



**Digital Video Broadcasting (DVB): Internet TV  
Content Delivery Study Mission Report**

**DVB Document A 145  
December 2009**

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Reference

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Keywords

DVB, Internet TV Services, Internet TV Content  
Delivery

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## Foreword

This Study Mission Report has been produced by the DVB Project. Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

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## Contributors

The following volunteers contributed to and assisted in the completion of this Study Mission Report:

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In addition, technology submissions were provided by non DVB members. The editors of these submissions are mentioned in Annex B-D of the extended Study Mission Report [4].

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## Introduction

In March 2009, the Technical Module (TM) of the DVB Project decided to launch a Technology Study Mission on Internet TV Content Delivery. This Study Mission was carried out in the ad-hoc group Internet Protocol Infrastructures (TM-IPI) of the Technical Module and was chaired by Dr. Thomas Stockhammer (LG Electronics). The rationale for this Study Mission was mainly to investigate technology options to deliver DVB type content over the Internet to a large number of CE devices (includes game consoles), PCs or mobile devices. DVB provided specific guidelines on what is expected from the study mission.

The Study Mission was kicked off on April 17, 2009 and was completed on September 22, 2009. The Study Mission report was presented to DVB Technical Module on September 25, 2009 and approved by the DVB Steering Board on 21 October 2009. During this period the Study Mission collected the information in this report within 27 regular meetings. Three of these meetings were face-to-face meetings, the remainder were online meetings. A significant amount of discussion also happened over an e-mail list that was specifically setup for this Study Mission.

The information collected in this Study Mission is to a large extent based on information collected during a public questionnaire process. The questionnaire triggered 21 replies on different technologies in the area of Internet TV content delivery. Additional information on other technologies was collected based on overview documents from technology providers or Study Mission internal summaries. The provided information is summarized in different categories.

This report is a short version of the DVB-internal Study Mission Report [4]. Whereas the DVB-internal version is only available to companies which are members of the DVB Project, the current version is made available to organisations outside DVB.

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# 1 Scope

The DVB Technical Module defined the following scope for the Internet TV Content Delivery Study Mission. The Study Mission should

- investigate technology options to deliver DVB type content over the Internet to a large number of CE devices (includes game consoles), PCs or mobile devices.
- focus on content delivery, other functions such as codecs, security, etc. can be considered, but need not be the core of the report and slow down the release.
- attempt to include subject matter experts in the field of Internet Content Delivery to ensure a wide and comprehensive consideration of technology options and the most accurate evaluation against the high level evaluation criteria.
- investigate suitability of Peer-to-Peer and compare it with other Internet distribution technologies such as:
  - Existing DVB-IPTV technologies, with any necessary modifications (e.g. CDS)
  - Technologies used in existing Internet TV deployments
  - Technologies specified by other standardisation and industry bodies
- investigate suitability of Peer-to-Peer in combination with other Internet distribution technologies
- consider all players of the Internet-TV value chain
- consider different types of DVB services
  - LiveTV (Streaming)
  - Content on Demand (Streaming or Download)

It was seen critical to have existing Internet TV service providers (including the major European broadcasters) involved. The Study Mission and this Study Mission Report attempt to fulfil the scope by collecting adequate technical and non-technical information. The collected information is provided in this Study Mission Report and evaluated and assessed to the extent it was considered reasonable.

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## 2 References

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

- [1] ETSI TS 102 034: "Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks".
- [2] ETSI TS 101 154: "Digital Video Broadcasting (DVB); Implementation guidelines for the use of MPEG-2 Systems, Video and Audio in satellite, cable and terrestrial broadcasting applications".
- [3] ETSI TS 102 005: "Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in DVB services delivered directly over IP protocols".
- [4] tm4283r2: "Digital Video Broadcasting (DVB): Internet TV Content Delivery Study Mission Report", October 2009.
- [5] cm-iptv0554: "Commercial case for Internet TV (Public Version)", October 2009.



## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

QoE: observed quality by the Internet TV Consumer

QoS: measurable quality of the content delivery.

NOTE: Additional definitions are interleaved in the remainder of the document.

### 3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAC	Advanced Audio Coding
AES	Advanced Encryption Standard
API	Application Programming Interface
ARIB	Association of Radio Industries and Businesses
ATSC	Advanced Television Systems Committee
AVMS	Audiovisual Media Services Directive
BCG	Broadband Content Guide
CAS	Conditional access system5
CDA	Content Delivery Assistance
CDN	Content Delivery Network
CDS	Content Download Service
CoD	Content-on-Demand
CEA	Consumer Electronics Association
CE	Consumer Electronics
CERNET	China Educational and Research Network
CI	Common Interface
CMS	Content Management System
CPU	Central Processing Unit
DiffServ	Differentiated Services
DNA	Delivery Network Accelerator
DRM	Digital Rights Management
DTCP	Digital Transmission Content Protection
DVB	Digital Video Broadcasting
DVB-AVC	DVB-Audio Video Coding
DVB-C	DVB-Cable
DVB-CPCM	DVB-Content Protection & Copy Management
DVB-FF	DVB-File Format
DVB-S	DVB-Satellite
DVB-SI	DVB-Service Information
DVB-T	DVB-Terrestrial
EBU	European Broadcast Union
ETSI	European Telecommunications Standards Institute
EU	European Union
FEC	Forward Error Correction
FLUTE	File Delivery over Unicast Transport
GEM	Globally Executable MHP
GOP	Group-of-Pictures
HDTV	High-Definition TeleVision
HbbTV	Hybrid Broadcast Broadband TV
HE-AAC	High-Efficiency AAC
HNEED	Home Network End Device
HTML	HyperText Markup Language

HTTP	Hypertext Transfer Protocol
HTTPS	secure HTTP
IC	Interaction Channel
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IPR	Intellectual Property Rights
IPTV	Internet Protocol TeleVision
ISO	International Standards Organization
ISP	Internet Service access Provider
ITU-T	International Telecommunications Union – Telecommunications Sector
ITVCP	Internet TV Content Provider
ITVSP	Internet TV Service Provider
LMB	Live Media Broadcast
MHEG	Multimedia and Hypermedia information coding Expert Group
MHP	Multimedia Home Platform
MP4	MPEG-4
MPEG	Moving Pictures Experts Group
NAT	Network Address Translation
nPVR	network Personal Video Recorder
NSP	Network Service Provider
OIPF	Open IPTV Forum
P2P	Peer-to-Peer
P2PSIP	Peer-to-Peer Session Initiation Protocol
PC	Personal Computer
PPSP	P2P Streaming Protocol
QoS	Quality-of-Service
QoE	Quality-of-Experience
RSA	Rivest, Shamir und Adleman (refers to algorithm for public-key cryptography)
RSVP	Resource Reservation Protocol
RTCP	Real-Time Control Protocol
RTP	Real-Time Protocol
RTSP	Real-Time Streaming Protocol
SCTP	Stream Control Transmission Protocol
SDO	StanDardization Organization
SD&S	Service Discovery and Selection
SDP	Session Description Protocol
SDTV	Standard-Definition TeleVision
SHA	Secure Hash Algorithm
SIP	Session Initiation Protocol
SRTP	Secure RTP
SSL	Secure Sockets Layer
SSM	Source Specific Multicast
STB	Set-Top Box
SVC	Scalable Video Coding
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TM	Technical Module
TM-IPi	Technical Module – IP Infrastructure
TPM	Trusted Platform Module
TS	Transport Stream
TV	TeleVision
TVA	TV Anytime
UDP	User Datagram Protocol
UNI	User-Network-Interface
URI	Uniform Resource Identifier
VoD	Video-on-Demand

WMA Windows Media Audio  
WMV Windows Media Video

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## 4 Executive Summary

### 4.1 Summary of the Study Mission Process

Providing DVB services over the Open Internet has been an ongoing discussion in commercial and technical groups in DVB for some time. In March 2009, DVB decided to launch a technical Study Mission on Internet TV Content Delivery to investigate technology options to deliver DVB type content over the Internet to a large number of CE devices (includes game consoles), PCs or mobile devices. DVB provided specific guidelines on what is expected from the study mission.

The study mission was kicked off on April 17, 2009 and was completed on September 22, 2009. The Study Mission Report is presented to DVB TM on September 25, 2009. During this five months period the Study Mission collected the information in this report within 27 regular meetings. Three of these meetings were face-to-face meetings, the remaining ones were telephone conferences and web sessions. A significant amount of discussion also happened over an e-mail list that was specifically setup for this Study Mission. A total of 140 DVB members had subscribed to this list. The number of participants in the meetings varied between four and 35 with typically more than 10 participants. The number of attendees was lower during the summer months July and August for obvious reasons.

To collect relevant information and to attract a significant amount of experts within and also outside DVB, it was decided to issue a public questionnaire to obtain information on existing technologies in the area of Internet TV Content Delivery. The first month of the Study Mission was dedicated to complete this public questionnaire and to identify relevant technologies in this area. The questionnaire was published on May 22<sup>nd</sup>, 2009, on the DVB website and it is included in the extended Study Mission Report [4] in Annex A. Members of the Study Mission task force explicitly contacted technology providers asking for the submission of technologies and providing assistance in case of questions. The questionnaire triggered 21 replies on different technologies in the area of Internet TV content delivery. Additional information was collected in Annex C and Annex D of the extended Study Mission Report [4] from technologies that did not have sufficient time to complete the questionnaire or did not respond to the request for information.

During two of the face-2-face meetings, the submitters of the technology were given the opportunity to present their technology within the DVB Study Mission. All submitters of the technologies accepted this invitation and presented their technologies within the Study Mission. The presentation slides, if used, have been made available to DVB and can be accessed in the DVB TM-IPI documents folder.

The Study Mission Task Force collected, categorized and summarized the information by middle of August 2009. As some of the replies and technology submissions were received only late in the process, the summaries needed to be updated continuously. To evaluate the different architectures of the submitted technologies, the Study Mission Task Force also created a sub-group to categorize the architectures, to identify commonalities and differences and to come up with functions and interfaces that may potentially be relevant for DVB specification efforts. This architecture group had seven online meetings in the month of August 2009 and their output is summarized in clause 10 of this Study Mission Report. Based on this collected information, the final weeks of the Study Mission Task Force were used to summarize opinions and options for DVB and to provide recommendations for DVB in the area of Internet TV Content Delivery.

### 4.2 How to read this Study Mission Report

This Study Mission Report is a collection of information on Internet TV Content Delivery. This collection has been done on a best-effort basis and within a rather short amount of time by committed DVB members. It is worthwhile to note that this effort has been very collaborative and all members and contributors should be acknowledged for their dedication to this Study Mission. Critical and contentious issues have not been excluded from the discussions, but all discussions were constructive and always based on solid technical arguments. Before providing an overview on the content of this report, a brief overview on what the report is and what it is not and what should be taken care of:

- A significant amount of additional technologies exist in the space of Internet TV Content Delivery. Every day new technologies are invented, implemented and deployed. The report is a snapshot on existing technologies as made available mid-2009 to DVB.

- This report is not a Technical Specification. It does not contain any normative aspects.
- This report is intended to be a technical document. Commercial aspects are not entirely excluded as technological and commercial aspects are tightly connected and once in a while technical advantages may only be understood based on commercial aspects in the area of Internet TV services. However, it is important to mention that DVB's commercial groups have not been involved in the generation of this Study Mission Report. The commercial groups in DVB have accompanying work items on Internet TV Commercial Case studies [5].
- This report is not a technical recommendation. Despite some technologies are discussed in more details than others and some advantages or disadvantages of certain technologies are explicitly mentioned, it is not the intention of this Study Mission report to recommend specific technologies. The report tries to extract trends in the market.
- The collection of information is mostly based on the technology submissions as provided in the Annexes of the extended Study Mission Report [4]. It is important to mention that the Study Mission task force did not have the time to verify all information that is provided in these Annexes. Technical summaries are accurate reflection based on the information provided in the Annexes.
- Due to the fact that information had been collected and summarized in parallel, and multiple contributors worked in parallel on different clauses, certain information may redundant and certain aspects may have been mentioned multiple times. Also certain important information may have been just overlooked, despite the information is available in the technology submissions. There was just not sufficient time to cross-verify all aspects and to ensure a completely coherent presentation.
- The Study Mission Report may have some inconsistencies in itself as multiple contributors have worked in parallel. In no way these inconsistencies have been integrated on purpose, but they may just have resulted from late-minute updates and integrations and may just have been overlooked. In case of any doubts, the Annexes of the extended Study Mission Report [4] should be checked to resolve the inconsistencies.

This Study Mission Report is structured as follows:

- Clause 5 provides a starting point on Internet TV content delivery. The information presented in this clause was collected in the initial phase of the Study Mission to come up with common objectives on the scope of the Study Mission Report. Some definitions are provided and the scope of the technologies to be considered in the study mission has been defined. Furthermore, some high-level criteria that are of interest for the different technologies had been collected. Those criteria stimulated the generation of the questionnaire. Relation between the questionnaire and those high-level criteria is provided in clause 8.
- Clause 6 describes the information gathering process and provides a high-level review of the provided technologies. The abstracts of each of the technology submission are copied into this clause. The summaries of the technologies in this clause 6 are word-by-word taken from the replies and the submitted documents.
- Clause 7 provides a first high-level analysis and categorization of the different technologies. This was seen necessary as the replies have been quite diverse in terms of what subjects they address. Therefore, to enable a better structuring of the replies and the available technologies, this clause provides a brief overview categorization of the different technologies in the scope of the technology, the content distribution methodology, the deployment status, the supported services, the target platform for the end device and the type of specification.
- Clause 8 provides a more detailed summary of different aspects in Internet TV content delivery. A couple of members of the Study Mission group volunteered to summarize the replies to the questionnaire in different categories and provide a brief motivation why the respective questions had been asked and how they connect to the high-level criteria. Commercial aspects, standardization and specification aspects, as well as technical aspects are considered.
- Clause 9 connects the collected information in this Study Mission Report to the findings and conclusions in the DVB Commercial Case study on Internet TV [5]. This clause was completed in collaboration between DVB technical and commercial groups.
- Clause 10 discusses architectural examples to identify commonalities and differences in different Internet TV Content Delivery technologies. For this purpose, a baseline architecture is defined taking into account different services. Specific focus is put on scalable content delivery architectures taking into account CDN-based, P2P-based and hybrid CDN/P2P-based architectures. Relevant functions

and interfaces are extracted. To verify the decomposition, some example architectures from the technology submissions are mapped to the generic architectures.

- Clause 11 provides a collection on opinions and options on what DVB can contribute on Internet TV Services and in particular on Internet TV Content Delivery. Some opinions are collected if DVB should start specification efforts or not and what areas may be of relevance. Options on potential specification efforts and specification areas are discussed.
- Clause 12 finally provides recommendations for DVB based on the Study Mission Report.

The extended Study Mission Report [4] also contains

- a collection on opinions and options on what DVB can contribute on Internet TV Services and in particular on Internet TV Content Delivery. Some opinions are collected if DVB should start specification efforts or not and what areas may be of relevance. Options on potential specification efforts and specification areas are discussed.
- recommendations for DVB based on the Study Mission Report.
- Annexes collecting the information, based on which the conclusions in this report have been drawn. Specifically, Annex A provides the published questionnaire, Annex B all replies to the questionnaire, Annex C a collection of technology submissions not in the form of a questionnaire reply and Annex D some information that had been collected by Study Mission group members based on public information.

The study mission report may be read as follows, depending on your available time:

- For those having very little time, only clause 4.3 may be read.
- For those having at least some time, clauses 7, 11 and 12 should be read.
- For those interested in the submitted technologies and the technological differences in the different categories, also clause 8 should be read.
- For those who are interested in the connection to the Commercial Case Study [5,6], clause 9 should be read.
- For those who are in addition interested in some more details on architectural commonalities and differences and relevant interfaces, also clause 10 should be read.

### 4.3 Major Conclusions

The DVB Technical Study Mission on Internet TV Content Delivery was able to collect relevant information on Internet TV Content Delivery. A significant amount of DVB and non-DVB members showed interest in the process and have contributed to this Study Mission. It showed, that the area of Internet TV Services and specifically also Content Delivery is very crowded, mostly by proprietary solutions, but also certain SDOs are working in this area, for example ETSI MCD, the Open IPTV Forum or the IETF. Furthermore, many proprietary solutions have been established in the market to enable delivery of TV-like services over the Open Internet – however mostly targeting PC platforms.

Of specific interest of DVB was to understand how a large number of receivers could be served by the network architecture. Scalable content delivery architectures can basically be classified in three categories:

- Content Delivery Network (CDN)-based distribution mostly reuses web content distribution principles such as distributed edge servers. In particular HTTP-CDN-based technologies promise fast deployment of Internet TV services as they rely on the use of existing standard HTTP servers for the scalable content distribution.
- Peer-to-Peer (P2P)-based technologies rely to a significant portion on other end devices serving the content. These peers share resources such as storage, cache, processing power, and uplink bandwidth with Internet TV service providers to enable scalable distribution of services.
- Hybrid P2P-CDN architectures use both, dedicated infrastructure components (super-peers) as well as end devices which may enable interesting and innovative deployment and business model options.

Another interesting observation is the popularity of HTTP/TCP as the primary transport protocol. This differs significantly from IPTV solutions primarily using RTP and UDP. DVB-familiar media codecs and encapsulation formats are still heavily used and applicable to Internet TV services, but also proprietary formats have non-negligible market share. Internet streaming services require protocols, codecs and formats that permit dynamic adaptation to varying bitrates.

From the experience gained in the study mission it can be derived that there is considerable scope for improving technologies for the reliable distribution of high-quality commercial AV content over the Internet to a large number of consumer end devices. So is Internet TV Content Delivery a DVB concern? DVB has not yet completed the discussion on this topic, but it is beyond any doubt that the market requires some standardised solutions to bring all types of DVB content across the open Internet to the general public as efficiently as possible. A DVB activity in this area may usefully complement the broadcast standards that DVB has successfully developed in the past, particularly in the context of the hybrid broadcast/broadband television which is gaining traction in many parts of Europe and worldwide.

## 5 Overview Internet TV Content Delivery

### 5.1 Definitions

#### 5.1.1 Internet TV Content Delivery

Internet TV Content Delivery is considered as the delivery of multimedia services over the Internet (non-managed network), or over a network that contains at least one non-managed portion in its end-to-end data flows, and thereby cannot guarantee QoS.

DVB and other organizations have existing specifications for IPTV, e.g. ETSI TS 102 034<sup>1</sup>. IPTV is defined by the ITU-T as multimedia services such as television/video/audio/text/graphics/data delivered over IP based networks managed to provide the required level of quality of service and experience, security, interactivity and reliability.

Both IPTV and Internet TV share the basic capabilities of an IP network. But they differ in the availability of some protocols and on the QoS characteristics. Typical characteristics of such an Internet TV system/service include:

- Elements of the system are open, without a single controlling authority or aggregator.
- Anyone with an Internet connection can make Internet TV services and content available, and will be able to access services.
- There is typically no end-to-end management of quality of service for content delivery.
- Internet TV content can be delivered without resource reservation.

In Internet TV Content delivery, it can typically be assumed that in contrast to IPTV, the following features are not available

- IGMP
- RSVP
- DiffServ
- QoS guarantees

#### 5.1.2 Considered Content Types

The Study Mission is mostly concerned to find potential solutions to deliver *DVB-type content* over the Internet. DVB-type content is considered as video and/or audio, subtitles, images/graphics, animations, text (incl. tele-/videotext), webpages or any other information that is intended to be delivered through DVB standardized transport mechanism to and consumed by a user. DVB content is formatted according to ETSI TS 101 154 or ETSI TS 102 005<sup>2</sup> as traditional DVB delivery systems typically only permit the transport of formats specified in either TS 101 154 or TS 102 005. However, specifically for the questionnaire conformance to ETSI TS 101 154 or TS 102 005 has *not* been considered essential and the questionnaire was open to technologies using other content formats and types.

## 5.2 Considered Actors in the Value Chain

Business value chains in the Internet TV environment are diverse. Nevertheless, a simple linear example business value chain is described in the following to address certain players considered in some areas of this questionnaire. The following actors are considered in the example value chain for Internet TV Content Delivery.

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<sup>1</sup> ETSI TS 102 034 specifies DVB-IPTV technologies, specifically the Transport of MPEG-2 TS Based DVB Services over IP Based Networks.



- Internet TV Content Provider (ITVCP), e.g. Broadcaster: provides TV-like content to be delivered over the Internet. Typically an ITVCP provides content not only for Internet TV content delivery, but also for other distribution means.
- Internet TV Service Provider (ITVSP): provides service to the ITVCP to deliver content over the Internet. The ITVSP may act as an aggregator for multiple ITVCP. The provided service may for example include service discovery, portal and content guide services, authentication and billing services, etc.
- Delivery Network Service Provider: provides generic delivery service to specific service providers to deliver generic content over IP networks in a scalable and reliable manner. This typically includes an Internet Service Backbone Provider as well as scalable delivery architectures, for example based on
  - a Content Delivery Network (CDN), or
  - a peer-to-peer (P2P) Delivery Network.
- Internet Service access Provider (ISP): provides transparent broadband Internet access for a generic broadband consumer
- Internet TV Consumer End-device Manufacturer: provides equipment to consume Internet TV, e.g. Set-top box, game console, PC software, etc.
- Internet TV Consumer: consumes Internet TV services provided by the ITVSP.

It should be noted that in actual deployments, one entity might take on the role of several of the above actors. Also, in other deployments some of the above actors may be further subdivided.

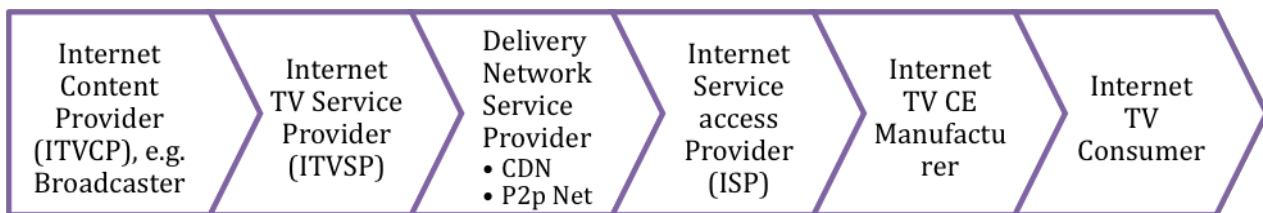


Figure 1 Considered Actors in Internet TV Content Delivery Value Chain

## 5.3 Technologies and Services in Scope of this Study Mission

### 5.3.1 Technologies

Technologies in the scope of this questionnaire explicitly include Internet TV content delivery solutions that permit to deliver audio-visual services (example services provided below) over the Internet to a large number of consumer electronic (CE) devices (including game consoles), PCs or mobile devices. Of specific interest for the questionnaire are technologies that support CE devices, DVB-type content and streamed services.

### 5.3.2 Example Services

The questionnaire addresses technologies that permit the provisioning of one or several of the below services:

- Linear TV Service, e.g. Live Media Broadcast
- Content-on-Demand Service
- Content Download Service
- Audio-only Services
- Accessibility Components, e.g. subtitles, closed captioning, sign language (either included in one of the above services or in combination with hybrid delivery)

- Network Personal Video Recorder Service (e.g. Catch Up TV service)

## 5.4 High-Level Evaluation Criteria

As set forth in the scope, the Study Mission should consider a wide and comprehensive consideration of technology options and the most accurate evaluation against the high level evaluation criteria. The following high-level criteria have been collected during commercial work items and the initial phase of the technical Study Mission:

- Cost effectiveness addressing
  - infrastructure
  - deployment
  - operations
  - maintenance
  - upgrading
- Service Availability / monitoring
- Compatibility with Internet Access equipment
- Compatibility with existing Internet TV deployments
- Fast service build up
- Runs on CE devices
- Content Security / Network Security
- Availability of the solution
- Compliance with existing regulatory provisions
  - Audiovisual Media Services Directive (AVMS Directive): [http://ec.europa.eu/avpolicy/reg/avms/index\\_en.htm](http://ec.europa.eu/avpolicy/reg/avms/index_en.htm)
  - EU Services Directive: [http://ec.europa.eu/internal\\_market/services/services-dir/index\\_en.htm](http://ec.europa.eu/internal_market/services/services-dir/index_en.htm)
- Network topology awareness
- User friendliness (e.g., plugin download)
- Robustness
- Content Integrity
- Supports for Live TV streaming
- Supports for VoD streaming
- Supports for Download-to-Play (non-streamed)
- Support for trick modes
- Resiliency from attacks (e.g. spamming, masquerading)
- Transparency in use of Internet resources:
  - Specifically use of upload/download bandwidth for sharing purposes if applicable
  - Customisation and/or enforcement of sharing ratios and capping of contributions to reassure end-users if applicable to the technology in focus
  - Accounting for contributions
- Protection of privacy rights of end users.

