/. February 2009.

[89]. **ZDF.** Glossar Digitales Fernsehen. [Online] http://www.unternehmen.zdf.de/fileadmin/files/Download_Dokumente/DD_Technik/Glossar-Digitales_Fernsehen.pdf. December 2008.

[90]. **The Database Marketing Institute, Ltd.** Glossary of Telecom Marketing Terms. [Online] http://www.telecom-marketing.com/index.php?q=node/7. December 2008.

[91]. **Digital Living Network Alliance.** Home - DLNA. [Online] http://www.dlna.org/. February 2009.

[92]. **International Organization for Standardization.** Homepage of ISO. [Online] http://www.iso.org/iso/home.htm. January 2009.

[93]. **World Wide Web Consortium.** HTML 4.01 Specification. [Online] http://www.w3.org/TR/1999/REC-html401-19991224/. February 2009.

[94]. **Institute of Electrical and Electronics Engineers.** IEEE. [Online] http://www.ieee.org/portal/site. January 2009.

[95]. **International Organization for Standadization.** *ISO/IEC 7498-1:1994(E) - Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model.* Geneva : 1994.

[96]. **International Telecommunication Union.** International Telecommunication Union. [Online] http://www.itu.int/net/homeindex.aspx. January 2009.

[97]. **Open IPTV Forum.** IPTV. [Online] http://www.openiptvforum.org/. February 2009.

[98]. **Kersten, Sascha.** IT-Handbuch für Fachinformatiker. [Online] http://openbook.galileodesign.de/it_handbuch/fachinformatiker_anh_a_glossar_001.htm. January 2009.

[99]. **ITU-T.** Joint Video Team. [Online] http://www.itu.int/ITU-T/studygroups/com16/jvt/index.html. January 2009.

[100]. **Free Software Foundation Inc.** Licenses. [Online] http://www.gnu.org/licenses/. March 2009.

[101]. **Moving Picture Expert Group.** MPEG-2: Generic coding of moving pictures and associated audio information. [Online] http://www.chiariglione.org/mpeg/standards/mpeg-2/mpeg-2.htm. January 2009.

[102]. **ITU-T FG IPTV.** *ITU-T FG IPTV-OD-0026 - IPTV Services, use cases, requirements and scenarios.* Geneva : 2006.

[103]. **Apple.** QuickTimer 7. [Online] http://www.apple.com/de/quicktime/. January 2009

[104]. **Internet Engineering Task Force.** RFC 2616 - Hypertext Transfer Protocol -- HTTP/1.1. [Online] http://www.ietf.org/rfc/rfc2616.txt. January 2009.

[105]. **Internet Engineering Task Force.** RFC 2960 - Stream Control Transmission Protocol. [Online] http://www.ietf.org/rfc/rfc2960.txt. January 2009.

[106]. **Internet Engineering Task Force.** RFC 4346 - The Transport Layer Security (TLS) Protocol Version 1.1. [Online] http://www.ietf.org/rfc/rfc4346.txt. January 2009

[107]. **Internet Engineering Task Force.** RFC 4566 - SDP: Session Description Protocol. [Online] http://www.ietf.org/rfc/rfc4566.txt. February 2009.

[108]. **Internet Engineering Task Force.** RFC 768 - User Datagram Protocol. [Online] http://www.ietf.org/rfc/rfc768.txt. January 2009

[109]. **Internet Engineering Task Force.** RFC 791 - Internet Protocol. [Online] http://www.ietf.org/rfc/rfc791.txt. January 2009.

[110]. **Internet Engineering Task Force.** RFC 793 - Transmission Control Protocol. [Online] http://www.ietf.org/rfc/rfc793.txt. Janaury 2009.

[111]. **Joint Photographic Experts Group.** The JPEG committee home page. [Online] http://www.jpeg.org/index.html?langsel=en. January 2009.

[112]. **Microsoft.** The LINQ Project. [Online] http://msdn.microsoft.com/de-de/library/aa479865(en-us).aspx. January 2009.

[113]. **Telecommunications and Internet converged Services and Protocols for Advanced Networking.** TISPAN. [Online] http://www.etsi.org/tispan/. January 2009.

[114]. **TV-Anytime Forum.** TV-Anytime. [Online] http://www.tv-anytime.org/. December 2008

[115]. **Microsoft.** Übersicht über XAML. [Online] http://msdn.microsoft.com/de-de/library/ms752059.aspx. January 2009.

[116]. **Fraunhofer FOKUS.** Welcome to Fraunhofer FOKUS. [Online] http://www.fokus.fraunhofer.de/en/fokus/index.html. February 2009.

[117]. **Fraunhofer FOKUS.** Welcome to the FOKUS Media Interoperability Lab. [Online] http://www.fokus.fraunhofer.de/en/fokus_testbeds/mi_lab/index.html. February 2009.

[118]. **UPnP Forum.** Welcome to the UPnP Forum. [Online] http://www.upnp.org/. February 2009.

[119]. **Microsoft.** Windows CardSpace. [Online] http://msdn.microsoft.com/de-de/netframework/aa663320(en-us).aspx. January 2009.

[120]. **Microsoft.** Windows Communication Foundation. [Online] http://msdn.microsoft.com/de-de/netframework/aa663324.aspx. January 2009.

[121]. **Microsoft.** Windows Presentation Foundation. [Online] http://msdn.microsoft.com/de-de/netframework/aa663326.aspx. January 2009.

[122]. **Microsoft.** Windows Workflow Foundation. [Online] http://msdn.microsoft.com/en-us/library/ms735967.aspx. January 2009.

[123]. **World Wide Web Consortium.** World Wide Web Consortium - Web Standards. [Online] http://www.w3.org/. February 2009.

[124]. **YouTube.** YouTube - Broadcast Yourself. [Online] http://www.youtube.com/. January 2009.

# Statement

I hereby declare that the present diploma thesis is written by me. Only the expressly named sources and tools were used in this diploma thesis. Verbal or corresponding thought of other people I have labelled as such.

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