## 6 Information Gathering Process and High Level Review

### 6.1 Information Gathering Process

The DVB technical module (TM) endorsed the creation of Study Mission in March 2009 and expected completion of the Study Mission by September 2009. With the kick-off there was less than 6 months time to obtain a Study Mission report with relevant information. To gather as much relevant information as possible within a short amount of time, the Study Mission agreed to issue a public questionnaire asking for replies to the questionnaires from technologies that are in the scope of the Study Mission. The questionnaire was prepared and finally published on the DVB web site on May 22<sup>nd</sup>, 2009. The published questionnaire is attached to the extended Study Mission report [4] in Annex A.

The initial deadline for reply was June 8, 2009, but it was extended several times as contributing technologies asked for more time. The Study Mission collected a list of possibly contributing technologies and reached out to key persons within the organizations to ask for feedback. The feedback was mostly positive and therefore a comprehensive list of 21 replies to the questionnaire were provided. The replies of the contributing technologies are attached in Annex B of the extended Study Mission report [4] and they are summarized in clause 6.2.

Several technology providers also were impressed and willing to contribute to the Study Mission, but due to lack of time, they could not complete the questionnaire. However, some of those technology providers submitted at least an overview of their technology. Those summaries are collected in Annex C of the extended Study Mission report [4] and they are summarized in clause 6.3. Furthermore, for some other technologies, members of the DVB Study Mission volunteered to collect information as they viewed the technology as relevant and in the scope of Internet TV Content Delivery. Those summaries are collected in Annex D of the extended Study Mission report [4] and they are further summarized in clause 6.4.

Disclaimer: Note that the summaries of the technologies in this clause 6 are word-by-word taken from the replies and the submitted documents. The text in clause 6 has only been subject to editorial modifications, no other changes have been done. The members of the Study Mission do not necessarily agree on all statements.

### 6.2 Technologies Contributing to Questionnaire

#### 6.2.1 Summary

The technologies submitted as replies to the questionnaire are provided in Table 1. The overview of each technology is provided in the remainder of this clause. The table also provides an acronym for each of the technology. The acronym is used to simplify descriptions throughout this document.

Table 1 Submitted technologies

Clause	Technology	Acronym	DVB doc	Annex B
6.2.2	Open IPTV Forum	OIPF	tm-ipi2752r1	[4], B.2
6.2.3	Anysee	Anysee	tm-ipi2753	[4], B.3
6.2.4	BitTorrent	BitTorrent	tm-ipi2754	[4], B.4
6.2.5	Gridcast	Gridcast	tm-ipi2755	[4], B.5
6.2.6	MHEG-5 with Interaction Channel	MHEG-5 IC	tm-ipi2756	[4], B.6
6.2.7	P2PSIP-based distributed IPTV system	P2PSIP-IPTV	tm-ipi2757	[4], B.7
6.2.8	PayTV DVB Tuner	PayTV-DVB	tm-ipi2758	[4], B.8
6.2.9	Samsung-P2P-TV	Samsung-P2P	tm-ipi2759	[4], B.9
6.2.10	StreamForge	StreamForge	tm-ipi2760	[4], B.10
6.2.11	NPO Hybrid Distribution	NPO Hybrid	tm-ipi2762	[4], B.11
6.2.12	Emundoo	emundoo	tm-ipi2771	[4], B.12

6.2.13	CoolStreaming	CoolStreaming	tm-ipi2773	[4], B.13
6.2.14	Predictable Reliability under Predictable Delay for IP media services	PRPD-IP	tm-ipi2775	[4], B.14
6.2.15	Nextshare	NextShare	tm-ipi2777	[4], B.15
6.2.16	ZDF Mediathek	ZDF Mediathek	tm-ipi2778	[4], B.16
6.2.17	GEM-IPTV	GEM-IPTV	tm-ipi2779	[4], B.17
6.2.18	Scalable Video Coding	SVC	tm-ipi2791	[4], B.18
6.2.19	Apple http live streaming	Apple-HTTP	tm-ipi2793	[4], B.19
6.2.20	DVB-IPTV Content Download Service (CDS)	DVB-CDS	tm-ipi2795	[4], B.20
6.2.21	IIS Smooth Streaming	IIS-SS	tm-ipi2799r1	[4], B.21
6.2.22	Philips Net TV	Philips Net TV	tm-ipi2815	[4], B.22

## 6.2.2 Open IPTV Forum

The Open IPTV Forum's release 1 specifications cover a full end to end system for the delivery of IPTV and Internet TV, focusing on user equipment side interfaces and based as far as possible on existing standards, with a focus on retail terminals. A *user network interface* (UNI) to deliver services is specified which is used for both managed network IPTV and Internet TV. As far as possible, the UNI is common to both models. This response only covers the Internet TV model.

The major technologies used by the Forum on the UNI for Internet services are as follows:

- A browser optimised for CE devices, based on CEA-2014
- Video coding based on H.264 and audio coding based on HE-AAC (referenced from DVB)
- Service and content protection, based on Marlin implemented in the terminal, or other solutions via a CI+ or DTCP-IP gateway
- Streaming content delivery using RTP (referenced from DVB) and RTSP, or HTTP
- Content download via HTTP
- Systems layer based on MPEG2-TS and MP4 File Format
- Metadata for service and content discovery using DVB SD&S and BCG
- An application execution environment (based on GEM-IPTV) in a gateway device

Complete technical specifications for release 1 were publishing in January 2009. The profiling specification which will complete release 1 is planned for summer 2009.

A second release of the Forum's specifications is planned for early 2010.

## 6.2.3 Anysee

Anysee is a P2P based live streaming system, which has been deployed on China's CERNET (China Educational and Research Network) since May 2004. From June 2004 to February 2005, there were over 60,000 connections to the AnySee platform.

A Anysee system comprises a track server (tracker), one or more broadcaster servers (BC), peers, and a web portal. The tracker is a well-known rendezvous for joining peers. It maintains a membership list of all joined peers to facilitate data sharing between peers. The BCs just broadcast streaming data to the connected peers directly. Videos are partitioned into chunks, each with a fixed playing time of 1s. Peers fetch chunks from sources or peers and cache them in local memory.

## 6.2.4 BitTorrent

BitTorrent is a protocol that is in wide use around the world and is well known for being the most efficient technology for delivering large files to a large audience. The technology is a peer to peer technology that through various internal mechanisms of the protocol is able to deliver best in class delivery speed on the Internet with economics that approach the fixed cost models of the traditional broadcast world. BitTorrent has further enhanced this technology for use by publishers with the necessary content control and mechanisms needed to ensure commercial adoption by a variety of publishers. This enhanced technology is offered as a service and marketed to publishers under the brand “BitTorrent DNA” or simply “DNA”.

## 6.2.5 GridCast

GridCast is an internet P2P system built with peer-assistance (P2P) technology, which has been deployed on China’s CERNET (China Educational and Research Network) since May 2006. In peak months, GridCast has served videos to approximately 23,000 users. GridCast doubles the bitrates of current popular internet VoD systems, provides a full set of VCR operations, and employs peer-assistance to improve scalability and continuity.

A GridCast system comprises a track server (tracker), one or more video source servers (sources), peers, and a web portal. The tracker is a well-known rendezvous for joining peers. It maintains a membership list of all joined peers to facilitate data sharing between peers. The sources store a persistent and complete copy of every video. Videos are partitioned into chunks, each with a fixed playing time of 1s. Peers fetch chunks from sources or peers and cache them in local memory and disk, evicting by LRU. Peers refresh their play-head information every 30s, and synchronize with the tracker every five minutes or on a user seek to obtain more candidate peers for sharing.

## 6.2.6 MHEG-5 with Interaction Channel

MHEG-5 with Interaction Channel provides a mechanism for delivering interactive content to digital television receivers via broadcast and IP data channels including streaming Video, Audio and Subtitles. The specification extends the existing MHEG-5 profiles by adding streaming protocols and streamed content types, together with interfaces to control presentation from an MHEG application. Applications and data are delivered via broadcast or online connections and applications can use both delivery methods concurrently and seamlessly.

## 6.2.7 P2PSIP-based distributed IPTV

The P2PSIP based distributed IPTV system consists of a Distributed Management Network, a Distributed Delivery network, and some additional servers. The Distributed Delivery Network is consists of media relays for the overlay multicast network. The Contents Provider(ITVCP) who wants to broadcast own IPTV contents, registers his contents information to one of Channel Managers in the Distributed Management Network. The Channel Manager manages the Contents Provider(ITVCP), Relays, and Viewers(CE) for the IPTV channel. The Channel Manager controls media flows among Relays so that the contents of the Contents Provider are delivered to the Viewers via the Relays. The Channel Manager uses a specific protocol to control entities in a Distributed Delivery Network. This protocol can be SIP. The Viewer(CE) who wants to watch the specific channel finds an appropriate Channel Manager for the channel from the Distributed Management Network. After a Viewer(CE) finds a Channel Manager, connects to the Channel Manager. The Channel Manager allows Viewers(CE) to watch the contents from the Relays.

### 6.2.8 PayTV DVB-Tuner

vBox designs and manufactures a DVB compliant Tuner that is designed to be attached via USB or network to PCs running any OS. As part of this solution we have built a “hybrid” websites where the Live SD/HD, EPG-SI, PVR are received via the PC tuner (Satellite, cable and terrestrial including CAS and DRM support), while the VOD and niche channels are coming from the Internet (bundled with a complete Web CMS solution).

### 6.2.9 Samsung P2P-TV

Samsung P2P-TV is a P2P-based streaming technology based on AnySee and GridCast. AnySee is a P2P based live streaming system and GridCast is a P2P-based video on-demand system. AnySee has been deployed on China’s CERNET (China Educational and Research Network) since May 2004 and GridCast has been deployed on CERNET since May 2006. In peak time, there were over 60,000 connections in AnySee and approximately 23,000 users in GridCast.

AnySee and GridCast have the similar system architectures. The system consists of a track server (tracker), one or more source servers, peers, and a web portal. The tracker is a well-known rendezvous for joining peers. It maintains a membership list of all joined peers to facilitate data sharing between peers. The source servers in AnySee broadcast a same area of video to the connected peers directly or through peers. The source servers in GridCast store a complete copy of every video and deliver video areas requested by peers to connected peers directly or through peers.

Videos are partitioned into chunks with a fixed playing time. In AnySee, peers fetch chunks from sources or peers and cache them in local memory. In GridCast, peers fetch chunks from sources or peers and cache them in local memory and disk. Peers refresh their playing information with the tracker periodically or on a user seek to obtain more candidate peers for sharing.

### 6.2.10 StreamForge

StreamForge has developed a new multimedia streaming technology on peer-to-peer (P2P) basis. Users are involved in the distribution process of the program they are currently receiving. That is, each user forwards parts of the stream to other members of the audience and in turn also receives data from them. Consequently, less server infrastructure suffices to reach the entire audience and the streaming costs are drastically reduced.

The StreamForge delivery network is built on cutting-edge research results and is specifically designed for live and on-demand streaming. There are no bottleneck limiting the scalability of the system and all components support redundant fallback systems to compensate for possible hardware outages. The employed streaming protocols are highly optimized and produce very little overhead. Additionally, the system incorporates various features such as Internet topology awareness, several layers of security, and sophisticated QoS monitoring.

For the full reply to the questionnaire of the StreamForge technology, refer to Annex [4], B.10.

### 6.2.11 NPO Hybrid Distribution

The submitter of the reply asked to not publish the information.

### 6.2.12 emundoo

emundoo provides a delivery system for packetized multimedia streams based on open standards. Content is delivered to end users through a dynamic, robust and secure P2P-network supporting live streaming and VoD like services in a content format agnostic way.

### 6.2.13 CoolStreaming

Coolstreaming is the first P2P-based media streaming service supports over 1 millions of users compared to the others works with less than thousands of users. The mechanism of CoolStreaming is similar to that of BitTorrent except live media transmission. As the content owners upload media, the content lists are shared. Main features of CoolStreaming protocols are peer selection scheduling to maximize the service availability and membership management using a gossip protocol.

CoolStreaming supported several different types of media players, such as Windows Media Player, Real Player or other media players. Originally, CoolStreaming has been developed with 2,000 lines of Python codes.

As of June 10, 2005, the Coolstreaming service had stopped due to copyright issues. CoolStreaming became the base technology of Roxbeam Corp., which is known to start live IPTV programs jointly with Yahoo Japan in October 2006. Roxbeam solution is quasi-commercial currently.

### 6.2.14 Predictable Reliability under Predictable Delay for IP media services

Future transport protocols for unmanaged delivery networks have to support a “Predictable Reliability/Predictable Delay” (PRPD) paradigm in order to serve the QoS requirements of audio-visual application and to minimize the amount of allocated network bandwidth at the same time. DVB for instance specifies a maximum packet loss rate of  $10e-6$  for MPEG-2 Transport Stream encapsulated digital SDTV over RTP/UDP/IP. For those services a one-way transmission delay of not more than 100 to 200 ms is desirable.

We chose an Adaptive Hybrid Error Correction (AHEC) approach as a basis for our media oriented transport architecture. This highly flexible composition of NACK based ARQ and adaptive packet-level FEC leads to near-optimal coding efficiency as it is controlled by analytical parameter derivation based on a statistical channel prediction model. The ability to fit to certain delay and reliability constraints even allows the parameter optimization beyond the end-to-end connection granularity: Wired and wireless networks usually significantly differ in terms of packet loss. On the other hand, home network segments provide a much lower round trip delay than IP based delivery networks. Obviously, pure end-to-end error correction schemes are not efficient in such heterogeneous network environments. Therefore, our AHEC scheme offers a link-level operation mode, which relieves reliable links from the redundancy required for more unreliable links.

### 6.2.15 NextShare

The ultimate goal of NextShare and the P2P-Next project, within which it is being developed, is to create a P2P content distribution platform that is flexible, yet appropriately focused in a way that allows maximum exploitation across diverse networks, end-devices, businesses and operational environments.

NextShare core networking stack shall be deployable to devices ranging from PC, mobile phones and other CE devices like iTVs and STBs, and aims to deliver a QoE comparable to existing digital broadcast mediums and include support for HDTV.

NextShare is presently BitTorrent based, but adds features for Live streaming through new incentive schemes, new NextShare does not preclude use of central administrative servers like trackers however.

### 6.2.16 ZDF Mediathek

The ZDF Mediathek service offer Live-Streaming, VoD, Pictures, Podcast and interactive application of our Broadcast content.

## 6.2.17 GEM-IPTV

GEM is a middleware standard for interactive digital TV receivers. It was created in the DVB and published as an ETSI standard. GEM defines a common middleware core across a variety of different TV devices, such as broadcast receivers, IPTV terminals and Blu-Ray players. It is based on Java and permits the creation of portable applications for digital TV environments. This allows writing iTV or web-2.0 style applications that don't need to know anything specific about the network it is carried on. GEM enables the creation of interoperable TV applications, which can run on various digital TV devices like terrestrial, satellite and cable set-top boxes, IPTV terminals and gateways, and Blu-Ray players.

GEM was derived from MHP, by providing an abstraction for DVB network specific signaling. The fact that GEM is essentially network independent makes it particularly useful in IPTV and hybrid broadcast/broadband environments.

GEM has now been adopted in a compatible manner by a number of other organizations including Cable-Labs, the ATSC, ARIB, and the Blu-ray Disc Association. GEM is the ITU-T recommended middleware standard for interactive television.

GEM currently defines 3 different "targets" designed for the different deployments scenarios: a

- "broadcast target" for broadcast TV using cable, terrestrial or satellite;
- "IPTV target" for IPTV based set-top boxes;
- "packaged media target" for use in disc-based devices.

All these targets share a common application model and a common set of core classes.

GEM-IPTV defines an IPTV target supporting DVB-IPTV. GEM-IPTV is a protocol independent subset of the IPTV profile in MHP 1.2. Since it is based on Java and GEM, it can share the rich ecosystem formed around both of them.

## 6.2.18 Scalable Video Coding

H.264 SVC is a scalable compression standard, finalized in 2007, third amdt of H264.

The layer based approach of scalable video coding allows for introducing new video formats such as 1080p with keeping backward compatibility with already deployed AVC based formats (1080i, 720p).

Moreover, H.264 SVC may improve the QoS by managing bandwidth throughputs which results in a continuity of service, by reducing the channel change delay...

## 6.2.19 Apple http live streaming

A continuous stream of digital media is divided into segment files. Each file URI is placed in a playlist file. The playlist files and segment files are distributed via HTTP. The client fetches the playlist and the segment files and plays them in order. It periodically refetches the playlist file to discover new segments.

## 6.2.20 DVB-IPTV Content Download Service (CDS)

The DVB-IPTV Content Download Service (CDS) is specified in ETSI TS 102 034 v1.4.1 as part of the DVB IPTV specification on Transport of MPEG-2 TS Based DVB Services over IP Based Networks. The main specification is provided in clause 10.

CDSs allow for the download of content items to a local storage of the HNED via a broadband IP connection. A CDS can be used to provide IPTV services in areas where a broadband connection suitable for streaming services is not available or prone to errors, for simultaneous delivery of multiple content items to



HNEDs or for reduced cost offers as the bandwidth consumption may be limited compared to streaming services.

DVB-IPTV CDSs supports two different service modes:

- The push download service mode that is defined as a distribution of content items where the distribution decision is taken by the SP, without explicit request from the user.
- The pull download service mode provides for download of content items at the explicit request of a user.

In support of these two service modes, the CDS delivery system supports two “download modes”: multicast download and unicast download. The protocol used for the multicast download mode is the File Delivery over Unicast Transport (FLUTE) protocol and may be combined with a file repair mechanisms. The unicast download mode is based on the HTTP 1.1 protocol. Download of a file from a single server and download of the file in chunks from multiple servers are supported. A reception reporting procedure allows the HNED to report the successful download of content.

The CDS functions enable to download content items. Content items consist of one or more files (e.g. A/V file and related metadata). The available content items, the related files for download and the download mechanisms are announced to the HNED using the Broadband Content Guide (BCG) and dedicated *download session descriptions*. The HNED either automatically initiates the download (push download service mode) or acts on a user request (pull download service mode).

The content download mechanisms are agnostic to the file formats that are transferred, but the CDS specification exclusively specifies the download of content encapsulated into an MPEG2 transport stream and related BCG metadata. Support of the DVB file format is an option. The usage of the specification for other content formats is not in the scope of the presentspecification.

CDSs are transparent to any content protection systems and therefore do not prevent the implementation of content protection systems that build for example on the DVB CPCM specification or others.

While the specification in the DVB IPTV handbook is targeted on managed networks, the CDS mechanisms are not limited to managed networks and can be used also in the Internet. Multicast might not be support in case of Internet deployments, but CDS can be use also in a pure unicast environment.

## 6.2.21 IIS Smooth Streaming

IIS Smooth Streaming is an HTTP-based adaptive streaming technology. It dynamically detects the local bandwidth and CPU conditions of each client and seamlessly switches the quality of delivered content in order to maximize the QoE of the service for the prevailing conditions. This allows HD-capable clients with high-bandwidth connections to receive HD content, while other clients with poorer connections and/or more limited CPU resources receive appropriately scaled down service quality to match their conditions.

IIS Smooth Streaming was introduced as a media delivery extension to IIS (Internet Information Services) 7.0, part of Windows Server 2008. It is typically coupled with Silverlight and a heuristics module on the client.

On-demand and live content is encoded at different rates, with each rate in a separate contiguous MP4 file. IIS Smooth Streaming then delivers MP4 file fragments to each client based on client conditions. Typically, 2-second fragments (the default GOP length) are used, allowing the adaptive switching to be performed at this granularity.

The fragment delivery mechanism provides the additional benefit of allowing the media to be easily cached along the edge of the network thus dramatically increasing scalability.

The resulting user experience is one of reliable, consistent playback without stutter, buffering, or "last mile" congestion.

## 6.2.22 Philips Net TV

Net TV technology allows users to access television and interactive content via the Internet on their television. It is based on elements of the Open IPTV Forum release 1 specifications, with some extensions and subsetting.

The major technical components deployed in products today are:

- Browser: CEA-2014 (CE-HTML) Rev A (minus notifications), Subset of : XHTML 1, CSS TV Profile 1.0, Javascript 1.5, DOM 2, Specific CE-HTML extensions for media-playback, spatial navigation (CSS3), text-entry (multi-tap), Screen resolution 1280 x 720 @ 16 bits, full screen
- Codec: Video: H.264 (preferred) ; WMV9/VC1 ASF, Audio: AAC LC (preferred) ; MP3 ; WMA v2
- Content Format: MPEG 4 Part 12 (MP4 File Format)
- Content Delivery Protocol: HTTP 1.1
- The next generation of TV sets will add: DRM (Marlin)

Note that it is expected that the platform will evolve over time and new products will include new and improved features. In particular, we expect hybrid broadcast/broadband services to become very important.

## 6.3 Other Submitted Internet TV Content Delivery Technologies

### 6.3.1 Summary

Other submitted Internet TV Content Delivery Technologies are provided in Table 2. These technologies had been submitted by the owners of the technology. However, the submission was not in form of a reply to the questionnaire, but as an overview document on the technology. The overview of each technology is provided in the remainder of this clause, more details and references are available in Annex C of the extended Study Mission Report [4].

Table 2 Other Submitted Internet TV Content Delivery Technologies

Clause	Technology	Acronym	Annex C
6.3.2	Octoshape	Octoshape	[4], C.2
6.3.3	Abacast	Abacast	[4], C.3

### 6.3.2 Octoshape

Octoshape provides of HD Quality, High Scale, and Cost efficient media delivery over the Internet. The Octoshape Infinite Edge is the only solution in the space to address all key components of the Internet delivery challenge that will fuel the business models driving the next evolution of Internet media delivery. Octoshape has created a suite of delivery technologies to catalyze this evolution including throughput optimization, loss resilient transport, adaptive bit rate, adaptive path optimization, and adaptive proximity delivery. Combined with the advanced feature set like Instant on, Digital Video Recording, and HD playback, content providers and aggregators are able to provide an innovative, next generation experience to their users. Most importantly, in order to truly monetize this experience, businesses need more accurate statistics and reporting on video consumption. Octoshape uses client side statistics to deliver real time data with accuracy that is not available with standard streaming media technologies today. When media companies and content aggregators look to get the edge with their Internet delivered content, they turn to Octoshape Infinite Edge.

### 6.3.3 Abacast

The Abacast Live and On-Demand Hybrid P2P service is a combination of the best features of peer-to-peer delivery together with the best features of central server or unicast delivery. Abacast has taken the security, high quality, and control of unicast technology and combined it with the extreme efficiency of peer-to-peer delivery. The result is a very secure, high quality, stable, resilient network that uses up to 95% less bandwidth. This makes it better than unicast and better than pure peer-to-peer.

## 6.4 Other Internet TV Content Delivery Technologies

### 6.4.1 Summary

Other Internet TV Content Delivery Technologies are provided in Table 3. The information on these technologies had been collected by volunteers of the DVB Study Mission task force based on publicly available information. The information given in this clause 6.4 is provided without written consent of the companies concerned. The submission was not in form of a reply to the questionnaire, but as an overview document on the technology. The overview of each technology is provided in the remainder of this clause

Table 3 Other Internet TV Content Delivery Technologies

Clause	Technology	Acronym	Annex D
6.4.2	Zillion TV	ZillionTV	[4], D.2
6.4.3	Move Networks	Move	[4], D.3
6.4.4	Velocix	Velocix	[4], D.4
6.4.5	PPlive	PPLive	[4], D.5
6.4.6	TVU Networks	TVU	[4], D.6
6.4.7	IETF P2P Streaming Protocol (PPSP)	PPSP	[4], D.7

### 6.4.2 Zillion TV

The ZillionTV ondemand service is delivered by ondemand streaming (no downloading, progressive download or P2P) Currently their content is centralized in – and delivered from - a single data centre, but more locations in the US are planned as the service grows. ZillionTV is taking attention with their approach towards broadband providers. They are partnering with broadband providers to deliver their service with a certain QoS to the end-user. ZillionTV is only available in areas where they have partnerships with a broadband provider. This approach has led in the US to more discussion concerning the net neutrality issue. ZillionTV is streaming at a bitrate of 1.5Mbps for SD(480p) streaming, codec unknown, a 3Mbps broadband connection is required by ZillionTV for SD. A HD service would also become available requiring a 7Mbps broadband connection.

### 6.4.3 Move Networks

Move Network showed significant interest in our Study Mission, but no full documentation was available on the latest product set at the completion time of the report. The new product set will focus on the full platform of “television over the Internet” and IPTV solutions to enable “TV Anywhere.” The latest information on Move Networks technologies can be accessed through <http://www.movenetworks.com>.

#### 6.4.4 Velocix

Velocix is a Content Delivery Network (CDN) solutions and services provider to the media, entertainment, software and telco industries. Velocix provides an Internet fast lane for digital assets. With Velocix, high quality streamed video plays uninterrupted and file downloads complete in a fraction of the time. The latest information on Move Networks technologies can be accessed through <http://www.velocix.com>.

#### 6.4.5 PPLive

PPLive is a peer-to-peer streaming video network created in Huazhong University of Science and Technology, People's Republic of China. It is part of a new generation of P2P applications that combine P2P and Internet TV, called P2PTV.

PPLive programs are targeted to Chinese audiences. A majority of them are categorized as movie, music, TV series or live TV streaming. Also available are some specialties covering sports, news, game shows, etc. Most available programs are in Mandarin, Cantonese or Korean. There are also increasing amount of programs in English, such as Hollywood blockbuster movies and popular American TV shows. All these English-speaking shows are hard-coded with Chinese subtitles.

The PPLive program is installable on Asian and English language versions of Windows 2000 and Windows XP. By default, it uses Windows Media Player and RealPlayer. The media player that is opened depends on the type of stream.

Since PPLive video streaming depends on the network connection and peer numbers, the occasional glitch such as the short pause during the viewing or re-buffer is not unusual. In some circumstances, the stream could stop completely if source video file crashes or not enough peers available to establish a smooth streaming.

#### 6.4.6 TVU Networks

TVU offers live broadcast services for home users and companies based on their own technology. Amateur broadcasting and viewing the streams are free of charge; however, for professional broadcasters TVU offers professional broadcast hardware and services.

TVU networks' core technology, Real-time Packet Replication (RPR), enables the delivery of a live TV signal, of up to HD quality, to millions of TV viewers around the globe using a single TVUBroadcast appliance and a single broadband connection. Since the bandwidth required to broadcast doesn't increase with the number of viewers, this technology allows TVU broadcasters to achieve massively lower broadcast costs than with today's streaming technology. The RPR technology also has the benefit that the content is delivered live, without being stored on TVU's or viewers' hard disks, and thus offers better protection to content owners.

Currently TVU offers both browser based (IE Plug-in) and stand alone players (TVUPlayer) for Windows (with at least MS Media Player 9) and MacOS X (in beta stage) and broadcasting software for both Windows and Linux. The minimum bandwidth requirement for the player is 300 kbps. The typical offered channels have a bandwidth between 280 and 400 kbps, but there is also support for higher-quality channels (above 500 kbps).

#### 6.4.7 IETF P2P Streaming Protocol (PPSP)

The scope of PPSP is CE devices and Mobile devices. IETF PPSP will cover the standardized interaction with trackers and among peers. This includes peer list exchange and chunk bitmap exchange between trackers and peers. The Signaling Protocol includes chunk description, bitmap and peer information. For the transport protocol to exchange data between peers existing transport protocols are evaluated.

## 6.5 Other Known Internet TV Content Delivery Technologies

Other known Internet TV Content Delivery Technologies have been collected. The Study Mission tried to reach out to the technology providers, but we could not engage them to provide any information for the Study Mission. Therefore, we have provided references to those technologies in Table 4.

Table 4 Other Known Internet TV Content Delivery Technologies

Technology	Reference
Adobe Flash	<a href="http://en.wikipedia.org/wiki/Adobe_Flash">http://en.wikipedia.org/wiki/Adobe_Flash</a>
Akamai	<a href="http://en.wikipedia.org/wiki/Akamai_Technologies">http://en.wikipedia.org/wiki/Akamai_Technologies</a>
ARD Mediathek	<a href="http://www.ardmediathek.de/">http://www.ardmediathek.de/</a>
BBC iPlayer	<a href="http://en.wikipedia.com/wiki/iPlayer">http://en.wikipedia.com/wiki/iPlayer</a>
HBBTV	<a href="http://www.hbbtv.org">http://www.hbbtv.org</a>
Hulu	<a href="http://en.wikipedia.org/wiki/Hulu">http://en.wikipedia.org/wiki/Hulu</a>
Joost	<a href="http://en.wikipedia.org/wiki/Joost">http://en.wikipedia.org/wiki/Joost</a>
Move Networks	<a href="http://en.wikipedia.org/wiki/Move_Networks">http://en.wikipedia.org/wiki/Move_Networks</a>
Netflix	<a href="http://en.wikipedia.org/wiki/Netflix">http://en.wikipedia.org/wiki/Netflix</a>
PPstream	<a href="http://www.pps.tv/en/">http://www.pps.tv/en/</a>
Rawflow	<a href="http://en.wikipedia.org/wiki/Rawflow">http://en.wikipedia.org/wiki/Rawflow</a>
Real Networks	<a href="http://en.wikipedia.org/wiki/Real_Networks">http://en.wikipedia.org/wiki/Real_Networks</a>
Velocix	<a href="http://www.cachelogic.com/">http://www.cachelogic.com/</a>
Yahoo TV	<a href="http://tv.yahoo.com/">http://tv.yahoo.com/</a>
Yahoo ConnectedTV	<a href="http://connectedtv.yahoo.com/">http://connectedtv.yahoo.com/</a>
YouTube	<a href="http://en.wikipedia.org/wiki/YouTube">http://en.wikipedia.org/wiki/YouTube</a>
Zattoo	<a href="http://en.wikipedia.org/wiki/Zattoo">http://en.wikipedia.org/wiki/Zattoo</a> <a href="http://www.crazyengineers.com/dr-sugih-jamin-foundercto-of-zattoo-iptv/">http://www.crazyengineers.com/dr-sugih-jamin-foundercto-of-zattoo-iptv/</a> <a href="http://intruders.tv/en-tech/essential-mediatech-sugih-jamin-of-zattoo-live-tv-on-your-pc/">http://intruders.tv/en-tech/essential-mediatech-sugih-jamin-of-zattoo-live-tv-on-your-pc/</a> <a href="http://www.eecs.umich.edu/~wenjiew/">http://www.eecs.umich.edu/~wenjiew/</a>

## 7 Categorization of Technologies

### 7.1 Introduction

The questionnaire triggered replies of a significant amount of technologies. The replies have been quite diverse in terms of what subjects they address. Therefore, to enable a better structuring of the replies and the available technologies, this clause provides a categorization of the different technologies in several categories. It is important to note that the categorization in this clause is a subjective attempt of several members of the Study Mission to structure the replies based on the information available from the questionnaires. Other categorizations or assignments may be applied. The clause is structured such that initially some definitions are given and then a categorization of the different technologies based on some selected categories is provided.

### 7.2 Definitions

In the context of this clause, the following definitions apply:

**Service:** is defined as an organized collection of audio-visual information commonly provided for users on a TV Set, e.g.

- Linear TV Service, e.g. Live Media Broadcast (LMB)
- Content-on-Demand Service (CoD)
- Content Download Service (CDS)
- Audio-only Services (Audio)
- Network Personal Video Recorder Service (nPVR)
- Interactive Services (interactive)
- Accessibility Components and others, e.g. subtitles, closed captioning, sign language (others)

**Platform:** some sort of hardware architecture or software framework that permits to operate services on top.

**Specification:** an explicit set of requirements to be satisfied by a product or service.

**Service Specification:** A specification describing a TV-like service as defined above.

**Delivery Specification:** A specification describing the delivery; in the ITVCD a delivery specification deals with the description of content delivery, including interfaces and protocols.

**Service Platform:** A platform that enables to provide a TV-like service as defined above.

**Delivery Platform:** A platform that enables the delivery of data and relies on embedded client software. The delivery platform may be independent of the service.

**P2P Delivery:** A delivery platform/specification for which a significant portion of the content is delivered from peers.

**Content Delivery Network (CDN):** A system of (managed) computers networked together across the Internet that cooperate transparently to distribute content for the purposes of improving performance and scalability.

**HTTP-CDN:** A CDN for which all connected computers are conventional web servers and standard HTTP caching servers.

**Enabling Technology:** A technology component that may be used in the context of Internet TV Content Delivery to enable or enhance the delivery.

### 7.3 Categorization

The technologies as they have been made available for this document are all in the context of delivering TV-like services over the Open Internet. However, the technologies differ in certain categories and have commonalities in other areas. Therefore, an initial high-level categorization of the different submitted technologies has been considered reasonable. The categorization has been done based on the available information in

the questionnaire and reflects the view of the majority of the contributors to this Study Mission report. It may well be that other categorizations may be as good or even more suitable.

For this initial categorization, the following categories have been chosen:

- *Scope* of technology. The following attributes are considered
  - o Service Specification (definition see above)
  - o Delivery Specification (definition see above)
  - o Service Platform (definition see above)
  - o Delivery Platform (definition see above)
  - o Service Package: uses a service and delivery platform to provide one or several TV-like services as defined above.
  - o Enabling Technology
- What is the applied content distribution architecture? The following types are used
  - o P2P delivery (see above)
  - o Gridcast: specific P2P delivery where each peer will relay either part or all of the stream they download to several other peers in the grid.
  - o CDN (see above)
  - o HTTP-CDN (see above)
  - o Broadcasting: A generic term for using a scalable broadcast or multicast technology such as DVB-T/S/C/IPTV.
- What is the *deployment* status of the technology?
- What *services* are supported by the technology?
- What Internet TV End Devices (*ITVED*) are supported?
- How is the technology *specified*?

Table 5 provides a high-level overview on the categorization of the technologies.

Table 5 Categorization of Technologies

Technology	Scope	Content Distribution	Deployed	Services	Target IT-VED	Specification
OIPF	Service + Delivery Specification	e.g. CDN, HTTP-CDN	Specification approved, Prototypes	CDS, interactive	CE, PC	Available Specification
Anysee	Service + Delivery Platform	P2P	Deployed	LMB	PC	Research Project
BitTorrent	Delivery Platform	P2P	Deployed	CoD, CDS	PC	may be standardized by IETF
Gridcast	Service + Delivery Platform	P2P	Deployed	CoD	PC	Research Project
MHEG-5 IC	Service Specification	Broadcast + e.g. CDN	Launch Dec 2009	nPVR, interactive, others	CE	Will be standardized
P2PSIP-IPTV	Delivery Platform	P2P	Lab	LMB	PC,	IETF Draft
PayTV-DVB	Service Package	Broadcast + e.g. CDN	Pilot	DVB services	PC	Proprietary
Samsung-	Service +	P2P	Prototype	LMB, CoD	TVs,	Research

P2P	Delivery Platform				STBs, PCs	Project
Stream-Forge	Delivery Platform	P2P	Internal beta	LMB, CoD, CDS	PCs	Proprietary
NPO Hybrid Distrib.	Service Platform	n.a.	Planning	VoD, interactive, others	Nav	Research Project
Emundoo	Delivery Platform	P2P	Alpha	LMB, CoD	PCs	Proprietary
Cool-Streaming	Service + Delivery Platform	P2P	Service closed	LMB	PC	Proprietary
PRPD-IP	Enabling Technology	n.a.	Research	LMB, CoD	n.a.	Research Project
NextShare	Delivery Platform	P2P	Prototype	CDS, LMB, CoD	PCs, CE	Research Project
ZDF Mediathek	Service Package	CDN	Deployed	CoD, LMB, CDS	PC, Hand-held	Based on Flash
GEM-IPTV	Service Specification	e.g. CDN	Deployed	LMB, CDS, CoD, Interactive, others	CE	Standardized
SVC	Enabling Technology	n.a.	Planning	LMB, CoD	n.a.	Standardized
Apple-HTTP	Delivery Platform	HTTP-CDN	Deployed	LMB, CoD, Audio	Mac, iPhone	Draft IETF Standard
DVB-CDS	Service + Delivery Specification	e.g. HTTP-CDN, CDN	Specification approved, prototypes	CDS	STB	Standardized
IIS-SS	Delivery Platform	HTTP-CDN	Deployed	LMB, CoD, CDS	PCs, CE	Proprietary <sup>1</sup>
Philips Net TV	Service + Delivery Platform	e.g., HTTP-CDN	Deployed	LMB (via unicast), CoD, Audio, nPVR	CE	Proprietary <sup>2</sup>
Octoshape	Delivery Platform	CDN + Gridcast (P2P-like)	Deployed	LMB, CoD	PC	Proprietary
Abacast	Service + Delivery Platform	CDN + P2P	Deployed	LMB, CoD, CDS	PC	Proprietary
Zillion TV	Delivery Platform	CDN	Deployed	CoD	CE	Proprietary
Move	Delivery Platform	HTTP-CDN	Deployed	LMB, CoD	PC	Proprietary
Velocix	Delivery Platform	Pure CDN and Hybrid CDN/P2P	Deployed	CDS, CoD, LMB	PC, CE	Proprietary
PPlive	Service + Delivery Platform	P2P	Deployed	LMB, CoD	PC	Proprietary
TVU	Service + Delivery Platform	P2P	Deployed	LMB	PC	Proprietary
IETF PPSP	Delivery	P2P	Early Draft	LMD, CoD	PC,	Draft IETF



	Specifica- tion		Specifications		CE. Mobile	Standard
Notes:						
<p><sup>1</sup> The Content Delivery by IIS and the Smooth Streaming mechanism is based on standard HTTP and the transport protocols and content coding are based on international and DVB standards. There is an additional communication protocol between client and server to manage the dynamic bandwidth adjustment provided by Smooth Streaming. This protocol is proprietary, but is freely available and implementable under the Microsoft Community Promise.</p> <p><sup>2</sup> system is based on elements of the Open IPTV Forum Release 1 specifications. Philips will publish a full "Public SDK" by the end of the year, including all the technical information needed to make a service available.</p>						

For the remainder of this document we refer to the following technologies:

- *P2P-based technologies* are technologies for which for the purpose of scalable distribution primarily a P2P delivery network is used. Technologies within this category are Anysee, Bittorrent, Gridcast, P2PSIP-IPTV, Samsung-P2P, StreamForge, emundoo, CoolStreaming, NextShare PPlive, TVU and IETF PPSP.
- *CDN-based technologies* are technologies for which for the purpose of scalable distribution primarily a CDN delivery network is used. Technologies within this category are ZDF Mediathek, Apple-HTTP, IIS-SS, Velocix and Move. Specifications that may be deployed in combination with a CDN and that also fall into this category are OIPF, Philips Net TV, DVB-CDS, GEM-IPTV and MHEG-5 IC. Parts of the technologies can be categorized under *HTTP-CDN-based technologies* as they rely to a large amount on the use of standard HTTP servers for the scalable distribution of content. Technologies within this category are Apple-HTTP, IIS-SS, Move, OIPF and DVB-CDS.
- *Hybrid P2P-CDN* technologies are technologies that dynamically switch between P2P-based and CDN-based delivery, depending on the content types, the availability of peers or the network topology. Technologies within this category are Abacast, Octoshape and Velocix, but by introducing CDN-based superpeers also other P2P-based technologies may be deployed in such a manner.

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## 8 Summary of Different Aspects in Questionnaire and Internet TV Content Delivery

### 8.1 Introduction

The replies to the questionnaire as well as the other information provides many details on different aspects on Internet TV Content Delivery. During the process of the Study Mission a couple of members of the group volunteered to summarize the replies to the questionnaire in different categories. The questions had been formulated to receive relevant information on some of the high-level criteria as specified in clause 5.4. The volunteers were asked to provide a brief introduction to the question itself, e.g. the motivation why it has been asked and if and how they relate to any of the high-level criteria in 5.4, as well as a summary of the replies to the questionnaire in different categories. The guidelines for the summary had been rather non-restrictive and it was accepted to receive different styles and formats of summaries. The summaries have been done in an objective, non-biased manner and they had been reviewed by the group, but they may contain subjective statements or may miss some information and may reflect the opinions of not necessarily all members of the Study Mission. For details, we refer to [4], Annexes B-D.

### 8.2 Commercial Aspects

Despite the Study Mission mostly deals with technical aspects, it was decided to also include some questions on non-technical matters. One set of questions deals with commercial aspects of the technologies addressing aspects how and where the technologies are used, what service types are supported, how the technology fits into the business value chain, if there is any knowledge on the IPR situation for the technology and on the competitive advantages of the technology. The question Q2-Q6 specifically address the following high-level criteria:

- Availability of the solution
- Supports for Live TV streaming
- Supports for VoD streaming
- Supports for Download-to-Play (non-streamed)

Specifically, Q2 enquires where the technology is used, by which parties it is deployed today or possibly when it will be deployed in future.

Content Distribution Networks (CDNs) are the principal mechanism for large-scale distribution of audio-visual media across the Internet. The CDN content delivery market for video continues to grow around the world (about \$400 million globally last year<sup>3</sup>) with Akamai, Level 3 Communications, Limelight and Edge-Cat Networks being the main CDN providers. The Study Mission could not capture any information from some major CDN providers, nevertheless those respondents that returned their submissions on CDN streaming technologies reported about their technologies as being currently in development [Hybrid broadcasting, ZillionTV] or just released [Apple HTTP streaming, SVC, Open IPTV Forum, Microsoft IIS Smooth Streaming].

In addition to CDNs, there is a new emerging distribution market of pure P2P and combined CDN/P2P approaches. A number of P2P technologies [Gridcast, Anysee, Coolstreaming, Octoshape, Abacast, Edmundoo and Nextshare] are already being used for commercial services of live and on-demand P2P streaming; today a number of them have commercial services deployed [Edmundoo as Alpa test, Octoshape and Abacast]. All the deployed technologies make use of P2P in combination with CDN streaming, a so-called hybrid internet distribution model. A few technologies [Samsung P2P TV, P2PSIP] are working towards a commercial deployment using the hybrid model.

Several middleware technology respondents submitted their responses to this survey. These platforms however are currently not deployed over the open Internet (which is the main focus of the present Study Mis-

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<sup>3</sup> See Streaming Media Magazine, Autumn 2009

sion). The middleware technology proponents such as GEM-IPTV and MHEG-5 have been quite successful commercially in several European markets and have collected significant numbers of consumers over the years since they entered the broadcast market.

Q3 enquires which TV service types are currently supported by the internet distribution technology. As expected, all respondents including P2P and CDN streaming technologies proponents do support the typical Internet TV services as live/linear TV and CoD. Some respondents named some specific technologies such as Content Download Services (CDS) service [Open IPTV Forum, Nextshare and DVB CDS].

The following service types have been mentioned by the respondents:

1. Live TV channels
2. Content on Demand (CoD), Video on Demand (VoD) including catch-up TV
3. Content Download Services (including Progressive Download)
4. Audio-only (radio and audio play lists) services
5. Subtitle (close caption) support
6. Personalisation and Interactivity services
7. Content guides (EPG) services

The purpose of Q4 is to investigate about the entities in the value chain that might propose and use the internet distribution technology to deliver DVB-type content in the open internet, and how respondents think of the business value and finally who are the enablers?

A simplified value chain is shown above in this document in Figure 1 to identify the main players.

The use of suitable distribution technology impacts all elements of the value chain. The P2P technology proponents consider their P2P technologies being useful particularly for content and service providers, as P2P technologies could potentially reduce server load and bandwidth requirement on the central side of the internet distribution chain. The ITV CE manufacturers are seen as an important enabler for P2P technologies and those manufacturers that responded to our questionnaire are generally supportive to embedding and standardising a P2P client in their CE devices.

When it comes to CDN technologies, the support from all players is greater than for P2P. For example, Open IPTV Forum sees the technology applicable for all players. ZDF Mediathek and Apple HTTP streaming regard CDN as being relevant in particular for the ITVCP. Hybrid Broadcasting considers CDN relevant for both the TV CE manufacturer and ISP. CE manufacturers are generally supportive to the CDN streaming technologies and see them as an important internet service enabler. For ZillionTV CDN is important for the ISP and the ITVCP. Microsoft IIS Smooth Streaming sees their technology applicable mainly by the DNSPs and ISPs. As their technology is quite similar to Apple HTTP streaming, Microsoft's views would probably apply to the Apple technology too.

Concerning the middleware technologies, the technology is applicable for the ITVCP on the 'left' side of the value chain. However, MHEG-5 and GEM-IPTV also see the technology applicable and enabled by the CE manufacturer.

*If the content is coded in Scalable Video Coding (SVC) format, its implementation influences all players in the value chain. This conclusion applies for scalable technologies as Microsoft IIS Smooth streaming and Apple HTTP streaming.*

Q5 enquires about the IPR situation, eventual licensing terms and patent pools.

Most commercial P2P systems deployed (or yet to be deployed) [Octoshape, Abacast, Edmundoo and Samsung P2P TV] are protected by some patents. The same applies for Gridcast and Anysee. The Nextshare EC-funded project has the intention to keep it license free, as the system is being developed under the GNU Lesser General Public License (LGPL) license terms. No patents pools are formed for these P2P technologies today.

For Open IPTV Forum, a patent pool is planned to be formed and IPR will be made available under "reasonable terms". The Apple HTTP streaming technology is covered by some patents and is available under

RAND<sup>4</sup> terms. Patent pools are formed for both H.264/SVC (MPEG LA) as for GEM-IPTV (Via licensing). DVB CDS IPR terms are defined by the DVB policy. Microsoft IIS Smooth Streaming is available as part of existing Microsoft product offering.

To be taken in consideration, most technologies make use of codecs such as H.264, AAC or MP3 which are covered by IPR and made available for commercial use under certain terms and usage fees.

Q6 is all about what is the competitiveness of the technology and the commercial benefit.

The P2P market is emerging, however, there are already a large number of P2P technology and service providers, so that the competitiveness of the P2P market today is already significant. Respondents supporting P2P technologies see most cost savings on the service infrastructure and see these as the main economical driver. Other perceived benefits associated with some P2P technologies being deployed are: wide codec support, advanced client monitoring/measurement, no central server for content/channel discovery, interworking with IMS, a simple extra plug-in/SW needed and (potentially) open source based.

The number of CDN providers is much larger than the number of P2P providers. The prices per GB have diminished by a factor of 10 in the past three years and are now quite comparable to those offered by the P2P provides. Respondents supporting CDN streaming technologies see most economical advantages by reuse existing streaming infrastructure. Reusing existing HTTP (cache) infrastructure [Apple HTTP streaming and Microsoft IIS Smooth Streaming] would be of a significant commercial benefit for ISPs and DNSPs.

Monetizing of services is based on PPV, subscription-based TV, and advertisements which might be targeted [MHEG-5, ZillionTV and Samsung P2P TV] or localized [P2P SIP].

### 8.3 Standardization and Specification Aspects

Question Q7 of the questionnaire deals with aspects regarding a potential future standardization within DVB of relevant technologies. This covers the respondent's consideration of DVB as an appropriate standardization body (Q7a), the general readiness to participate in such a specification activity (Q7c) and to contribute owned technologies (Q7d). The desired time frame for the standard's availability (Q7e) as well as a potential application of the standard to a wider range of devices (Q7b) is asked for. For most of the technologies, DVB is considered as an appropriate body for standardization in this technology field (Q7a) and the respondents are either prepared or considering to contribute to such an activity (Q7c) and to submit owned technologies (Q7b). This is the case for *Apple-HTTP*, *Anysee*, *BitTorrent*, *emundoo*, *GridCast*, *NPO Hybrid Distribution*, *IIS-SS*, *NextShare*, *Philips Net-TV*, *PRPD-IP* and *Samsung-P2P*. Other technologies are already standardized (DVB-CDS, *GEM-IPTV*, *OIPF*, *MHEG-5-IC*, *SVC*) or planned to be standardized (*P2PSIP-IPTV*). In these cases, the respondents are prepared to cooperate but favour referencing the existing specification documents or suggest technical guide lining of the existing spec. As a general remark, some of the answers suggest to carefully scope DVB standardization efforts to avoid duplication of work. For *ZDF MEDIATHEK* and *PayTV-DVB*, Q7d (submission of owned technology) is not applicable, *CoolStreaming* indicates that they would be prepared to submit owned technology to specification.

When answered, the respondents do not oppose the extension of a potential DVB standard to a wider range of devices. However, there are different levels of support and some comments suggest to liaise with appropriate bodies and to focus on CE devices. When answered and not already in the market, the mentioned respondents favour end of 2010 as the latest date for the availability of the specification (Q7e). According to the *NextShare* response, specification work should conclude between 2010 and 2012.

Question Q8 addresses specification-related details of the respective technologies. This includes references to documentation (Q8b), the appropriateness for inclusion into DVB standards (Q8c) as well as the type (proprietary, standard, open source, etc.) of the specification in general (Q8a). In case the technology is standardized, further details about the specification are requested in Q8d, such as maturity, date of approval, approving body/authority and availability of the specification. According to the *OIPF's* response, the specification is published and approved by the forum, freely available on their website and may be included into DVB standards by reference. Release 1 of the specification was published and approved in Jan 2009, work for release 2 is in progress. The Philips Net TV specification, which is a subset of OIPF with some extensions, is controlled by Philips and made available to partners as required. For *IIS-SS*, the specification is freely avail-

<sup>4</sup> RAND stands for "reasonable and non-discriminatory" terms

able under Microsoft Community Promise. *MHEG-5-IC* has been standardized and approved (2009) by the Digital Television Group (DTG) and is therefore accessible for DTG members. Furthermore, since the standard is based on ETSI ES 202184 with extensions, it is planned to publish the whole specification as a new version of the ETSI standard. *GEM-IPTV and DVB-CDS* are published and implemented DVB specifications and may therefore be included/referenced into future specifications. For *SVC*, the situation is similar: Being part of the *H.264 AVC* specification, *SVC* has already been referenced by existing DVB specifications and may therefore be referenced by future specifications as well. In general, most of the technologies are at least partly appropriate for inclusion into DVB standards (Q8c). These are *Apple-HTTP, DVB-CDS, emundoo, GEM-IPTV, PayTV-DVB, P2PSIP-IPTV, PRPD-IP, BitTorrent, IIS-SS, MHEG-5-IC, NextShare, SVC* and *Samsung-P2P*. *NPO Hybrid Distribution* may potentially be included into and *OIPF* may be referenced by a DVB specification. Some of the technologies responded “not applicable” (*CoolStreaming, ZDF Mediathek*) or “not available” (*StreamForge*). *Samsung-P2P, P2PSIP-IPTV, PRPD-IP, NPO Hybrid Distribution* and *NextShare* are specified by research projects. *P2PSIP-IPTV* is also available as an IETF draft. The other technologies are proprietary (*PayTV-DVB, emundoo, StreamForge* (partly)), based on Technical Papers (*CoolStreaming*), Open Source (*BitTorrent*) or have been published as an informational Internet Draft (*Apple-HTTP*). *IIS-SS* has been built around standardized technologies. According to the BitTorrent response, the specification is being submitted to standardization bodies. References for further Information have been given via Website-Link (*BitTorrent, StreamForge, PayTV-DVB*), Wikipedia-Link (*CoolStreaming*) or IETF-Draft (*P2PSIP-IPTV*).

Regarding Q8d, which addresses specification details in case the technology is standardized, nine respondents answered “not applicable” (*StreamForge, PayTV DVB-, Tuner, Samsung-P2P, NPO Hybrid Distribution, emundoo, NextShare*) or “not available” (*GridCast, AnySee*). According to the response, *BitTorrent* is a de-facto standard since 2005 and is managed by the community following the *BitTorrent* processes. The *P2PSIP-IPTV* IETF draft will be updated in July 2009 and is “available under certain conditions”; *IIS-SS* is available under NDA.

For the submitted technologies, compliance to the specification is ensured by different means. For *emundoo, GEM-IPTV and MHEG-5-IC*, test suites are available. Implementations of the underlying Java platform of *GEM-IPTV* may be validated by a Technology Compatibility Kit. For *PayTV-DVB* and *PRPD-IP*, an open API is available. Philips Net TV products are tested internally by Philips, whereas for *Anysee, Cool Streaming, Gridcast*, no means for conformance tests are available. Some of the respondents are planning to provide compliance tests in the future (*Samsung-P2P, NextShare, P2PSIP-IPTV*), some are developing test specifications (*OIPF*) or test tools (*Apple-HTTP*). The *BitTorrent* technology ensures compliance by testing interoperability with the client base. For *SVC*, compliance is ensured by the standard itself. According to the *DVB-CDS* response, compliance and interoperability aspects are not handled by DVB but may be dealt with by other organizations. For *NPO Hybrid Distribution, IIS-SS, StreamForge* and *ZDF Mediathek*, an answer was not available.

## 8.4 Technical Aspects

### 8.4.1 Architectures

Internet TV Content Delivery requires specific network-side architectures to support the delivery of Internet TV content services over the Open Internet. It is important to understand how Internet TV Content providers could possibly distribute their services over the Open Internet in a cost efficient manner. Therefore, Q10-Q16 in the questionnaire addressed architecture specific questions. Specifically Q10 ask for an overview on the architecture of the respective solutions, for example point to P2P, CDN, etc. A small excerpt of the architecture has already been addressed by the categorization in clause 7. We will briefly add additional aspects in this summary. More details on architectural examples are discussed in clause 10, in particular different functions and interfaces. By the questions that are asked, Q10 addresses at least to some extent the high-level criteria on:

- Cost effectiveness addressing
  - Infrastructure
  - Deployment
  - Operations

- Maintenance
- Upgrading
- Compatibility with existing Internet TV deployments
- Availability of the solution
- Robustness

The answers to Q10 on the generic architecture were very diverse and also made it clear that the term “architecture” is interpreted differently by different technology submissions. In particular architectures may describe logical or functional service architectures, physical architectures such as explicit hardware, client architectures that describe the functions on the clients and other types. Therefore, the replies to Q10 are not consistent and a comparison of the different architectures is basically impossible. Nevertheless, we attempt to summarize some relevant aspects to highlight some key commonalities as well as some specific components and assets of some architectures.

In almost all architectures, at least certain services are delivered over IP unicast generally only assuming a best effort connection. Certain architectures combine the use of IP unicast with other distribution means such as managed IPTV including multicasting (e.g., DVB-IPTV CDS, StreamForge) as well as broadcast distribution over classical broadcast networks (e.g. GEM-IPTV, MHEG-5 IC, Philips Net TV or PayDVB Tuner).

Certain architectures are only logical in order to augment a specification of interfaces, e.g. OIPF, DVB-CDS or GEM-IPTV. In this case, mostly the client functionalities as well as the interfaces are specified, but no details of a physical architecture are provided.

Also, architectures may differ depending on the service. In terms of content delivery, mostly Linear TV, on-demand and content download is differentiated. However, other services are supported and augment the content delivery. These services are typically also provided over the Open Internet and include: service discovery and metadata, reception reporting, content and network security, authentication, sign on, remote management and other applications.

Typical architectural components in the context of Internet TV content delivery are the corresponding network side servers and receiver side clients functions as well the delivery functions for the individual services. Certain client functions also use generic functionalities such as generically available players (e.g. Windows media players, Quicktime or Flash Players) or web browsers, in particular for discovery of services.

In many deployments the role of the different players is clearly separated between ITV content providers, ITV service providers and Delivery Network Service Provider. Especially the latter is responsible for scalable distribution of the different services. In many deployments, the DNSP is not even aware of which service is distributed. Several technologies, e.g. OIPF, MHEG-5 IC, ZDF Mediathek, Apple-HTTP, IIS-SS, DVB-CDS, Philips Net TV, Zillion TV, use or at least permit the use CDNs for the scalable distribution of content and other services. CDNs typically provide caches, edge servers and other network infrastructure to support low-latency and high availability to web content. In a similar manner, generic P2P-based technologies can be used for scalable content distribution such as BitTorrent or emundoo. They may only offer supporting services for specific Internet TV distribution. In contrast, other P2P-based technologies are more specifically designed for the distribution of Internet TV services (Anysee, GridCast, Samsung-P2P, PPLive, CoolStreaming, NextShare, Octoshape, etc.) and in this case the ITVSP and the DNSP may be integrated in one entity. Octoshape for example highlights the timing synchronization of the different architectural components as a key asset. However, the technologies may still be used in combination with standard media players by using local sockets that connect media players and the delivery client (Anysee, Gridcast, Samsung P2P).

P2P-based delivery architectures generally include additional architectural components to optimize and manage the P2P-based distribution. Optimization in P2P-based delivery may be achieved by the use of superpeers and seeders (dedicated hosts serving as initial data access points, load balancers and fallback data providers, CDN-like), see e.g. emundoo, BitTorrent, Abacast. Note that these deployments may be flexible to dynamically balance between peer contributions and network side contributions to the content delivery. Management components in P2P delivery may be centralized (BitTorrent, Anysee, Gridcast, Samsung P2P, emundoo, Abacast), usually referred to as tracker, or also distributed (see e.g. NextShare, P2PSIP-IPTV). Typical management functionalities in P2P-based distribution are peer discovery, content map exchange, location awareness, Distributed Hash Tables (DHT). NextShare for example considers distribution also in case of the availability of a home network with many devices connected: In such cases, a centralized proc-

essing on one powerful PC participates in the construction of the overlay network and the remaining devices act as extender devices only.

An important aspect for most distribution means is the segmentation of the original content stream into chunks. Most ITV specific delivery systems propose to apply time-based chunking rather than media-unaware chunking, especially in case streaming or live services are to be supported. Examples for this are Anysee, Gridcast, Samsung P2P, Apple-HTTP, IIS-SS, NextShare, etc. Chunk sizes may be service dependent.

Within the architecture related questions, specifically Q11 asks for the necessity of specific network infrastructure such as NATs, super-peers etc. Also of interest is the behaviour in case of network asymmetry, i.e. in case down and up link capacities may differ by for example a magnitude. This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - infrastructure
  - operations
- Compatibility with Internet Access equipment
- Transparency in use of Internet resources:
  - Specifically use of upload/download bandwidth for sharing purposes if applicable

For basically all technologies some specific network infrastructure is needed to prepare, publish, announce, host and serve the media content. For services that rely on HTTP for delivery, the origin server may be a standard HTTP server and then no network infrastructure beyond ISP-provided best effort network connection to Internet TV Service Provider is required, see OIPF, Apple-HTTP, GEM-IPTV, DVB-CDS unicast, MHEG-5 IC, ZDF Mediathek. IIS-SS, Philips Net TV also uses HTTP-based delivery, but as content origin servers IIS-SS IIS 7.0 web servers with IIS Smooth Streaming extensions are required. The content is tunneled through HTTP and as such it is carried across the public Internet and standard routers without any problem. In case multicast (DVB-CDS multicast) or broadcast delivery (PayDVB Tuner) is used, the additional functionalities such as multicast routing and IGMPv3 need to be supported.

Also, many technologies rely on web portals for service announcement and therefore do not need any specific servers for this purpose. Additional servers may be necessary for supplementary services such as security-related services, reception reporting, audience measurement, etc.

For P2P-based delivery, typically a tracker functionality is introduced as well as super-peers for data-seeding and accelerated boot-strapping. NextShare also reports the availability of a distributed STUN relay functionality for the purposes of NAT traversal.

In terms of network asymmetry all CDN-based architectures such as OIPF, MHEG-5 IC, PayTV DVB Tuner, NPO Hybrid Distribution, ZDF Mediathek, Apple, IIS-SS, DVB-CDS, Philips Net TV, no issues are reported. For P2P-based systems, network asymmetry is a well-known problem and therefore different mechanisms are used to overcome these deficiencies. Typically a client can receive the content from multiple peers and is able to aggregate the content to match the bitrate of the content, see e.g. Anysee, Gridcast, Samsung P2P, BitTorrent, NextShare, DVB-CDS (in case of P2P-based deployment), Abacast, Octoshape, etc. Only a fraction of the incoming stream is contributed back to the network if upstream capacity is lower than the bandwidth required by the incoming stream. Highly asymmetric links reduce effectiveness but do not prevent operation of P2P-based distribution.

Especially for VoD services, network asymmetry is overcome as the audience grows using content seeding, see e.g. BitTorrent, CoolStreaming, NextShare. For linear TV, fundamental limits of the P2P-based infrastructure result in some serious consideration for such services, see BitTorrent reply. Effectively finding and utilizing capable peers while moderating the reliance on less capable peers is critical. StreamForge and NextShare try to use available idle upload capacity of connected end users.

If this upload capacity is insufficient, it is attempted to solve the asymmetry transparently: the remaining upload capacity is provided by seeders, see e.g. emundoo, StreamForge, NextShare, Abacast, PPLive, Octoshape, etc..

Further architecture related aspects are addressed in Q12. Specifically it is asked for the availability of network topology awareness. If available, it was of interest how efficient this technology is, how the network topology is discovered, and how this information is used to optimize the delivery.

This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - infrastructure
  - deployment
- Network topology awareness

Especially non-P2P-based technologies, e.g. OIPF, MHEG-5 IC, PayTV DVB-Tuner, NPO Hybrid Distribution, ZDF Mediathek, GEM-IPTV, SVC, Apple, DVB-CDS, IIS-SS, do not include network topology awareness. No specific benefit is seen.

P2P-based technologies, e.g. Anysee, BitTorrent, Gridcast, P2PSIP-IPTV, Samsung P2P, StreamForge, Emundoo, PRPD-IP, NextShare, Abacast, PPlive, include network topology awareness and view this as a critical asset to their technology. The network topology awareness is mainly used to create efficient application-level overlays for sharing cached media data chunks. Local connections are generally preferred. Long range connections should be avoided for two reasons. First, local connections are more stable than for example intercontinental links. Second, the costs of operation for ISPs are reduced in our approach. Anysee, Gridcast and Samsung P2P report a decrease of server load by 76% when compared to traditional client-server architecture.

For the purpose of creating such specific location-aware overlays, either internal measurements or external topology databases or a mixture of the two are used. For external databases BitTorrent explicitly mentions the efforts and cooperation with operators using IETF ALTO solutions. Information can be queried from an authoritative resource like a P4P database, see NextShare and Abacast. Databases may contain as simple information as “preferred” and “to be avoided” network address ranges that the client can utilize when making initial peer selections. NextShare is investigating PEX-based protocols that besides exchanging the raw IP addresses of peers for discover purposes, also provides detailed statistics of upload/download speeds.

Sensing and measuring of network awareness may be provided for example by ping-time measurements, see Anysee, Gridcast, Samsung-P2P, StreamForge, or by passive sensing, see NextShare and BitTorrent.

Also of interest within the architecture context is the scalability of the technology. Therefore, Q13 asks on the architectural support for scalability. Scalability is of interest in terms of number of participating users in the service, in terms of bandwidth, the number of necessary servers per active ITV consumers as well as the network load in different parts of the network.

This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - infrastructure
  - deployment
- Robustness

In terms of scalability, client-server based architectures rely on CDNs. The expectation and experience is that services scale similarly to current web-content deployments. For example, OIPF, ZDF Mediathek, GEM-IPTV, MHEG-5 IC, Apple, IIS-SS, Philips Net TV and Zillion TV rely on CDNs by pulling the content from the distributed CDN servers, in most cases HTTP infrastructure. Typically several thousands of users can be supported from a single server, see e.g. ZDF Mediathek, Apple-HTTP and IIS-SS. Connection to the origin servers is only needed in certain cases, e.g. for the delivery of cipher keys (Apple-HTTP). This is due to the fact that CDNs are currently of no great help in scaling secure connections. Zillion TV is partnering with ISPs to improve QoS and scalability.

A major claimed benefit of P2P-based technologies (Anysee, Gridcast, BitTorrent, Samsung P2P, StreamForge, emundoo, PPlive, NextShare) is that they are organically scalable. Performance improves as the audience grows as each user brings increasing resources to bear in delivering the media. Clients accessing the same service form an application-level overlay. Furthermore, for on-demand and download services caching of data on peers can provide additional benefits as not only the actual service can be served, but also other services or the services in a time-shifted manner. According to BitTorrent and emundoo, the typical ratio of infrastructure (servers) relative to traditional CDNs is about 1000:1.

Furthermore, combinations of P2P-based approaches with CDNs are used, partly by the use of super-peers in P2P-based distribution, e.g. NextShare, BitTorrent, Abacast, Octoshape, PPlive, etc.



Additional scalability may be provided by dedicated infrastructure such as broadcast systems, e.g. PayTV DVB-Tuner, or multicast distribution such as DVB-CDS. At least popular services can be offloaded to broadcast distribution and only supplementary services are supported by regular unicast delivery.

In terms of bandwidth-scalability, generally the protocols that are used are independent of the bandwidth, see e.g. emundoo reply. Also, if TCP/IP is used inherent bandwidth scaling by the use of congestion control is applied. BitTorrent offers an advanced congestion detection method that recognizes local overload and yield capacity immediately, and in the process prefers peers on less loaded areas of the network. The resulting bandwidth variations may result in slower downloading, but for content download services this is less critical. DVB-CDS also provides mechanisms for multicast rate adaptation algorithm by the use of multiple layered multicast channels.

For live and on-demand content, Apple-HTTP, Move Networks and IIS-SS improve bandwidth scalability by offering multiple versions of the content at different bitrates and adjusting the bandwidth delivered to fit that available.

Continuing with architecture related questions, Q14 asks for any specific requirements of Customer Premises Equipment (CPE) such as specific ISP functionalities, minimum access bit rates, specific open ports and specific versions of IP.

This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - infrastructure
  - deployment
  - operations
- Compatibility with Internet Access equipment

Typically, for almost all technology the ISP or the Internet Access equipment in the home requires no specific equipment is required, except for a compliant receiver and a normal broadband connection. The receiver may be a software client or in rare cases be a dedicated hardware device. For streaming services, i.e. Linear TV and Content-on-Demand, sufficient downlink access bitrates need to be available to at least match the content rate, see e.g. Anysee, GridCast, Samsung P2P, OIPF, P2PSIP-IPTV, emundoo, BitTorrent, NextShare, ZDF Mediathek, GEM-IPTV, Apple-HTTP, IIS-SS, TVU Networks. However, it is important that the access bitrate can be measured to adapt the delivery.

For some technologies it is even sufficient if an HTTP connection and an open outbound port 80 is supported, e.g. OIPF, MHEG-5 IC, DVB-CDS, GEM-IPTV, IIS-SS, or Apple HTTP. This allows to bypass firewalls. Some other technologies require the support of UDP and additional ports. BitTorrent enables NAT and firewall traversal by the support of UPnP and NAT-PMP by the CPE devices.

Certain technologies are currently only provided on top of IPv4, some are also accessible on top of IPv6. However, there seems no fundamental problem to support all technologies on either IPv4 or IPv6 in the future.

Specifically Q15 asks for service-related requirements, namely how services can be made available and how they can be deployed and made accessible, e.g. by specific APIs and if the service supports trick modes.

This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - deployment
- Service Availability / monitoring
- User friendliness (e.g., plugin download)
- Support for trick modes

For easy deployment it is of interest how ITVSP/ITVCPs can make services available, for example independently using the technology (e.g., similar to the world wide web), or through a single entity that aggregates all content and services available via the technology or that otherwise controls which services are available (e.g. as typically done in IPTV services). For standardized technologies such as OIPF or GEM-IPTV, services can be made available as long as compliance to the standard/specification is ensured. Similarly, NextShare and Apple-HTTP provide specifications such that anyone can publish content for end devices supporting their technology. For other technologies such as Anysee, Gridcast, Samsung-P2P or IIS-SS

a specific network-side platform needs to be supported. For P2PSIP-IPTV and StreamForge, a server aggregates all content and services. For MHEG-5 IC, the provisioning of the service is governed by signaling and certificates carried in the broadcast network, so to an extent this limits the availability of access. For DVB-CDS access to the service is provided through DVB SD&S that supports among others several service providers.

To simplify deployments OIPF, DVB-CDS, Philips Net TV reuse existing technologies are used as far as possible. OIPF stresses the importance that specification selects a single technology to address each function and does not provide multiple options. Specifically the use of HTTP as transport protocol is stressed by Apple-HTTP, NextShare, OIPF, and GEM-IPTV. The reuse of existing media players using well-known protocols such as HTTP and RTP/RTSP is also helpful according to Samsung-P2P. If client plugins are unavoidable, it is at least essential that plugins or specific client software are easily accessible and installed as for example addressed by IIS-SS, Abacast, Octoshape, TVU Networks, or PPlive.

The provisioning of APIs for certain services may simplify deployments. The specifications of different technologies, e.g. OIPF, Samsung P2P, DVB-CDS, IIS-SS, cover interfaces between the receiver and the service provider for different services such as content discovery, registration, authentication, purchasing, auditing, advertising, interfaces to usage, state of the user, connection type, upload/download capabilities. BitTorrent can be integrated using a Proxy and Control API where DNA is addressed by passing properly formed URLs to the DNA proxy. These URLs can initiate, adjust and monitor content delivery for an object. For MHEG-5 IC, all content is accessed via a broadcast portal which is a small application. Each broadcast channel may have its own portal. The IP delivered services can be seamlessly merged with the broadcast interactive services. NextShare will provide a rich language and platform independent API. In Philips Net TV, content discovery can be performed via the Philips portal or potentially via other providers. Registration, authentication and purchasing are performed using the browser. APIs are generally platform independent, for example by the use of Java-based or interfaces (emundoo, GEM-IPTV, Philips Net TV) using Javascript and ECMAScript or by the use of XML-based descriptions (Samsung P2P, DVB-CDS) or the specification can implemented with any programming language, e.g. OIPF.

The support for trick modes in case of VoD services, OIPF and GEM-IPTV use RTSP for RTP streamed services. For HTTP streaming and download services, trick play is implemented by the receiver, for example, using byte range requests as suggested by OIPF, BitTorrent, GEM-IPTV, or NextShare and DVB-CDS. The P2P VoD platforms of Gridcast, Samsung-P2P, and emundoo support typical VCR functionalities such as play, pause, stop, random seek, details are not provided. For certain technologies, e.g. MHEG-5 IC, StreamForge, Apple HTTP Live, IIS-SS, Philips Net TV initially only a limited amount of functionalities are supported (pause, goto & skip forward/backward) others are not (fast forward/rewind and slow motion).

Specifically Q16 asks for the management of the client by the ITVSP addressing technical, operational and security-related mechanisms. Features include awareness of physical identity, registration and authentication, maintenance of privileges and remote configuration of services.

This question addresses the following proposed high-level criteria:

- Cost effectiveness addressing
  - maintenance
  - upgrading

To maintain and upgrade clients, the clients need to be identified. OIPF and Philips Net TV propose to use standard web technology such as browser cookies, also BitTorrent and NextShare provide unique client identifications. NextShare specifically provides two types of identifications, namely transient and short-lived as well as security and permanent peer identifiers. ZDF Mediathek only requires specific client capabilities such as geo-location, color-depth, display resolution, and operation system. GEM-IPTV provides a Java-API to retrieve the hardware or installation details, e.g. smart-card, MAC address of the client, or available browser cookies. IIS-SS uses heuristics on the client determine the processing capability to select the appropriate bitrate version of the content.

Registration and authentication is specified by OIPF, emundoo and Philips Net TV. BitTorrent asked for an agreement to an End-User License Agreement (EULA). In Apple-HTTP, registration and authentication is provided through establishing a secure session gating access to the encryption keys. Privileges to access the various services are provided through registration, authentication and content protection interfaces.

Remote management is specified for OIPF and StreamForge. For BitTorrent client behavior can be configured on an object-by-object basis by passing the right parameters along with the request for content object. Emundoo also supports remote configuration of network and local data storage parameters may be configured. For DVB-CDS, the DVB RMS/FUS functionalities for storage and content management may be used.

## 8.4.2 End-device Functions and Platforms

Embedding within CE devices is acknowledged as important in almost all responses; with the majority either already supporting deployment to CE, or actively working towards this end.

Examples of primary target devices for the technologies include:

- Commodity PC
- Set-Top-Box
- Digital Media Players
- Networked DVD/Blueray Players
- iDTV
- DVR/PVR
- Mobile Phones

With secondary consideration being given to:

- NAS
- Games Consoles
- HNGD (Gateway Devices)
- Digital Photo Frames

Traditional Unicast and CDN-based technologies are readily embeddable to low-cost CE devices, with the only distinction from tuner-based media devices being the inclusion of Internet connectivity as the source interface for data.

P2P-based and other piece-oriented, or adaptive, technologies tend to require greater processing power, and suffer from the lack of dedicated hardware blocks to accelerate their processes. This is part of the reason that movement to CE devices is only at the planning stage, with the exception of BitTorrent, Samsung P2P, and NextShare, that each claim to have deployed to CE devices.

With regard to mobile embedding, most responders report plans, or existing lab projects underway, to verify applicability. Battery life was reported as a primary consideration with respect to the effectiveness of P2P on the context of mobile deployments.

In principle, any computing device with an Internet connection can host streaming, CDN or P2P-based software, as long as the run-time requirements (OS and/or virtual machine) are accommodated for. Support for Linux-based deployment is recognised as an important basis for portability between PC and other embedded deployments.

### Adaptation

Some technologies focus on adaptation to adverse network conditions as a central consideration - such as Smooth Streaming - whilst at the other extreme we have ITVCD technologies that strictly profile requirements on the CE devices that consume services, and constrain service providers to limited formats and resolutions, with limited switching or adaptation in evidence.

The following patterns have emerged within the questionnaire responses so far with regard to adaptation:

- Adaptation to local network availability and CPU utilisation at the terminal device
- Multi-service provision (simulcasting) whereby a terminal device switches to the most appropriate stream to maximise QoE, where multiple stream may exhibit differing spatial, temporal, or quality characteristics
- Multi-layer provisions whereby a terminal device selects the best combination of layers and combines their content to maximise QoE

- Network awareness, in particular the intelligent selection of CDN server, or dynamic optimisation of swarms (population of peer devices) based on their network locality, latency, congestion, packet loss, and other properties

P2P-oriented technologies each acknowledge the importance of maximising QoE with respect to available downstream bandwidth, but in addition are concerned with maximising the utility of their sharing activities and use of the uplink from the terminal device. Without multi-layered coding (SVC/MDC) or multi-stream support, peers with poor uplinks e.g. are less useful in sharing content. This situation is most pertinent in Live streaming scenarios. In the case of a HDTV stream > 1Mbps in bandwidth for example, almost all residential ADSL(2+) connected devices in the market today would be unable to serve as an effective relay within a P2P overlay for a Live service; albeit useful contribution in a VoD or download context would be possible.

As such, almost all P2P-oriented responses indicate research into integration with multi-layer coding schemes, with some extending their field of consideration to FEC provisions - such as erasure codes or digital fountains - to further improve robustness. Lack of SoC support for SVC/MDC decoding today is important limiting factor in bringing such technology to bear in CE devices.

### Forms of Technology

Not all technologies reported in the questionnaire responses are actually implemented, some are merely specifications backed up by stakeholder agreement or laboratory experimentation; or exist in a partial form.

In general, the following forms emerged on the ITVED side:

- Stand-alone application (PC)
- Monolithic CE firmware image (incorporating application)
- Browser-based (including Flash oriented systems)
- Applet-based (hosted by a virtual machine)
- Combination (Browser + background application)

Additionally, some technologies provided APIs adding further flexibility to deployment.

### Platform Support

Almost all technologies run on the Windows platform (except. Apple Live Streaming).

Technologies for which only a specification is currently defined and no implementation or deployment exists, were deemed platform neutral as the only dependency they have is that of TCP/IP stack.

Linux support was common to many technologies, which leads one to the conclusion that many of the technologies could be ported relatively easily to Linux-based CE devices. Only the following technologies reported no support for Linux:

- Apple Live Streaming (although this runs on a Unix-style OS)
- CoolStreaming
- P2P-SIP

Java-based solutions were considered platform independent; although the performance overhead of running the more complex - piece-oriented - CD algorithms within a virtual machine on low-cost CE hardware could be a limiting factor. Real-world performance figures for throughput of such systems on CE device were not provided in the responses.

### Device Resource Requirements

This clause looks at the demands made by the ITVCD technologies, in terms of CPU usage, code space and dynamic memory requirements.

Depth of reporting within the responses for this area was limited and vague, with the exception of NextShare, which reported details of the target device specifications, test setup, and graphed performance results.

Ignoring the issue of codec processing, which is considered to be accelerated through dedicated codec blocks on target devices and therefore incur minimal CPU overhead, it is reasonable to conclude that performance concerns of ITVCD are mostly rooted around the P2P solutions, rather than traditional Unicast/CDN solutions. With P2P approaches, a multitude of network connections to other peer devices are common and content sharing can be highly granular, with piece sizes being in the order 32KByte each and piece selection decisions very dynamic.

The bulk of performance reports focused on the SDTV @ 2.5Mbps example, with only Smooth Streaming and NextShare venturing to provide performance figures in the 1080p HDTV domain. NextShare reported support for up to 20Mbps of piece throughput (upload + download) on a mainstream 400Mhz SoC from ST Microelectronics. This was based on a test-swarm of 22 peers in lab conditions, where each peer was playing back the same Live Stream. On the other hand, Smooth Streaming reported playing back 1080p24 6 Mbits/s IIS Smooth Streaming content in Silverlight 3 on a Core 2 Duo 2.5 GHz Windows PC requires approximately 80% CPU usage; indicating limitations in what could be deployed directly to CE devices today, without technology specific optimisation.

It is difficult to make an assessment as to whether certain approaches to ITVCD are prohibitively expensive without further R&D Lab analysis by DVB member teams, but there are positive indications of viability arising from the Study Mission initiative.

### Security Aspects

Another potentially expensive operation for CE devices is the authentication and/or integrity checking of content arriving from ITVCD servers, or other peers.

NextShare was the only technology which made explicit provision for hardware acceleration of both SHA-1 digest and RSA signature authentication/integrity checking of the P2P pieces it processed.

Almost all other solutions neither made, nor acknowledged, any specific provisions for security processing as being required for low-power CE devices, with respect to ITVCD. One can only presume that security is considered an over-the-top or orthogonal issue, transparent to that of the content delivery itself. However in the case of P2P, the content security and authentication challenges are unique and often complicated, and as such merit further analysis.

### 8.4.3 Content and Network Security

Questions 19, 20, 21, and 22 of the questionnaire provide information on the following high-level criteria.

- Content Security / Network Security (addressed by Q19, Q20, and Q21).
- Compliance with existing regulatory provisions (partly addressed by Q22).
- Content integrity (partly addressed by Q21).
- Resiliency from attacks (addressed by Q20).
- Protection of privacy rights of end user (addressed by Q22).

Q19 enquires about the way the Internet TV consumer would sign-in to the service or otherwise authenticate his/her device.

Only two technologies, Emundoo and Samsung P2P-TV, enforce explicit authentication of the client device with the server.

PayTV DVB tuner and GEM-IPTV use or support a Conditional Access System (CAS) solution, which is a security system that enables the broadcaster or service provider to control the subscriber's access to digital and Interactive TV services. CAS ensures that only users who have registered to obtain a smartcard or token (which may be electronic) for their personal use can gain access to services for which they are authorised. Moreover, some CA systems for broadband environment include authentication of client devices with the provider server(s). PayTV DVB tuner, OIPF, Philips Net TV and Microsoft IIS Smooth Streaming support the use of Digital Rights Management (DRM) systems, which, in turn, allow authentication of client devices.

Apple needs a user sign-in (via a browser or a client application) to establish a secure session over HTTPS. Microsoft manages the access by using the standard web access means. Next to it, PayTV DVB tuner, OIPF, Philips Net TV and GEM-IPTV allow for a browser-based sign-in for [additional] services (e.g. personalisation).

Table 6 summarizes the replies to Question Q19.

Table 6 Summary of replies to Q19

Technology	Sign-in / authentication
Emundoo	Explicit authentication
Samsung P2P-tv	Explicit authentication

PayTV DVB tuner	CAS support / DRM support / optional sign-in
GEM IPTV	CAS support / optional sign-in
OIPF	DRM support / optional sign-in
Apple TV	Enforced sign-in over HTTPS
DVB CDS	
MHEG-5	
NextShare	
ZDF Mediathek	
BiTorrent	
StreamForge	
SVC	
Gridcast	
Anysee	
Microsoft IIS Smooth Streaming	DRM support
Philips NetTV	DRM support / optional sign-in

Q20 addresses the issue of protection against attacks of infrastructure.

The vast majority of the responses indicate that their solutions employ existing standard Internet technologies to deal with the threat of a “*man-in-the-middle*” attack. This is an active attack, by which the attacker sets up connections to two parties and reads their sent messages, while the two parties believe they are communicating privately with each other. SSL/TLS are used by the OIPF, Philips Net TV, Apple, and DVB-IPTV CDS. HTTP authentication and digital signature of applications are used by GEM-IPTV. HTTPS is employed by Apple, DVB-IPTV CDS and MHEG-5 IC (with root certificate sent via broadcast chain - DSMCC). To protect against man-in-the-middle attack, NextShare needs to ensure that files containing piece digests and public keys have not been tampered with. That is done by delivering these files out of band to the content itself.

The “*denial-of-service*” attack makes resources or/and services unavailable to users. The technologies that use a CDN (ZDF Mediathek and Apple) shift the responsibility to deal with this threat to the CDN provider. The OIPF, Philips Net TV and GEM-IPTV rely on the use of standard Internet techniques without defining them in the specifications. P2P-based solutions make no specific provision for denial-of-service attacks, because they believe that P2P systems are relatively tolerant to such attacks due to the design which assures that content delivery will continue should servers become unavailable.

For the protection against “*spoofing or masquerading*” attacks, where an attacker tricks the receiver into thinking he has a different identity, the OIPF, Philips Net TV, GEM-IPTV and Apple rely on the use of SSL/TLS. MHEG-5 IC and GEM-IPTV distribute an approved server list to their client devices. NextShare reduces the risks of the attack by a process of signing content carried out by the Internet TV Content Provider (ITVCP) or Internet TV Service Provider (ITVSP); further verification of the identity of peer devices may use techniques such as distributed reputations management. In P2P networks reputation is based on the ratings that one peer in the network receives from other peers. A reputation management system rewards peers that cooperate with other peers and punishes peers that cheat or behave maliciously.

The “*spamming attacks (poisoning)*” threat, by which mislabeled content is offered in a P2P setting (whether on complete file level, or on chunk level), is consequently only considered by P2P-based solutions. To prevent anonymous spamming Emundoo issues certificates to the clients, specifying that all network traffic not coming from authenticated sources must be ignored and warning that certificates of misbehaving clients can be revoked at any time. NextShare reduces the threat of spamming by accepting information only from trusted peers in accordance with their reputations. BitTorrent uses SHA-1 hashes of content to minimize the effects of poisoning attacks – in the environment with many peers, poisoning is extremely difficult as peers will quickly identify abusive peers and ban them.

The “*transitive trust*” issue (if A trusts B, and B trusts C, can there be a trust relation between A and C?) is considered by about one third of the solutions. Once again, the OIPF, Philips Net TV and GEM-IPTV rely on

SSL/TLS. Since Emundoo uses mandatory authentication of client devices, no entity in the system is trusted without having undergone authentication. MHEG-5 IC relies on the approved server list sent via the broadcast chain. NextShare claims that normal firewall practices will provide a high-level of defence against Peer ID hijacking (but it should be noted that security is compromised if the private key of a Peer ID is disclosed).

StreamForge is the only solution that relies on a proprietary cryptographic protocol to address “*man-in-the-middle*”, “*spoofing or masquerading*”, and “*spamming attacks (poisoning)*” threats.

Table 7 summarizes the replies to question Q20.

Table 7 Summary of replies to Q20

Technology	Threat protection				
	<i>man-in-the-middle</i>	<i>denial-of-service</i>	<i>spoofing or masquerading</i>	<i>spamming attacks (poisoning)</i>	<i>transitive trust</i>
Emundoo				Authentication / certificates	Authentication
Samsung P2P-tv		P2P solutions relatively immune	Reputation management		
PayTV DVB tuner					
GEM IPTV	Authentication + signed applications	"Standard internet techniques" (no detail)	SSL/TLS		SSL/TLS
OIPF	SSL/TLS	"Standard internet techniques" (no detail)	SSL/TLS		SSL/TLS
Apple TV	SSL/TLS + HTTPS	Assumes CDN deals with this	SSL/TLS		
DVB CDS	SSL/TLS + HTTPS				
MHEG-5	HTTPS + broadcast root certificate				
NextShare	Piece digests and public keys delivered out of band	P2P solutions relatively immune	Signed content and reputations		Firewall
ZDF Mediathek		Assumes CDN deals with this			
BitTorrent		P2P solutions relatively immune <sup>1</sup>			
StreamForge					
SVC					
Gridcast		P2P solutions relatively immune <sup>1</sup>	Reputation management <sup>1</sup>		
Anysee		P2P solutions relatively immune <sup>1</sup>	Reputation management <sup>1</sup>		
Microsoft IIS Smooth Streaming					
Philips Net TV	SSL/TLS		SSL/TLS		SSL/TLS

<sup>1</sup>NOTE: The responder did not provide an answer to the question. All P2P systems, however, should have similar behaviour.

Q21 deals with content protection and conditional access techniques.

Only five solutions specify “*content protection mechanisms to be used*”: PayTV DVB tuner (NDS DRM, MS-DRM and [optionally] more), ZDF Mediathek (Geotargeting, FSK from MPAA), the OIPF (Marlin DRM, CI+, DTCP-IP), Philips Net TV (Marlin DRM) and Microsoft IIS Smooth Streaming (PlayReady DRM). Other solutions (BitTorrent, NextShare, Emundoo, SVC, DVB-IPTV CDS) are agnostic to content protection mechanisms, allowing CAS and/or DRM systems to complement the technology.

All respondents but one claim that their “*architecture/technology does not prevent the use of other content protection solutions*”. Philips Net TV plans to support only Marlin DRM.

Content encryption, message authentication and hashing are used to “*ensure content integrity*”. Emundoo uses SRTP with encryption (AES – no further details) and message authentication (SHA-1) enabled. The OIPF, Philips Net TV, PayTV DVB Tuner and Microsoft IIS Smooth Streaming use DRM. StreamForge signs streamed data using a custom developed cryptographic protocol. BitTorrent uses SHA-1 hash per content piece and per file; failed hashes result in banned peers. NextShare works in a similar way; the client device calculates a SHA-1 digest for a received piece of content and compares that with the digest reported by the ITVCP/SP. SVC does not enforce a mechanism to “*ensure content integrity*”. Apple uses TCP claims that it provides “*fairly reliable delivery*”.

Standard Internet techniques are utilized by MHEG-5 IC, DVB-IPTV CDS and Emundoo to “*authenticate content as coming from the source it is claiming to be from*”. MHEG-5 IC uses HTTPS for initiation of service and setting up of any handshake; DVB-IPTV CDS uses HTTPS and TLS; Emundoo uses SRTP. PayTV DVB Tuner uses a CAS to protect content, so an attacker would have to gain access to keys or entitlements by hacking or other means to be able to decrypt content such that it can be correctly processed by the client device. BitTorrent specifies that the content must reside on a server that the publisher controls and configures in the system; if the content is not present on the server, no delivery is permitted by peers. The OIPF offers content protection by encrypting content and delivering and managing content rights. Rights can be authenticated as originating from the claimed source. Philips Net TV relies on Marlin DRM to provide content authentication. NextShare verifies that received pieces of content have come from the source claimed using the public key of the ITVCP/SP to compare the RSA signature. StreamForge uses a custom developed cryptographic protocol which it claims is optimized for secure low-delay streaming.

Only ZDF Mediathek has the built-in capability to “*limit transport to a specific geographic region of the Internet*”. Emundoo, StreamForge, MHEG-5 IC, BitTorrent, OIPF, Philips Net TV, NextShare, Microsoft IIS Smooth Streaming and GEM-IPTV define geographic limitation as an optional feature that can be easily enabled/developed.

Table 8 summarizes the replies to question Q21.

Table 8 Summary of replies to Q21

Technology	Content protection			
	<i>integrated solutions</i>	<i>content encryption</i>	<i>message authentication</i>	<i>geographic restriction</i>
Emundoo	Agnostic	SRTP + AES encryption	SRTP + AES encryption	Could be provided
Samsung P2P-tv				
PayTV DVB tuner	NDS DRM, MS DRM, others	NDS DRM, MS DRM, others	Via DRM	
GEM IPTV				Could be provided
OIPF	Marlin DRM, CI+, DTCP-IP	Marlin DRM, CI+, DTCP-IP	Via DRM	Could be provided
Apple TV		TCP		
DVB CDS	Agnostic		HTTPS + TLS	



MHEG-5			HTTPS for initiation and handshake	Could be provided
NextShare	Agnostic		RSA signature via ITVCP/SP	Could be provided
ZDF Mediathek	Geo-targeting and FSK from MPAA			Integrated
BitTorrent	Agnostic	SHA-1 hashing		Could be provided
StreamForge		Signing using own cryptographics	Signing using own cryptographics	Could be provided
SVC	Agnostic	Agnostic		
Gridcast				
Anysee				
Microsoft IIS Smooth Streaming	PlayReady DRM	PlayReady DRM	Via DRM	Could be provided
Philips Net TV	Marlin DRM	Marlin DRM	Marlin DRM	Could be provided

Q22 addresses concerns about privacy of the end-user.

Nearly two-thirds of respondents “*monitor the viewing behavior of the end-user*”. StreamForge logs time on stream per user and may log additional information. Samsung P2P-TV selectively monitors channels. Gridcast and AnySee monitor user-behaviour for academic research. BitTorrent collects aggregated statistics about the viewing habits to provide for anonymity, as well as a breakdown in the way and the extent to which users interact with the content (how much of a video is typically viewed, etc.) ZDF Mediathek keeps log files and page impressions. Emundoo records user actions for accounting/billing purposes. Information about the end-user experience with Microsoft IIS Smooth Streaming can be collected through the use of another IIS extension, called Advanced Logging. NextShare, GEM-IPTV, the OIPF, Philips Net TV, Apple, and DVB-IPTV CDS specify no functions for monitoring end user behaviour, leaving application and service providers the possibility to implement such mechanisms.

Only half of the technologies that allow monitoring of the behaviour of the end-user addresses “*measures for the protection of end-users privacy rights*”. Emundoo claims that the system does not send any personal information on its own across the network and that all information identifying entities or media sessions within the network is transmitted over channels employing strong encryption. BitTorrent and Samsung P2P-TV claim that collected information can be, or is sufficiently anonymized. Although BitTorrent would like to use the viewing habits of its users for more targeted advertising opportunities, these measurements are not yet implemented because of concern about the privacy and the care that must be exercised. According to the respondents, GEM-IPTV, Philips Net TV and the OIPF specifications do not enable violation of privacy beyond what is generally possible with any Internet-based service.

NextShare is aiming to respect all applicable EU laws, regulations and best-practices with respect to individual privacy. If users, however, are to benefit from the content discovery options opened up by engagement with social network facilities, then they must opt-in to sharing of metadata about their viewing behaviours.

Table 8 summarizes the replies to question Q22.

Table 9 Summary of replies to Q22

Technology	End user privacy	
	<i>monitoring end user actions</i>	<i>privacy protection</i>
Emundoo	Records user actions for billing	Personal data encrypted and not transmitted alone
Samsung P2P-tv	Selective monitoring	Personal data is anonymised
PayTV DVB tuner		

GEM IPTV	No logging implemented	Normal internet
OIPF	No logging implemented	Normal internet
Apple TV	No logging implemented	
DVB CDS	No logging implemented	
MHEG-5		
NextShare	No logging implemented	Complies with EU laws and regulations
ZDF Mediathek	Log files and page impressions	
BitTorrent	Collects but aggregates	Personal data is anonymised
StreamForge	Extensive logging of all users	
SVC		
Gridcast	Monitor user behaviour for academic research	
Anysee	Monitor user behaviour for academic research	
Microsoft IIS Smooth Streaming	Possible with another IIS extension	
Philips Net TV	No logging implemented	Normal internet

#### 8.4.4 Communication Protocols

The question related to the utilized protocols (Q23) was answered by all respondents but two, *NPO Hybrid Distribution*, indicating that no information is available, and *SVC*, which is only an enabling technology, without any need for communication protocols. Four solutions, like *emundoo*, *StreamForge*, *ZDF Mediathek* and *GEM-IPTV* specify proprietary protocols for all five subclauses that are either service provider dependent (*GEM-IPTV*) or extend existing protocols (*emundoo*, *Streamforge*, *DVB-CDS* and *ZDF Mediathek*) like FLUTE, UDP, HTTP or RTP/RTSP/RTCP. The *PayTV-DVB* solution is fully based on the DVB MPEG2-TS which is indicated as the used protocol in all five subclauses. Solutions like *MHEG-5-IC*, *Apple-HTTP*, *Philips NetTV* and *IIS-SS* are fully based on the standard HTTP protocol which is directly used for data transport, media control, service discovery, metadata delivery and QoS/QoE reporting. *DVB-CDS* uses everywhere a series of standardized protocols running on top of HTTP, and *CoolStreaming* indicated TCP as the only protocol used for achieving the above mentioned tasks. The responses belonging to the other eight solutions are summarized below.

On the Data Transport subclause, the answers are split between connection-oriented and connection-less protocols, the solutions usually defining an application layer protocol built on top of either TCP/IP or UDP/IP. Technologies like *Anysee*, *NextShare*, *BitTorrent* and *GridCast* define proprietary protocols on top of the UDP packet structure, whereas TCP packet structure is used by *Samsung-P2P*. The other three technologies use standardised application layer protocols like RTP (*OIPF*, *P2PSIP-IPTV*, *PRPD-IP*) or HTTP (*OIPF*).

If we look at the protocols used for Media Control, we find solutions like *OIPF* (multiple protocols), *Anysee*, *GridCast* and *Samsung-P2P* (multiple protocols) using RTSP to control the data streams and HTTP being used by *OIPF* (multiple protocols), *BitTorrent* and *Samsung-P2P* (multiple protocols). Here, the *PRPD-IP* solution mentions only UDP as protocol for media control, a proprietary protocol being defined by *P2PSIP-IPTV* on top of standard SIP, and no protocol being specified by *NextShare*.

For Service Discovery the vast majority of solutions (*OIPF*, *Anysee*, *BitTorrent*, *GridCast*, *Samsung-P2P* and *NextShare*) rely on HTTP, with the only notable exception the *P2PSIP-IPTV* solution that is based on the recently standardized P2PSIP protocol (being standardised by the IETF). As expected, *PRPD-IP* does not specify any protocol for service discovery or metadata delivery, the solution being only oriented on how to optimally distribute multimedia related information over RTP.

Since service discovery and Metadata Delivery work hand in hand, for the forth clause we get a very similar picture. The vast majority of solutions (*OIPF*, *Anysee*, *BitTorrent*, *GridCast* and *Samsung-P2P*) use HTTP to deliver the content metadata, the only exception here being *P2PSIP-IPTV* which uses a “proprietary”-protocol it currently standardizes within an IETF working group (P2PSIP). We also have *NextShare* indicating TCP as the used protocol for metadata delivery and *PRPD-IP* solution specifying, as before, no protocol at this subclause.

From the above technologies only six support QoS/QoE Reporting, *GridCast* and *Anysee* giving no information here. The *OIPF*, *P2PSIP-IPTV* and *PRPD-IP* solutions rely either on RTCP or on RTSP, whereas *NextShare* and *BitTorrent* build on top of HTTP. The *Samsung P2P-TV* uses standard TCP connections for QoS/QoE reporting.

Table 10 summarizes the replies to question Q23.

Table 10 Summary of replies to Q23

Technology	Data Transport	Media Control	Service Discovery	Metadata Delivery	QoS/QoE Reporting
OIPF	HTTP/RTP	HTTP/RTSP	HTTP	HTTP	RTSP/RTCP
Anysee	Proprietary	RTSP	HTTP	HTTP	-
BitTorrent	Proprietary	HTTP	HTTP	HTTP	HTTP
GridCast	Proprietary	RTSP	HTTP	HTTP	-
MHEG-5-IC	HTTP	HTTP	-	HTTP	-
P2PSIP-IPTV	RTP	SIP	HTTP	HTTP	RTCP
PayTV-DVB	MPEG2-TS	MPEG2-TS	MPEG2-TS	MPEG2-TS	MPEG2-TS
Samsung P2P-TV	Proprietary	HTTP/RTSP	HTTP	HTTP	HTTP
StreamForge	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
NPO Hybrid Distribution	-	-	-	-	-
emundoo	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
CoolStreaming	TCP	TCP	TCP	TCP	-
PRPD-IP	RTP	UDP	-	-	RTCP
NextShare	Proprietary	-	HTTP	TCP	HTTP
ZDF Mediathek	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
GEM-IPTV	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
SVC	-	-	-	-	-
Apple-HTTP	HTTP	HTTP	HTTP	HTTP	-
DVB-CDS	HTTP	HTTP	HTTP	HTTP	HTTP
IIS-SS	HTTP	HTTP	-	HTTP	HTTP
Philips NetTV	HTTP	HTTP	HTTP	HTTP	HTTP

#### 8.4.5 Content Search and Metadata

Internet TV services will offer a large variety of content. Therefore, content search, discovery and access based on metadata is a key asset for any Internet TV service. Q24 therefore asked how the Internet TV Consumer can locate content items through this technology and what standardized or proprietary metadata format is used.

ITVSPs provide content discovery mechanism and content guides to all connected ITVEDs. The ITVED searches the content when the user selects the Internet TV service. The metadata presents content information and relevant references on the Internet, typically in form of extensible and flexible language.

Content Metadata is essential information provided by the ITVSP to the ITVED. Generally, metadata is a well-defined format, for example by using XML. Each ITVED device is able to search the content with same syntax and understand the metadata that describes content properties, content location, protocol, applied codecs and typically many more information. The replies to the questionnaire on this subject are summarized in the following.

Open IPTV Forum provides two methods for content discovery, namely either the content guide is served by ITVSP itself or DVB-IPTV SD&S, BCG and TV Anytime metadata is reused. Anysee, Gridcast and Samsung provide non-standardized XML-formatted metadata through the web portal. MHEG-5 with Interactive Channel considers the use of TVA-like metadata in applications. The MPEG-5 portal delivers the information via broadcast channel, embedded in the MPEG-2 TS. P2PSIP-IPTV uses a DHT server and the ITVED can search the content with keywords. Then the content location is provided to the ITVED. The metadata to be used in P2PSIP-IPTV is TV Anytime. PayTV DVB-Tuner reuses DVB-SI. Stream Forge uses a “stream descriptor” on each stream. The descriptor includes XML-code location and content information. emundo being a delivery platform does not specify content metadata, but SDP may for example be used. BitTorrent does not provide details as metadata is on top of the delivery platform. The ITVED downloads the ‘torrent’ file from Portal and the file includes content information and tracker location to access the resources where the content is available. NextShare can be combined with several mechanisms to access the URI locator, e.g. via E-Mail, Instant message, RSS Feed, Portal, EPG and BCG. The ‘tstream’ file describes the NextShare content and services. The metadata can be aligned to TV Anytime. ZDF Mediathek supports a web portal and search engine to discover the content, also a scheme based on RSS can be used. GEM-IPTV mentions two methods for content discovery similar to Open IPTV Forum approach. Apple HTTP live Streaming and Microsoft IIS Smooth Streaming use URIs in web portals. DVB-IPTV CDS uses the DVB-IPTV SD&S and BCG for content discovery and BCG based on TVA is used for content metadata schema. Philips Net-TV uses the CEA-2014 compatible browser to search the content. The metadata is delivered within the CEA-2014 web page.

Table 11 summarizes the replies to question Q24.

Table 11 Summary of Content Discovery and Content Metadata Scheme

Technology	Content Discovery	Metadata Schema
Open IPTV Forum	Web Portal DVB-IPTV SD&S, BCG	TV Anytime
Anysee	Web Portal	XML Metadata
Gridcast	Web Portal	XML Metadata
Samsung P2P-TV	Web Portal	XML Metadata (no standardized schema)
MHEG-5	MHEG-5 Portal	TV Anytime like metadata (Planning)
P2PSIP	DHT Server	TV Anytime
PayTV DVB-Tuner	DVB-SI(from web)	DVB-SI
Stream Forge	Stream descriptor	XML Metadata
emoondo	(Depends on application)	SDP
BitTorrent	Web Portal/Tracker	torrent file
NextShare	Web Portal/Tracker, EPG, BCG...	tstream file
ZDF Mediathek	Search Engine	RSS Format
GEM-IPTV	Web Portal DVB-IPTV SD&S, BCG	
Apple HTTP Live Streaming	Web Portal	Not available
Microsoft IIS Smooth Streaming	Web Portal	Not available
DVB-IPTV CDS	DVB-IPTV SD&S, BCG	TV Anytime
Philips Net-TV	Web Portal	CEA-2014 web page

All presented technologies have their own content discovery mechanism and metadata schema. Content discovery is primarily based on Web Portals and DVB-IPTV SD&S and BCG. Some technologies reuse TV

Anytime metadata or it is at least no excluded to be used within their technologies. Several technologies also use proprietary XML-based metadata.

### 8.4.6 Codec and Encapsulation Formats

Audio/video codecs (Q25) and encapsulation/file formats (Q26) are addressed in the “Technical Features – Formats” clause of the questionnaire. As well as collecting information about favoured codecs and formats, the questions sought to verify the applicability of the codecs and encapsulation format (i.e. MPEG-2 TS) adopted in TS 101 154 and TS 102 005.

Responses received from within the industry standards realm - DVB CDS, GEM-IPTV, OIPF, MHEG-5 IC – are either codec agnostic, or just assume standard codecs, and in fact refer to the DVB specifications for their usage. Outside of DVB, some – OIPF and MHEG-5 IC - go further by mandating the support of one video and one audio codec from the DVB toolbox in the interest of interoperability.

Contributions that result from deployed end-to-end content services – ZDF Mediathek - do adopt content and transport formats, although the systems are not bound to these formats and they are just used for the service. Here a mix of open standards and proprietary codec and encapsulation formats are used, whereby the prime motivation of such service offerings presumably is to make the content available to as wide a population of receivers as possible. In the absence of a single widely adopted standard, many formats have to be supported by the service.

For responses that concentrate on distribution technologies, because the content is generally packaged in an encapsulation format for distribution, they are generally agnostic as regards video and audio codecs. None of the technologies, including their content delivery method, would prevent the use of any DVB codecs as specified in TS 102 005 and TS 101 154. Where such responses also cover deployments of the technology, both standard and proprietary codecs are used.

From all responses, the video codecs mentioned are:

- Open-standard formats: H.264/AVC, MPEG-2, VC-1, which are already in use, and SVC possibly for future use;
- Proprietary formats: Windows Media Video (WMV), Real Media Video.

From all responses, the audio codecs mentioned are:

- Open-standard formats: HE-AAC, AAC, MPEG-1 Layer II or III (MP3), AC-3;
- Proprietary formats: Windows Media Audio (WMA), Real Media Audio (RMA);
- Open source format: Ogg/Vorbis.

For encapsulation formats, technologies conceived for live streaming tend to adopt MPEG-2 TS. Some download oriented technologies do not use MPEG-2 TS but do not necessarily preclude its use.

Contributions that are focussed on delivery, mainly P2P – like BitTorrent, AnySee or GridCast, or on optimised delivery mechanisms, like Smooth Streaming, are completely agnostic of codec and encapsulation formats. Some others are independent of audio and video codecs, but are tailored to particular transport formats. Mainly they adopt MPEG-2 TS – namely NextShare, PLPD media delivery, but in some cases MP4FF – namely emundoo, StreamForge.

Technologies for which a choice of a particular encapsulation format has been made – StreamForge, Anysee – do not support MPEG-2 TS currently, but some – StreamForge - state that their technology would not preclude the use of MPEG-2 TS.

Encapsulation formats mentioned are:

- Open-standard formats: MPEG-2 TS mainly for streaming, MP4FF mainly for download – also the DVB File Format variant in the case of responses from within DVB, and 3GP and the PIFF variant in IIS-SS reply;
- Proprietary formats: ASF, AVI, RMVB, Xvid;
- Open source format: Ogg (audio encapsulation).

### 8.4.7 QoS Tools

Among others, Internet TV Content delivery according to the definitions in clause 5 is explicitly characterized that no network QoS guarantees are available end-to-end. Network based timely delivery of multimedia,

admission control and QoS can not be considered for Internet TV Content Delivery as such guarantees depend on a service level agreements (SLAs) between the Delivery Network Service Provider and the Internet Service access Provider. Such guarantees in managed IPTV networks typically ensure guaranteed bitrates, very low to negligible packet loss rates as well as support of many concurrent users. In Internet TV Content Delivery this issue needs to be resolved by other means, typically in an end-to-end fashion without explicit support of the underlying network. Questions 27 and 28 of the questionnaire explicitly address the QoS issue and try to provide background information on high-level criteria

- Service Availability / monitoring
- Robustness
- Content Integrity

Q27 addresses the QoS Tools that are deployed or at least considered for usage in the different technologies.

Packet loss is one phenomenon in Internet delivery. Packet losses may for example occur due to congestion losses, losses on the access network or due to so called "late" losses where packets occur so late that they are no more useful in the receiving function of the protocol stack, for example as playout deadlines have been expired. Packet losses can typically be compensated by retransmission, forward error correction or media decoder concealment methods. Also combinations of the three methods may be applied.

For all http-based delivery mechanisms such as Open IPTV Forum, MHEG-5 IC, ZDF Mediathek, GEM-IPTV, Apple HTTP Live Streaming, DVB-IPTV CDS, Philips Net TV, Abacast VoD and File Delivery as well as IIS Smooth Streaming the technologies mostly rely on the underlying TCP retransmissions to compensate packet losses. If deployed on top of a CDN or when using multiple http servers, the retransmission may be directed to alternative servers.

For P2P-based delivery, similar retransmission methods are applied: StreamForge for example reports to maintain connections to multiple peers to compensate individual packet loss: If delivery of the data packet from peer fails, another one will provide the missing data. CoolStreaming, Emundoo and Samsung P2P-TV also applies P2P-based retransmission.

In case of UDP-based data delivery, the Open IPTV Forum or NextShare for example consider the use forward error correction based on erasure codes. DVB-IPTV CDS also uses FEC in the multicast-based delivery.

Scalable video coding and PRPD Media Distribution address the potentials of cross-layer designs to compensate packet losses or to at least minimize the impact of packet losses to the end-to-end quality. However, no deployed solution has been presented.

Another way to prevent the system using lossy links is reported by emundoo for which traffic rerouting is used on a best effort basis.

Particularly for download applications, content integrity is of major relevance. Bittorrent for example reports the use of SHA-1 hashes delivered as part of the torrent file ensure that the right content is delivered in its entirety to the destination. DVB-IPTV CDS uses similar technologies and permits unicast file repair, i.e. connecting to different servers, to complete the delivery of partly delivered files.

In Internet TV Content Delivery typically bitrates cannot be guaranteed. This means that the bitrate may vary depending on the time-of-the-day, the access network or other circumstances. Bitrate variations may occur in different time-scales, i.e. within seconds up to minutes or hours.

In case of download services, bitrate variations are compensated by regular TCP congestion control (see for example OIPF, DVB-IPTV CDS, etc.). However, this may obviously adversely affect download times. In case of multicast delivery for DVB-IPTV CDS, a specific multicast rate adaptation may be performed.

Several of the technology support (or at least mention the option to support) multiple bitrate versions by the provisioning of the content in different quality versions, e.g. BitTorrent, MHEG-5 IC, StreamForge, Emundoo, NextShare, GEM-IPTV and Apple HTTP live streaming. Some technologies (emundoo, Apple HTTP Live Streaming, IIS Smooth Streaming) provide or at least suggest to use dynamic switching between different quality versions such that bitrate variations during one content streaming or download session can be compensated. In the case of Apple HTTP Live streaming, clients can change to the currently best version dynamically. In deployments commonly a single layer video codec such as H.264/AVC is used to provide multiple bitrate/quality levels for the same content. However, an alternative to provide different quality/bitrate versions for content is scalable video coding as for example suggested by BitTorrent, StreamForge and NextShare, but no deployments of the use of SVC are yet reported. BitTorrent also mentions that in case

of the use of SVC in P2P architectures, the base level is shared by everyone and is well suited for P2P, but the incremental layers are increasingly rare, lowering the effectiveness of P2P with each increment.

Content Delivery Servers may fail. In IPTV services, the service operator usually provides sufficient redundancy to ensure robustness in the media delivery, typically service level agreements (SLAs) between service providers and server vendors exist to ensure high availability. In Internet TV content delivery such SLAs may not exist or are impossible to realize due to the applied architecture and business models. Other means for robustness need to be provided. An interesting aspect has been mentioned by PPlive that due to the heterogeneous network, unpredictable user patterns, asymmetric networks and generally poor network condition, the realistic conditions in a large-scale deployment are usually very different from the analysis in labs. Therefore, stronger, smarter and more robust algorithms should be used in Internet TV Content Delivery.

Solutions that rely on CDNs typically defer this high availability issue to the CDN provider. CDNs can ensure robustness by providing a network of servers that deliver content to a user based on the geographic locations of the user, the origin of the content and a content delivery server. The content is replicated and cached in the CDN to ensure high availability. Specific SLAs between ITVSPs and CDN provider may exist to ensure robustness and high availability. Specifically OIPF, GEM-IPTV, ZDF Mediathek, Apple HTTP live, Philips Net TV streaming and IIS Smooth Streaming mention this deployment scenario. IIS Smooth Streaming provides some insight into CDN functions that may provide such robustness: Standard HTTP load balancers, traffic managers, and use of multiple encoder or servers at any given distribution layer can eliminate single points of failure.

Technologies that do not rely on CDNs (BitTorrent, StreamForge, emundoo, Samsung P2P-TV, Octoshape, or NextShare) provide robustness by similar means as CDNs do, namely the provisioning redundant servers. BitTorrent refers to their system to be designed end-to-end to “fail open”, i.e. in case of outages of certain dedicated servers content will continue to be delivered from origin servers without interruption. Octoshape has a multi fail over system (any component can fall out without interruption in the stream as long there is a path from source to destination). NextShare also explicitly mentions that by a distributed P2P approach the system is very robust in the presence of serving-peer outages. Deployments that heavily depend on super-peers should undertake suitable high-availability designs similar to CDNs to minimize the impact of server outage. DVB-IPTV CDS enables the deployment of multiple download server locations and automatic redirection of clients to compensate such outages.

A typical major problem in Internet TV Content Delivery for Live TV services is the abrupt increase in the number of concurrent users, e.g. in the beginning of very popular events, so called “flash crowds”. Robustness for such events is critical to withstand the unexpected and overloading surge of traffic.

For CDN-based systems this may again be part of the CDN provisioning and an SLA between the CDN operator and the ITVSP as suggested by OIPF, Apple HTTP Live Streaming, IIS Smooth Streaming or GEM-IPTV. Arrangements for on-demand capacity from the CDN supplier may be taken for such expected popular events. According to IIS Smooth Streaming, once content fragments are cached at the edge, scalability is typically limited only by the number of HTTP caching servers available, which is typically an order of magnitude higher than the number of traditional streaming servers. As an alternative, an IIS extension called Application Request Routing can be used to create intelligent IIS caching servers in the middle and edge layers downstream of the origin servers ensuring the upstream servers are not overwhelmed at the start of highly popular events. In the case of DVB-IPTV CDS, again the use of multiple server locations and redirections may be used to compensate such events. Finally CDN-based delivery methods such in IIS Smooth Streaming, Apple HTTP Live Streaming or others, are stateless - unlike traditional streaming solutions. Thus, if a caching server goes off-line, standard traffic management tools can re-route any given fragment request to another server without any interruption to the end-user.

Another interesting aspect is addressed by the reply of GEM-IPTV, PayTV DVB Tuner and DVB-IPTV CDS, namely that such popular highly-demanded scheduled events are usually distributed over massively scalable broadcast channels or multicast distribution links in case the Internet TV Content Delivery is part of a hybrid broadband/broadcast deployment. This also holds of other hybrid broadband/broadcast technologies such MHEG-5 IC or possibly the OIPF.

P2P-based architectures such Anysee, Samsung P2P-TV, Bittorrent, StreamForge, emundoo, CoolStreaming or NextShare accommodate flash crowds quite well, as they can “organically” create the necessary infrastructure with each new user that joins the service. To provide support of flash crowds, decentralization and distribution is important, central management component of the system are very light weight and can handle



several thousand concurrent connections per server (StreamForge). Newly connected clients are directly integrated in the P2P network. Nextshare for example is fundamentally scalable with respect to flash-crowd behavior patterns due to its distributed mesh topology and cooperative design.

Emundoo applies the concept to redirect clients to dedicated seeders in case of overload and at the same time the delivered bandwidth is reduced applying dynamic rate adaptation as discussed earlier. This rate adaptation is in principle independent of the architecture and may again be favourably supported by the use of scalable video decoding, but again no deployments have been reported.

StreamForge addresses that in P2P networks also the simultaneous disconnection of many users can cause significant availability problems, but simulations have shown that the StreamForge solution can handle concurrent disconnection of up to 80% of all users without negative impact to the remaining users. Unfortunately no further technical details are provided.

NextShare addresses that in the Open Internet congestion aware solutions are relevant. TCP/IP inherently includes congestion awareness, but for other protocols, in particular based on UDP, additional work is considered and NextShare is developing a next-generation, congestion aware, UDP-based protocol for live streaming.

To support retransmission and adaptation mechanisms, but also for the purpose of QoS and QoE monitoring, Internet TV Content Delivery provides unique options as due to the bidirectional setup of connections, feedback from the ITVEDs to different network functions is easily supported. Therefore, in Question 28 of the questionnaire, it was attempted to understand if QoS and QoE measurements and reports are supported and if yes, how they are used to optimize the delivery, e.g. for adaptation, re-routing, charging policies, etc.. A large portion of the replying technologies uses or at least plans to use QoS/QoE measurements for different purposes, mainly for delivery adaptation and platform optimization.

Some of the technologies view QoE reporting as an application function and are therefore not core of their delivery solution. However, service provider may use proprietary methods for QoE measurements.

For RTP-based streaming services such as supported by the OIPF, emundoo, P2PSIP-based IPTV or PRPD Media Delivery, RTCP is used for QoS reporting (delay, loss rates, jitter) for the Delivery Network Service Provider. Such measurements may be used for bitrate adaptation (kind of congestion control) as well as re-routing.

P2P-based solutions report the use more detailed measurements. Bittorrent uses client-configurable measurements for rerouting in real-time. StreamForge clients measure their QoS in terms of packet loss and buffer occupation, the received quality is logged for each user. The measurement data is used for rerouting to other peers, but may also be used for billing purposes. Samsung P2P-TV uses the measured end-to-end delay to periodically select the candidate peers for the next transmission. To support QoS measurements, NextShare is instrumented to report various statistic about the operation of the P2P client software. Such feedback is currently only used to improve the system design, but not as real-time operational feedback. Abacast does real-time QoS-monitoring leading to higher quality streaming connections and performance than unicast.

CDN-based solutions also report the use is of measurement feedback, e.g. ZDF Mediathek, Octoshape, DVB-IPTV CDS Apple HTTP live streaming, and IIS Smooth Streaming. DVB-IPTV CDS permits the report of the successful delivery of content items, files, or chunk of files. Philips Net TV use the observance of HTTP connection drop out or slow downs to provide visibility on the performance of the solutions. Apple measures the current ratio of download-to-playback bandwidth to dynamically choose the currently best version in terms of bitrate/quality. Octoshape not only measures and knows how much have been sent but also how much have been received and how well have it been played. In case of IIS Smooth Streaming QoS/QoE measurements are inherently a part of the feedback loop for the adaptive bit rate switching. Depending on the distribution network, this information may be completely isolated from the IIS Smooth Streaming origin server through the use of basic HTTP caches on the edge. In addition, QoS/QoE details can be recorded in a real-time log file using IIS Advanced Logging. The measurements are used for bit rate adaptation to suit the prevailing connection and client capability. Additional information about QoS/QoE collected using IIS Advanced Logging could be used by a third party to create new value-added services (e.g., billing) for the ITVCP, ITVSP, or DNSP.

#### 8.4.8 Key Performance Indicators

Internet TV Content Delivery may have to compete with existing other video distribution means such as satellite, cable, terrestrial, or managed IPTV. Therefore, audiovisual quality as well as other performance indi-



cators relating to delays and responsiveness of the system and services are typically expected to be at least similar or even better than for existing delivery systems. Also of interest for different player is the value chain is how well the delivery method can cope with a large amount of users and what the costs are to support additional users accessing the services. Therefore, the questionnaire has included several questions to benchmark the performance of different technologies based on several typical key performance indicators. Specifically, Questions 29, 30 and 31 of the questionnaire explicitly address key performance indicators and try to provide background information on high-level evaluation criteria:

- Cost effectiveness addressing infrastructure, deployment and operations
- Fast service build up
- Support for Live TV streaming
- Support for VoD streaming
- Support for Download-to-Play (non-streamed)

Q29 addresses supported bitrates as well as the audiovisual quality that are deployed or at least considered in the different technologies.

In terms of supported bitrates, technologies that are based on the DVB codec toolbox in ETSI TS 101 154 , i.e. OIPF, PayTV DVB tuner and DVB-IPTV CDS claim the support of all bitrates of the codecs in the toolbox. However, it is important to understand that OIPF and DVB-IPTV CDS are download services and therefore the delivery bitrate may be lower than the media bitrate. The PayTV DVB tuner anyway relies on the broadcast feed, similar as MHEG-5 IC and others and therefore does not necessarily deliver the AV content through the Open Internet.

Typical supported live or on-demand streaming services in today's deployments are between several hundred kbit/s up to 2-3 MBit/s, e.g. as reported by Anysee (up to 800 kbit/s), Bittorrent (1.16 MBit/s), Gridcast (up to 800 kbit/s), NPO Hybrid Distribution (up to 1.8 MBit/s), emundoo (up to 2 MBit/s), Nextshare (between 1 and 2 MBit/s), ZDF Mediathek (up to 1.5 MBit/s), Apple http live streaming (up to 1.5 MBit/s), IIS Smooth Streaming (up to 3 MBit/s), PPlive (around 400 kbit/s) and TVU (up to 400 kbit/s). Limits are due to network restrictions, but also processing power on CE-like end devices (see Nextshare reply on this subject). Only in dedicated lab environments (P2PSIP) or first test deployments (Bittorrent, emundoo, Octoshape) or with further implementation optimizations (NextShare, Abacast) bitrates in the range of 5-10 MBit/s and beyond are supported. Many of the technologies also provide lower bitrate versions to address the heterogeneity in terms of end devices and access bitrates. In unmanaged networks one cannot expect the availability of bitrates as may be required by codecs in the DVB toolbox.

Based on the variations of the supported bitrates, also different video resolutions and audio qualities are supported. Typically Internet TV technologies aim to support VGA or SD-like resolutions. For audio typically bitrates of 48 or 64 kbit/s are considered. If mobile devices are targeted or if support of a wider range of access networks is considered (Apple http live streaming, ZDF Mediathek, emundoo, IIS Smooth Streaming), also smaller resolutions such as QVGA are offered and deployed. StreamForge today only deploys audio streaming up to 160 kbit/s. Download services such as OIPF and DVB-IPTV CDS support also higher AV qualities such as HD video, obviously at the expense of possible long download times. If one of the downloading technologies would be used for streamed services or progressive download the limiting factors today are the capacity of the CDN, the ISP's network and the user's Internet connection as these will not be able to sustain high bitrates to large numbers of users.

Most of the technologies do not yet deploy any HD services, but they basically claim that the support of HD is feasible with their technology with sufficient consumer infrastructure as for example available in Japan, South Korea, and parts of Europe (see Bittorrent). North American infrastructure is not yet sufficient to support P2P delivered HDTV streaming. For P2P, mostly the uplink bitrates are the limiting factors. Nextshare provides great insight that live streaming HDTV is possible only to PCs, and only by adding a super peer infrastructure in order to plug the bandwidth gap exposed by the deployment of such services. The support of live HDTV streams on constrained CE devices and in a meshed P2P network requires additional research. Nevertheless, some of the technologies (Abacast, emundoo, P2PSIP, NextShare, etc.) give hope that P2P delivery technology may also enable the economical distribution of the high fidelity content, including HD quality video.

Q30 addresses responsiveness and delays for live and real-time services that are deployed or at least considered in the different technologies. It was also asked if the technologies could provide some insight in the contributors of the delay and possible optimizations.

Service startup times, channel change times and adhoc seek times are generally in similar ranges. According to P2PSIP-TVs lab trials, in ideal conditions the delays in Internet TV CD and even P2P may be quite low around 1-2sec. However, in practical deployments typically these times are in the range of several seconds to several tenth of seconds, and commonly the times/delay are not constant, but distributed over the user population, e.g. Anysee and Samsung P2P-TV live TV (< 20 sec for 80% of users), Gridcast and Samsung P2P TV VoD (< 5 sec fo 70%, < 10 sec for 90%), CoolStreaming (5-20 sec, but up to 90 sec in measurements), StreamForge (2-7 sec), emundoo (4-10 sec), and NextShare (2-3 sec on a PC and 10-20 sec on an STB) Apple HTTP live streaming (2-10 sec), and IIS Smooth Streaming (1-2 sec). Main contributors for these delays are the network delay, buffer requirements for uninterrupted playback within the media player, and media encoding delays to locate random access points. In case of P2P, emundoo also reports that locating the streaming sources may add to startup, channel change and seek times. Apple http live streaming also reports that channel change times may be much higher (30-40sec) in case the channel is not yet served and need to be setup. In this case the real-time buffer must be generated prior to start of playback to compensate for network bandwidth jitter.

Emundoo uses optimizations including burst-downloading initial data from dedicated streaming peers (for VoD) and always selecting dedicated seeders when joining the network to allow for playback while additional sources are discovered. NextShare expects that an optimized UDP-based protocol for streaming to be developed by the end of 2010 can provide better access latency figures. Apple http live streaming optimizes access and channel change times by optimized placement of Instantaneous Decoder Refreshes (IDRs) and adaptation of stream segment length. P2PSIP-TV optimizes channel switching by proactively locating the relay candidates for adjacent channels. Samsung P2P-TV also plans to improve channel change times by adding a sophisticated algorithm.

For any technology that buffers the certain parts of the stream on the disk such as download services (OIPF or DVB CDS) or do pre-loading such as emundoo, adhoc seek times may be very fast as long as the content is accessible on the disk.

Interestingly, basically all technologies report significantly longer end-to-end delays than channel access times, StreamForge reports 3-15 sec end-to-end delay (3 times more than seek times), emundoo 30 to 150 seconds (10 times more), Apple http live streaming 30 sec (3-10 times more than seek) and IIS Smooth Streaming 5-15 seconds (3-10 times more than seek). The main contributing factors are that the content needs to be pushed/pulled down the delivery tree. For emundoo, the height of the P2P distribution tree and differences in network delays to particular peers when reconstructing a stream from multiple fractions requires this buffering. This delay may be lowered by reducing the overall height of the tree by placing peers with high upstream capacity close to the root, using network topology information for optimizing the tree topology, i.e. integrating super-peers. Apple http live streaming reports as main contributor that segments (referring to the individual files that are created from the MPEG-2 TS) must be completed before distribution via HTTP and clients requires 3 segments for buffering. There is a tradeoff between segment duration and the cost of increased server load due to more-frequent access. IIS Smooth Streaming provides similar considerations.

None of the technologies reported any issue in turning around content before distributing over their respective delivery or changing from live to on-demand content. This means that typically no specific encoding is performed for on-demand content or the encoding/transcoding can be done in real-time.

Q31 addresses key performance indicators that express the scalability of the system, in particular the cost of extending the number of concurrent end-devices/users over a Live TV and on-demand service, and the influence of such an increase on the involved actors. In a pure client-server architecture, the number of required servers would basically increase linearly with the number of new users/clients. So technologies try to reduce these costs by different means.

For technologies that can be deployed on CDNs such as OIPF, DVB CDS, ZDF Mediathek Apple http live streaming and IIS Smooth Streaming, the scalability is comparable to the scalability of typical HTTP web deployments. CDNs provide the option to scalably distribute HTTP content. Therefore, no dedicated streaming servers are necessary but standard and more cost-efficient http servers can be reused. In addition, specific discounts are available in CDNs for larger amount of users/traffic (see ZDF Mediathek reply). Therefore, the

costs for adding additional users are generally lower than a linear increase. For initial content ingest, generally dedicated servers are required (see e.g. IIS Smooth Streaming). IIS Smooth Streaming provides some typical numbers that with each new server up to 2,000 concurrent Live TV service users can be supported and each new server is in the range of several hundred Euros.

P2P-based systems such as Samsung P2P-TV, P2PSIP-IPTV, StreamForge, emundoo, NextShare, Abacast or Octoshape promise to offload serving capacity to peers once additional users are added to the service and greatly decrease the network load of source servers. Therefore, with P2P technology, little incremental server capacity is required to support more peers, resulting in low impact to the ITVCP or ITVSP. However, for P2P systems to provide a high degree of scalability it is necessary that the serving peers for each requested service or VoD stream provide a sum upload capacity to match all user requests. Emundoo mentions that the costs for deploying their P2P technology are highly dependent on network asymmetry and topology and no reliable data exists yet.

If the service bit rate is higher than the upload bandwidth provided by the peers then a bandwidth gap problem exists. Different solutions are proposed and deployed to overcome this problem:

- NextShare proposes intelligent peer caching, i.e. idle peers contribute upload on behalf of the community in an automated and self-organizing fashion, or super peers must be provisioned.
- StreamForge also mentions that dedicated servers have to provide this missing bandwidth. Due to the sophisticated server cluster management of the StreamForge solution additional servers may be added on-the-fly and also be disconnected if they are no longer required.
- Abacast and Octoshape rely on hybrid P2P delivery platforms to overcome this bandwidth gap. For their on-demand service, Abacast manages the network cache based on both anticipated and current demand. This means that all or most of the content can be served from the efficient Abacast Hybrid P2P network, even under initial demand spikes.

PPlive also mentions that for P2P-based streaming simultaneous consumption of the content does not necessarily improve the viewing experience, especially if the user scale and the architecture are not well adequately coordinated. Therefore, PPlive has continuously changed the architecture with the increasing number of subscribers, recently relying on a significant amount of super-nodes.

Despite P2P technologies can offload serving capacity to peers it transfers a lot of bandwidth burden from source servers to ordinary overlay users. Then, an increasing number of end-devices/users result in more network load to ISP-managed users, which consequently cause much more cost for ISP (Anysee, Gridcast, Samsung P2P-TV, NextShare). By deploying P2P technology and provided the newly user is located on the NSPs/ISPs network or accesses other clients located within these networks, NSPs and ISPs see a linear increase in network traffic (emundoo). StreamForge connects peers, which are in the same IP subnet and in geographic vicinity to each other such that "local clusters" of users are formed who share the stream among themselves. This reduces costs for ISPs. Whenever possible, StreamForge relieves the Internet backbone from parts of the traffic and moves it into the local networks of the ISPs.

Due to this additional network burden of P2P technologies, ISPs may throttle P2P traffic (see Abacast reply). The recent P4P Working Group (P4PWG) industry initiative addresses ISP concerns in this area by specifying how ISP's can expose details about their network, enabling P2P vendors to significantly increase the efficiency and performance of data transfer within these networks. The P4PWG initiative enables P2P vendors who comply with the initiative to provide significant value propositions to ISPs. The IETF PP2P also mentions that mobile cellular or general wireless infrastructures with bottlenecks in the uplink and centralized access points do not necessarily well fit with P2P. However, the work in PP2P attempts to address solutions to this problem as well without specifying any further details.

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## 9 Relation to Business Models and Commercial Case Study

### 9.1 Introduction

DVB has completed an Commercial Case Study on Internet TV available in document CM-IPTV0554 [5]. This clause provides a connection between the information in this Study Mission Report and the technology submission and the information in this Commercial Case Study. It addresses synergies and complementary aspects between the two documents.

The “Commercial case for Internet TV” document presents Internet-TV, which is defined as multimedia services running over Internet (i.e. non-managed network). It compares IPTV with Internet TV, provides the Internet-TV value chain and describes new multimedia services. An overview of the market relevance and potential business models demonstrates the relevance of Internet-TV. A section on the regulatory issues addresses some specific legal issues that may be relevant for Internet delivery of TV. Finally, a description of past and on-going work on this area into different standardization initiatives, including DVB itself, is provided.

### 9.2 Novel Aspects of Internet TV

Similar to the definition on clause 5 of this document, the Commercial Case Study document defines Internet TV as multimedia services running over Internet (non-managed network). The lack of QoS, multicast, and bandwidth guarantees is also stressed in this document. Due to the lack of QoS, the commercial document also addresses the necessity of dynamically adaptive technologies as well as the support of Content Delivery Networks (CDNs). Further technical discussions are provided that mostly align with the findings in this Study Mission Report.

According to the commercial document, user experience and expectations in Internet TV services may be different when compared to classical broadcast and IPTV services:

- Internet TV services may not only target regular TV sets, but also include PC screens as well as cell phones that are equipped with Internet connectivity.
- The user expectations may be different for Internet TV services than for traditional TV. Lower quality in the viewing of video may be acceptable if it is balanced by additional advantages such as price, number of available services and/or additional features.
- Users will be more and more oriented to personalized ‘on-demand’ services. The technical challenges in terms of scalability are expected to be different kind than in traditional TV programs as each user receives different content.

Other trends that are expected to emerge in Internet TV services is the coalescence of Internet search engines and TV service discovery, possibly augmented by new portals. Also P2P and Web2.0 technologies are expected to influence future Internet TV services. Personalized video services and interactivity may be improved by the flexibility provided for Internet TV services. The conjectures collected in the commercial study are to the most extent verified by the replies to the questionnaire.

Another interesting trend that has been verified in the technology submissions to the Study Mission addresses new business models for Internet TV services. In contrast to IPTV and broadcast TV, the end user generally does not have a specific agreement with the ISP or broadcaster to access video services, but the business relationship is with the over-the-top service provider. This service provider itself may generate revenue streams based on subscriptions or ad-support, possibly exploiting personalized advertising as known for example from Web2.0 technologies.

### 9.3 Market Situation and Evolution

Convergence of different TV service offerings is addressed in the Commercial Case Study. From a network service provider perspective, the opening of their existing IPTV platforms to support also Internet TV services may be attractive for additional business opportunities. Also the convergence of broadcast and Internet TV services to enhance regular TV service offerings with long-tail on-demand and content download ser-

vices provides new business opportunities for broadcasters and end device manufacturers. These deployment options have been addressed by several of the technologies within this Study Mission Report, such as MHEG-5 IC, GEM-IPTV or HbbTV.

The Commercial Case Study also identifies different players in the value chain, similar to value chain in clause 5.2 of the study mission report. The Commercial Case Study provides more details on Internet TV Content Provider, Internet TV Service Provider, Network Service Provider and the Broadband Consumer. Also identified are services in the context of Internet-TV. Whereas the considered services in the Study Mission Report (see clause 5.1.2) are mostly concerned with the distribution of AV multimedia data, the Commercial Case Study provides an overview of additional services such as programme guides, next generation teletext, interactivity components for linear TV, geo-location services as well as audience measurement. Such services are only briefly addressed in the Study Mission Report as they are less challenging in terms of content distribution. Therefore, on services the Commercial Case Study document provides interesting complementary aspects to the information in this Study Mission Report.

Internet TV services differ significantly from traditional TV and IPTV in terms of the model for the consumer, the publisher and for the infrastructure. The creation of a service end point is facilitated and therefore permits individual or smaller entities to publish and distribute TV-like content. The convergence with regular web services and experiences will drive the market adoption. Furthermore, Internet-TV uses a global reach business model, where video and television services that are offered in one area can also be accessed from other areas (as long as content distribution rights are in place). The challenges for successful Internet TV services are summarized in the Commercial Case Study as:

- 1) Enormous leverage that broadcast industry has over the distribution of video products;
- 2) Leverage (and control) in the physical infrastructure operated by large telecom providers;
- 3) Content holders issues. Intellectual property rights and clearance issues. Channel conflict issues for existing operators. Security concerns, piracy issues, DRM;
- 4) Technology barriers, evolution of technologies getting video content into living rooms and elsewhere.

The Study Mission Report has collected potential technologies to overcome these barriers and challenges, but some of the challenges remain and require standardized solutions.

The Commercial Case Study also addresses revenue and business models for Internet TV. The major potential is initially not considered in a competition with traditional TV and IPTV, i.e. the provision of a Linear TV services, but in Internet-TV platforms, which focus on non-linear content, supporting to bring large premium content libraries to end users. There will also be business for hybrid broadcast / Internet-TV platforms to combine broadcast with Catch-up TV and access to premium content catalogs. It is also identified that new forms of advertisement is enable by Internet TV services similar to web-based advertisement allowing banners, personalized ads, interactive ads and specific product placement. The Study Mission Report provides little information on these matters, as advertisement is mostly independent to content distribution. Therefore, for everyone interest on this subject, complementary reading of the Commercial Case Study document is recommended.

The Commercial Case Study has also identified that for successful deployment of the Internet TV services, any potential blocking points in the value chain need to be resolved. A key issue as identified is the expected increased traffic over backbones and access networks. Therefore, efficient content distribution is considered as one of the primary tasks to be resolved in Internet TV services and this Study Mission Report can provide answers on this subject.

## 9.4 Regulatory Issues

It was suggested and considered that the compliance to existing regulatory provisions is one of the high-level criteria that should be investigated during this Study Mission. However, no questions in the questionnaire had been included to address this subject as it had been considered as a non-technical issue. Furthermore, the details of such regulatory provisions would have required more detailed explanations that was considered cumbersome in the questionnaire. The Commercial Case Study provides exactly this information in a comprehensive manner. The following regulatory issues are discussed:

- 1) *Distinction between Scheduled versus On Demand content*. The Audiovisual Media Services Directive (AVMS Directive, for details refer to [http://ec.europa.eu/avpolicy/reg/avms/index\\_en.htm](http://ec.europa.eu/avpolicy/reg/avms/index_en.htm)), formerly called "Television without frontiers Directive", is based on the assumption that a clear distinction

can be made between non-linear services - Video on Demand (VoD) and linear services (scheduled programmes). The question whether the AVMS Directive applies to these AV services over Internet is important because the rules applied for linear services are somewhat tougher than those applied for non-linear services. For details, refer to the Commercial Case Study.

- 2) *Advertising rules*: In the AVMS Directive, no quantitative rules for advertising exist for non-linear services. However, all media audiovisual services (linear and non-linear) are subject to “qualitative” rules (on the protection of minors, on human dignity and on public health) and the rules on sponsorship and product placement.
- 3) *Must carry*: Must-carry rules seek to ensure that consumers have access to a range of radio and television channels and services as determined by their national or local government. Traditionally, public service channels have a guaranteed place on terrestrial, cable and satellite television platforms and within IPTV services offered by network service providers. However, must-carry rules are not an appropriate instrument with respect to “open” networks, the principle of net neutrality is more relevant.
- 4) *Net neutrality*: At its simplest network neutrality is the principle that all Internet traffic should be treated equally. Unfortunately, no clear conclusions are yet available on net neutrality. Net neutrality is currently under discussion in several regulation bodies and countries. The reader is encouraged to monitor the outcome of these discussions as it may have impact on Internet-TV business cases.
- 5) *Country-of-origin-of-initial-transmission*: If content is offered through the open Internet, the content may cross national borders. It is expected that decisive is the law in which the originator of the broadcast resides aligned to what is used for other media law and transport purposes.

In summary, for any regulatory issues the information in the Commercial Case Study provides excellent complementary information to the technical information collected in this Study Mission and anyone interested in this subject is referred to the commercial document.

## 9.5 Standardization

The Commercial Case Study also collected relevant information on standardization organizations that may work on topics related to Internet TV. The DVB activities in CM-IPTV and TM-IPI are summarized, namely:

- Content delivery over Internet (including P2P delivery);
- Identification and personalization;
- Content protection;
- Metadata & search;
- Flexible service composition.

The W3C started an activity called “video on the web” mid 2008 in 3 working groups: media annotations, media fragments and timed text. New audio and video APIs will be defined (x)HTML5 pending resolution of some sticking points mainly related to IPR issues.

The IETF has no explicit workgroup addressing “Internet-TV”, but audio and video transport is discussed in different working groups such as AVT, P2PSIP or ALTO. During the progress of the Study Mission, the work in IETF has progressed and this Study Mission Report contains more information on IETF P2PSIP as well as new work item on IETF PPSP. The Study Mission Report and the Commercial Case Study are complementary on IETF matters.

Information on ETSI activities in the area of Internet TV has been provided, with specific mentioning of the ETSI Media Content Distribution (MCD) group established in the beginning of 2009. Detailed scope and work plan are not yet available and even during the Study Mission no new information had been collected. DVB has informed ETSI MCD on the work with in the Internet TV Content Delivery Study Mission and ETSI MCD expressed significant interest in the outcome of this Study Mission.

The Commercial Case Study also includes overview information on the Open IPTV Forum (OIPF). However, the information on OIPF in this Study Mission Report is much more detailed based on the submitted questionnaire reply by the OIPF. Therefore, the interested reader is referred to this document for details on OIPF standardization efforts.

Additional initiatives mentioned in the Commercial Case Study are ISMA, ITU-T SG13, Open P4P, HbbTV and Canvas without providing any further details.

## 9.6 Summary

In summary the Commercial Case Study and the findings in this Study Mission Report are very well aligned. The documents can be viewed complementary on certain subjects and provides a comprehensive overview on technical and non-technical matters on Internet TV services. No obvious contradictions on the findings in these two documents have been observed. Nevertheless, in case of any inconsistent terminology or ambiguities between the two documents, the reader should understand that different groups with different objectives have compiled the documents.

## 10 Architectural Examples

### 10.1 Introduction and Scope

The realization of Internet TV services in the different considered technologies is based on different architectures. There may be different understandings and interpretations for the term “architecture” as has been observed from the questionnaire replies. Therefore, this clause attempts

- to collect different example architectures, in particular from the questionnaire replies and the considered technologies in [4], Annex B-D,
- to come to a common basis what could be understood as a relevant “architecture” within this study missions,
- to define and classify different example architectures,
- to investigate and extract common pieces in the architectures, to name and define architectural functions and components, and to generate converged architectures for different use cases,
- to identify relevant interfaces for a potential specification effort in DVB.

Architectures as provided in the technology submissions may be categorized in

- functional architecture: description of functional components and the interfaces between these functions to enable the service. Also referred to as logical architecture.
- physical architecture: description of the actual physical components and equipment that are used in the deployment of the service.
- Client architecture: a description of the functions, components and interfaces to the network that are integrated in the end device. The end device typically enables the service to the end user.
- Network architecture: a description of the functions, components and interfaces of the network that enables the service. May also be referred to a service architecture.
- Ecosystem and value chain: defines the business roles and interfaces between the different players to enable the service to the end user.

The technical study mission group agreed that for any potential technical specification work within DVB almost exclusively a functional logical client architecture is of relevance. However, for exploring use cases and examples during the study mission in particular functional network architectures are important as the submitted technologies differ significantly in the network architectures. To some extent also the physical architectures are of relevance for example to get an estimation on deployments costs. Ecosystem and value chain considerations are deferred to commercial discussions in DVB, but they are considered as relevant as the Internet TV services are quite often deployed not in a dedicated service environment, but in combination with multitude of other services on top of common platforms. A good overview on this subject has for example been provided by the NextShare reply (see Figure 2) showing how the NextShare platform operates in the context of the modern digital media ecosystem that exists today.



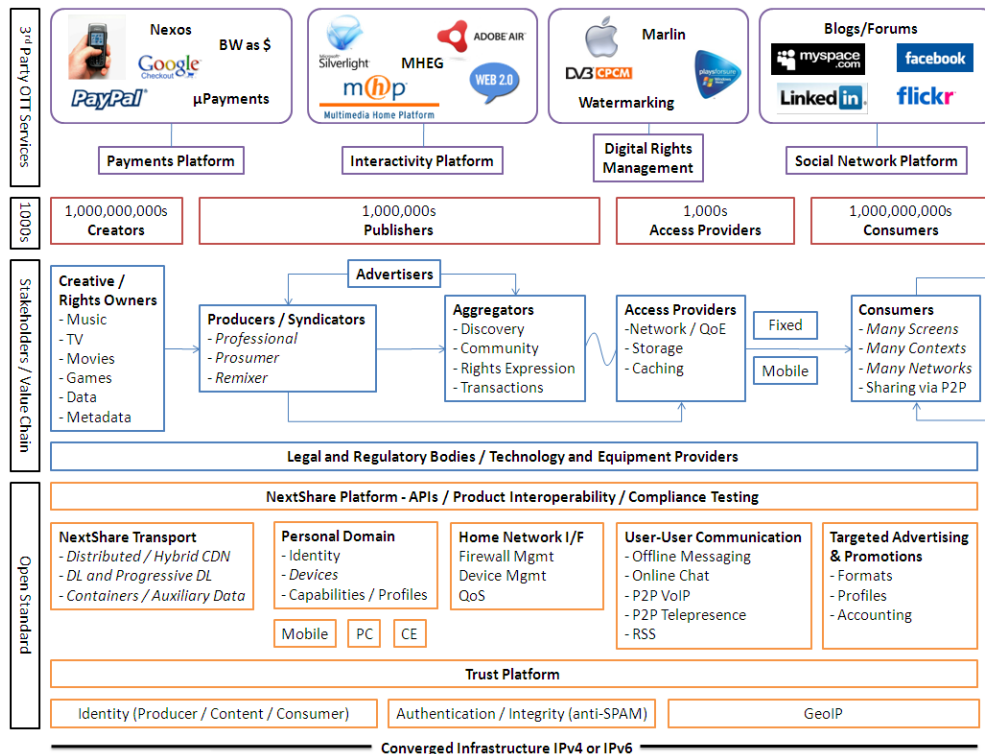


Figure 2 Example for an ecosystem including Internet TV content delivery provided by NextShare.

As already mentioned, in addition to functional components of particular interest within any technical specification work are the interfaces between the functional components as they ensure interoperability. Within this technical study mission it was agreed that only generic logical functional interfaces should be investigated. Specific protocols are not further discussed, but would obviously be the core part of a potential specification work.

The approach that has been taken to achieve the above objectives was to define a simple baseline architecture. Different members of the study mission group then checked if specific architectures as provided in the technology descriptions can be mapped to this baseline architecture and the baseline architecture was extended by missing functions and interfaces. By this iterative process refined architecture diagrams have generated. The results of this exercise is presented in the following. Clause 10.2 defines a baseline architecture for Internet TV services, and clause 10.3 deals specifically with scalable content delivery architectures and refines those for different use cases and deployment scenarios. In clause 10.4 the architecture of some selected technologies are reversely mapped onto this generic architectures to show the validity of our efforts.

## 10.2 Baseline Architecture

The discussions within the study mission group resulted in an agreement on the baseline architecture as shown in Figure 3. It is important that this architecture is only considered as an initial example to permit structured discussions in the context of Internet TV services. The architecture is organized as a matrix. In the horizontal dimension, the different services are considered. In the second dimension, for each end-to-end service that is considered in the context of Internet TV services, four different high-level functionalities are considered, namely

- Service Provisioning on the network side
- The delivery of the service
- The functions on the Internet TV End Device (ITVED) Functions
- The user interfaces that present the service to the user.

It is understood that especially the service provisioning on the network side may be significantly more complex, but for the purpose of the study mission efforts, the description is currently considered sufficient.

In terms of services, there is specific focus on services that associated with Content Delivery as this part has been considered the main mission of this technical study mission. Therefore the specifically considered services are:

- Internet TV Services such as Linear Media Broadcast, Content-on-Demand or Content Download, in particular the content delivery within this service as well as the control of the delivery session.
- Service Discovery and Service Announcement, i.e. how the service can be discovered.
- Content and Service Protection (CSP), i.e. any aspects that are related to content security.

However, in the technology submission in addition to the above services a significant amount of other services are integrated for a complete service offering. Among other, the following services may be considered:

- Remote Management Services
- Firmware Update Services
- Sign-on and Identity Services
- Reporting Services
- Audience Measurement Services
- Geo-location Service
- Service Provider Discovery Services

It is also important that not necessarily all services within a complete service offerings may be distributed over the open Internet, but may also be distributed through other means. We focus in the following on architectures for which at least one main service (LMB, CoD or CDS) is distributed over the open Internet.

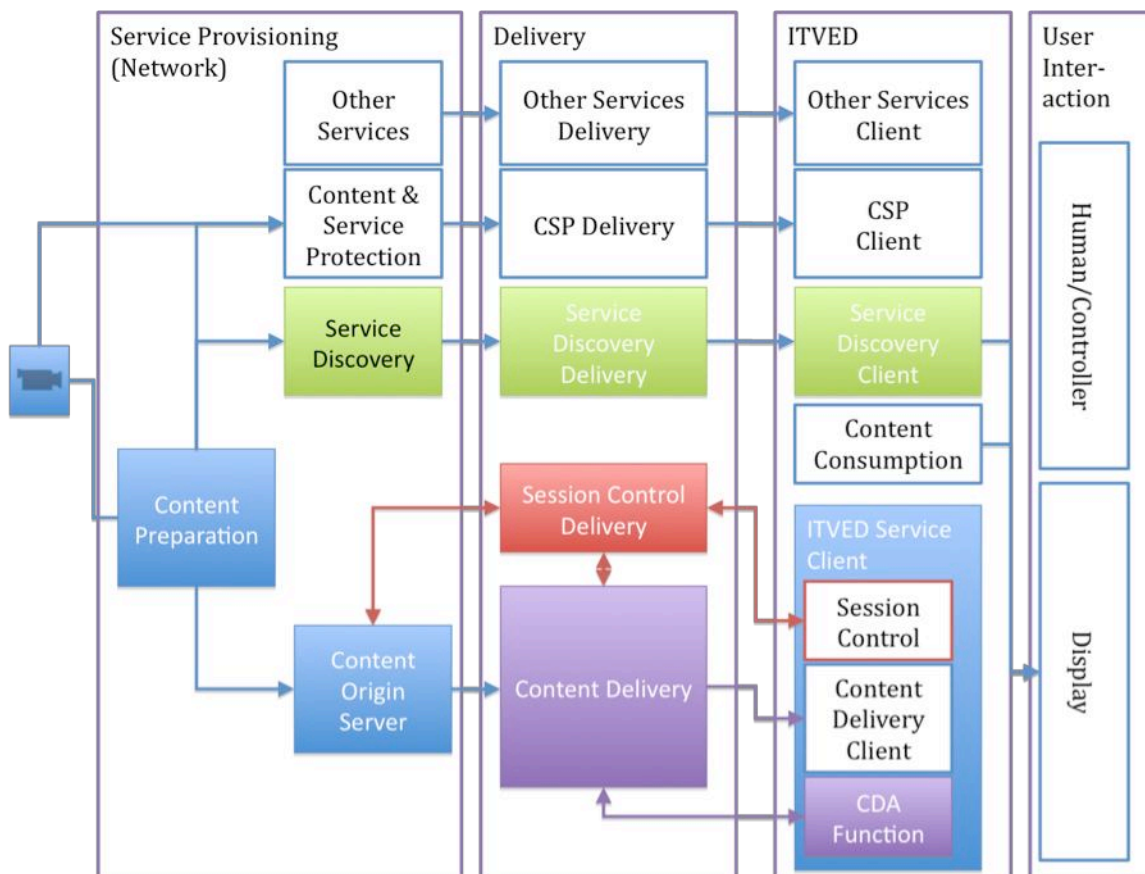


Figure 3 Example Baseline Architecture

In the following we provide a summary of the main relevant function as shown in the example baseline architecture as shown in Figure 3.

The Content Preparation function receives content from a “content” provider and makes it available as DVB content. It prepares the content for distribution over Internet. This content preparation function may for example include:

- encoding or transcoding of the media components
- encapsulating the content in a transport or container format
- provisioning of QoS support, e.g. encoding in multiple bitrates, multiple description coding, forward error correction of similar.
- Providing sufficient information to publish the content including the generation of the metadata and making it available to service discovery function.
- Forwarding the content to content origin server which makes the content available on the Open Internet.

The Content Origin Server mainly serves content to ITVEDs through the open Internet. It may for example perform the following functions:

- Serving content to ITVEDs through the open Internet
- Hosting content as provided from content preparation
- Providing session control for ITVEDs

The Service Discovery Function announces scheduled services and content items. In the context of DVB, the announcement is for DVB scheduled services and DVB content items. The function provides a unique reference to the delivery network and to the content within the delivery network, e.g. comparable to a DVB triplet. The Service Discovery Function may be realized in different manners, e.g.

- EPG-like information as for example provided by SD&S or BCG
- A web portal
- A messaging or announcement service
- Decentralized, for example within a P2P network using distributed keyword search implemented via epidemic protocols.

The Content and Service Protection (CSP) Function on the network side provides all functionalities to protect the content items and services. It also generally provides functions to the CSP client to access network resources and content.

The delivery of the services is part of the Delivery functions. These services may be delivered over the same network, over different networks, with different protocols and so on. For example in a Mixed broadcast Internet environment, service discovery information may be delivered over a classical broadcast network whereas the service itself is delivered through the open Internet.

Of the specific interest in the context of the study mission is the delivery of the content and possibly the session control. The Content Delivery function delivers the services or content items from the content origin server to the ITVED client in a scalable manner providing certain QoS despite the typical QoS features as known from managed IPTV services are not available. The QoS may be expressed in terms of minimum bitrates, service availability, latencies, etc. The Content Delivery function may be assisted by Content Delivery Assistance (CDA) functions for which the physical location may be in the Internet TV End Device. More details on the content delivery functions are provided in clause 10.3.

The Internet-TV End Device (ITVED) primarily discovers the content and services and makes them available to the end user through the User Interface. The ITVED includes several client functions for the different services, such as service discovery client, content and service protection client, etc. It also contains a content consumption client function responsible for playing out and rendering the service to the user. For each of main Internet TV services such as LMB, CDS or CoD, an individual service clients may be available in the ITVED client. The content in context of DVB activities will most likely be professional content, e.g. content generated by public or commercial broadcasters. User Generated Content (UGC) may not be excluded in such services as long as it can be discovered by and distributed to the ITVED following the rules as specified in a potential specification.

Specifically the ITVED Service Client enables the access to ITVED Services such as LMB, CoD and Content Download as well as flavours of those in different environments. The clients may be different for each service as the service requirements are generally quite different. It ensures that the different services can be

made available to the end user through the user interfaces. The ITVED Service Client controls the delivery of the content, executes the content delivery and may assist the network-side content delivery. For this purpose, the ITVED Client includes a session control function for the purpose of an end-to-end control of the delivery session. The content delivery client acquires the content from the network and makes it available to the content consumption. The ITVED Service Client may include a Content Delivery Assistance (CDA) function that is logically assigned to the content delivery on the network side. More concrete realizations of the different function are discussed in the following clauses 10.3 and 10.4.

## 10.3 Scalable Content Delivery Architectures

### 10.3.1 Introduction

The primary scope of the study mission is content delivery. TV Services over the Internet target the distribution of high-quality commercial content over the Internet to a large number of consumer end devices in an efficient fashion. This requires intelligent content delivery architectures that are able to ensure reliability and guarantee sufficient quality and cost efficiency. In the context of the Internet TV services, the delivery may be partly or entirely done through the Open Internet, but parts of the services may also be delivered over broadcast networks such as DVB-T/S/C or over managed IP networks as considered in DVB-IPTV. If delivered over the Open Internet, then some of the properties that are available in broadcast or multicast systems are also introduced into system architectures. However, the features are not support on physical and network layer, but only on top of IP unicast and very often on top of TCP or even HTTP/TCP. Therefore, such architectures are also once in a while referred to as overlay multicast or application-layer multicast as they try to emulate classical IP multicast on top of unicast networks. The major aspects in delivering video services are the construction of the overlay, the relation of the overlay to the session (how dynamic the overlay can be changed), the way how the data and the subsets of the data are discovered and how they are actually delivered.

This clause focuses on the function delivery and specifically the functions shown in Figure 4 are investigated more closely focusing on session control delivery and content delivery from the content origin server to the ITVED client. The relevant interfaces are any interfaces to and from the ITVED related to content delivery including session control interfaces, content delivery interfaces and CDA interfaces as those interfaces need to be implemented by the ITVED Service Client. Depending on the architecture type, the ITVED may or may not be involved in one or several of the delivery tasks as mentioned above. Different scalable content delivery architectures are briefly introduced and further refined within this clause.

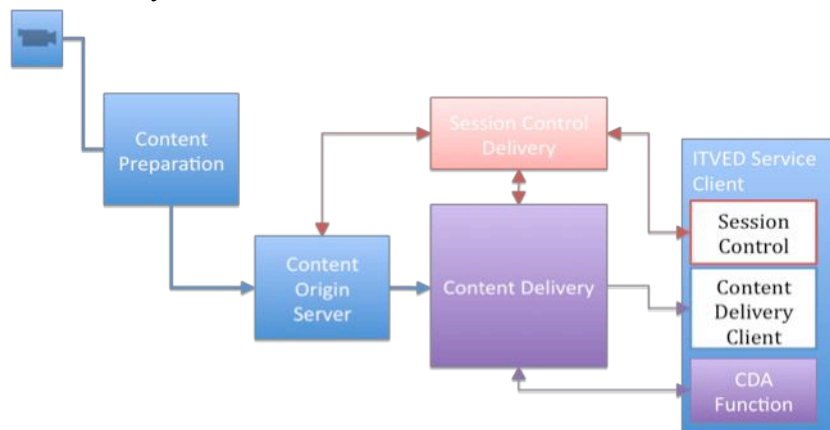


Figure 4 High-Level Content Delivery Architecture

### 10.3.2 Broadcast and Multicast Architectures

The delivery of content to many Consumer End Devices in classical DVB environments is primarily based on broadcast distribution technologies such as DVB-S/T/C as well the second generations of these systems. Broadcasting inherently includes scalability, especially in cases for which a single transmitter can serve a large amount of end-devices. In a similar manner, IP multicast transmission provides large scalability for scalable distribution of IPTV services. The availability of IP multicast and IGMP in routers enables a scalable and fast distribution over managed Internet systems. Service offerings for which parts of the services are

distributed over such a “walled-garden” managed environment are quite common nowadays. The major disadvantage of such architectures is the unavailability, or at least the low efficient support of tail programmes within LMB, Content-on-Demand Services and Content Download Services. However, several technologies such as MHEG-5 IC, DVB-IPTV CDS, GEM-IPTV or HBBTV already propose the combination of Broadcast or Multicast architectures with Internet TV services to provide Interactive TV services. Therefore, content delivery over such highly scalable architectures will remain important for distributing DVB-type content and may be augmented by Internet TV distribution.

### 10.3.3 Server-based Scalability – CDNs

Delivery of video services in the Open Internet is typically based on a client server model. The content is prepared and hosted on a content origin server. However, if a large number of ITVED Service Clients access the content concurrently, the server may get overloaded as its processing power as well as its egress bitrates typically support only a couple of hundred, or at most a couple of thousand concurrent users, depending on the type of server as well as on the bitrates of the content streams. Therefore, redundant servers are required to serve the same content. The servers are typically cache servers, i.e. they cache/replicate the original content. A possible architecture for Internet TV content delivery over Content Delivery Networks (CDNs) with cache servers is shown in Figure 5. CDNs provide cache server architectures that are able to provide high availability, these cache servers being usually placed at strategically optimized points in the networks. They may, for example, be placed deep within the ISP’s network or close to Points-of-Presence (PoPs) of large ISPs, such that access latency for the end user is minimized and their bitrates and availability is therefore maximized.

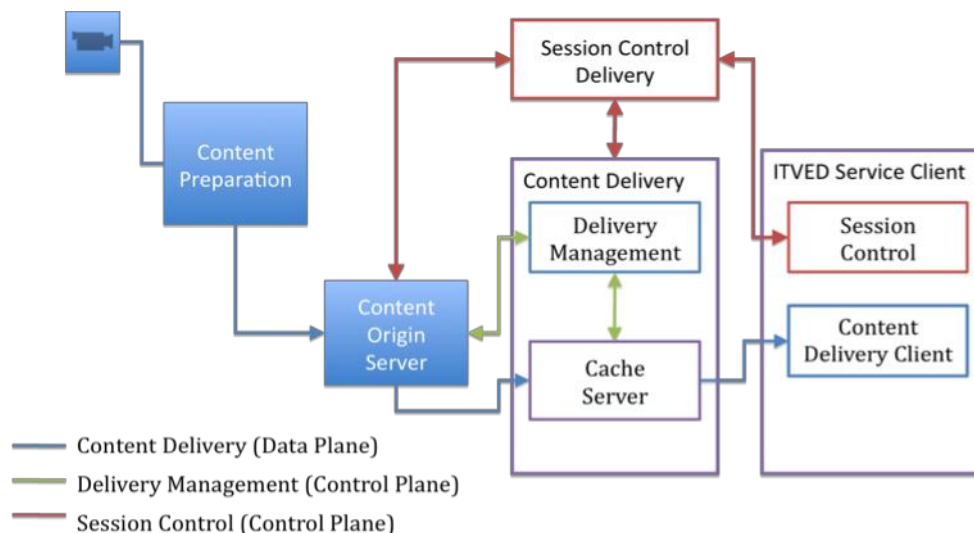


Figure 5 Example Architecture for CDN-based Content Delivery

When distributing Internet TV services over CDNs, the content delivery management assists the Content Origin Server in establishing and controlling the content delivery to ITVED in order to reduce bandwidth costs, improve QoE and/or increase availability of content. The delivery management in CDNs is heavily optimized. It may for example perform tasks such as global and local server-load balancing, request routing information based on DNS, or take into account location awareness. In the context of Internet TV Content delivery, Cache Servers can be viewed as an infrastructure component that shares DVB services and content with ITVED and other caches to provide advanced QoS parameters such as availability, high access bitrates and so on. The ITVED does generally not have an interface to the CDN, but it virtually connects to the content origin server and the ITVED is rerouted to the cache servers. The cache servers itself may be specifically deployed for the TV-service or they may be generic web caches, generally based on caching content delivered over HTTP. The latter case is attractive as many CDN infrastructures are already deployed for HTTP-based delivery of web content. The reuse of this infrastructure for Internet TV services offers an attractive and quick deployment option, and is used by several of the submitted technologies, e.g. Apple-HTTP and IIS-SS. Dedicated infrastructure components may offer further enhancements, especially for streaming and live services, since the delivery of files over HTTP may result in significant latencies.

For Internet TV Services offered over a CDN-based architecture, the interfaces of interest for a potential specification work in DVB should concentrate on Session Control and Content Delivery. The overlay architecture for scalable delivery is setup and managed transparently to the end device. Therefore, the content delivery interface is mostly concerned with accessing and acquiring the content from a content origin server. This interface takes into account that a scalable deployment on existing CDNs is enabled.

In a variant of client-server based delivery the ITVED client may contain some service-assistance, or content-delivery assistance function that supports either the service or the content delivery in providing the Internet TV service. Typically, in content download services, the service operator gets assigned some resources on the ITVED to offer for example PushCoD services, i.e. content is pre-emptively delivered to the ITVED Client based on the decision of the service provider and without user interaction. This can be also viewed as the content delivery assists a CoD service provider in delivering its CoD service more efficiently by pre-emptively downloading popular content. Therefore, the content delivery allocates a CDA function in the ITVED Service Client as shown in Figure 6. The management of the CDA function is assigned to the Content Delivery Management and may include allocation of memory, uploading or removing of content items, etc. In multiple-service provider deployment scenario, the CDA may have to be shared among different service providers. The relevant interfaces in this architecture case are the same as in Figure 5 and in addition a management interface to control the CDA function in the ITVED is added.

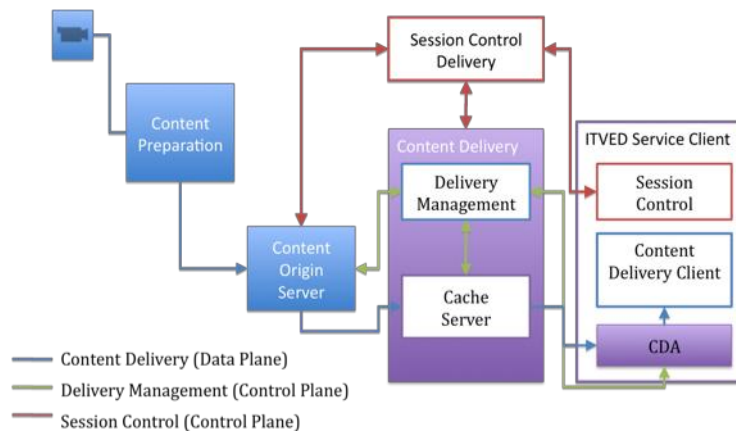


Figure 6 Client-Server based delivery with CDA-function

### 10.3.4 Peer-to-Peer-based Scalability

An alternative way to approach the problem of scalable distribution and making content and services available to many users is the use of Peer-to-Peer (P2P) distribution. In this case ITVEDs support the Content Delivery by dedicating resources to the Content Delivery, resources that can be used to serve other ITVED clients. Figure 7 shows a simplified example of an architecture used for P2P-based content delivery, and a so-called Content Delivery Assistance (CDA) -Function is introduced. In this figure the CDA-Function is present in the ITVED as well as in the Content Delivery function. The first one express more the physical location, whereas the second the logical assignment. The CDA function is considered to be logically assigned to Content Delivery, but if the ITVED contains a CDA-function then it is generally referred to as *peer*. Depending on the service to be supported the CDA function does relay, cache or store data. The ITVED CDA-Function communicates with the Delivery Management Function about the way it is integrated in the overall content delivery network, e.g. what resources it can share, how it is integrated in the overlay multicast, and what content it can serve.



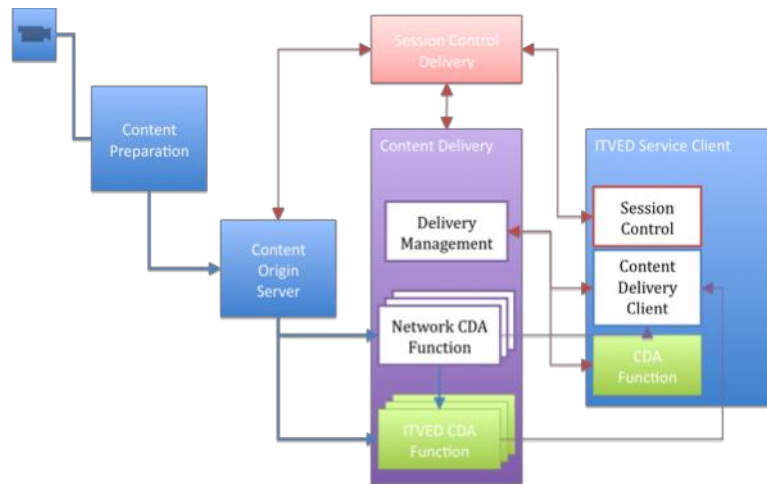


Figure 7 Example architecture for P2P-delivery

In most P2P-based technologies, as they were provided for this Study Mission report, in addition to CDA functions on the ITVED also the network infrastructure provides super-peers to support the content delivery. Such Network CDA functions do generally have same functionality as ITVED CDA, but they are highly powered and highly resourced. They may have for example additional cache and storage functionalities, very high ingress and egress bitrates, etc. Furthermore such network CDA functions may provide initial access to content or maximize the availability of content (generally referred to as seeders). Other functionalities include the provisioning of low-latency access to content (e.g. similar to fast-channel change servers). Network-CDA, as heavily under control of the service provider, may also be used to pre-emptively acquire content from the origin server for higher availability, etc. Super-peers generally have similar tasks as cache servers in CDNs.

An important component in P2P-based delivery is the delivery management information assisting both the ITVED client and the CDAs to establish and control the content delivery from the content origin server to the ITVEDs. The delivery management function may also include functionalities such as Tracker Servers, Peer-list server, information about content and chunks available on CDAs, act as a resource management function (e.g. for bitrates, storage, cache space, or CPU) as well as building the overlay network required to distribute the content.

From a logical and interface point-of-view, there is no difference between network-CDAs and ITVED-CDAs. Therefore, Figure 8 simplifies the presentation and reduces the functional blocks to CDAs. The focus is on interfaces, especially the ones relevant from the network to the ITVED: For P2P-based delivery in addition to the content delivery interfaces from the CDAs to the Content Delivery client (which may be very similar to the interfaces from cache servers to the Content Delivery in the CDN-based delivery) the ITVED Service client also requires interfaces to the content delivery management. Obviously also the serving interface functionality from CDA to other CDAs requires to be added in case of P2P-based delivery.

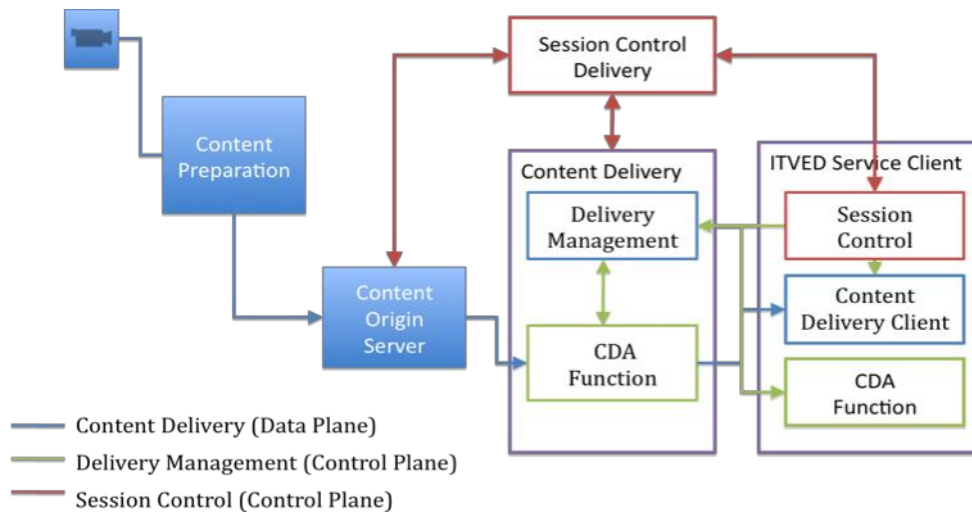


Figure 8 Example for P2P-based delivery with Interface Definitions

The delivery management in P2P networks may be centralized, typically in within a tracker, or it may be completely decentralized, i.e. the management functions are hosted on ITVEDs. Figure 9 shows an example for a centrally managed tracker-based P2P-based delivery. In this case, the ITVEDs CDA function allocates resources for the content delivery, it reports its available content maps or programs to the tracker. The tracker manages the connection and the overlays, and the Content Delivery client needs to connect to the appropriate resources from where the service or content can be acquired. This is assigned to the P2P Delivery Management function.

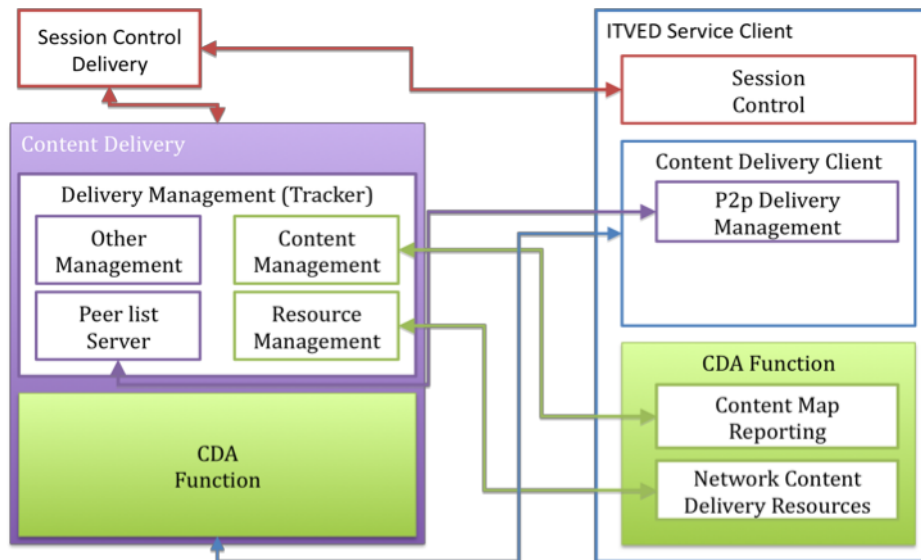


Figure 9 Example for centrally managed tracker-based P2P-based delivery

The tracker may host among others

- a peer-list server that provides a list of available peers to ITVED
- content management servers that maintains chunk maps of content on different CDA functions
- resource management function that allocates and manages resources on ITVED clients to enable delivery. Typically resources to be managed are storage, cache, CPU, bandwidth, on-time.
- Other Network Management function such as NAT, load balancing, location awareness, traffic management or congestion control. Such functions are typically very similar to CDN-based delivery management functions.

The relevant interfaces in this case are the

- Content Delivery from CDA to ITVED Client



- Content Management – Content Map Reporting for the purpose of buffer map exchanges
- Peer-List Server – P2P Delivery Management: for the purpose of providing the resources from where to acquire the content and services.
- Resource Management – CDA Function: for the purpose of allocating and managing resources on the ITVED. This aspect is of particular relevance if multiple service providers access the same ITVEDs.

As already mentioned, in certain P2P-based delivery environments, not only the content delivery is distributed, but also the management. Despite the fact that such architectures were initially developed mostly for illegally distributing content, these architectures might have additional advantages over classical P2P-based delivery. In this case, additional management functions such as the peer-list management and the content management are moved to the CDA functions as well. Additional interfaces are required for the purpose of decentralized peer-list management, usually referred to as gossiping.

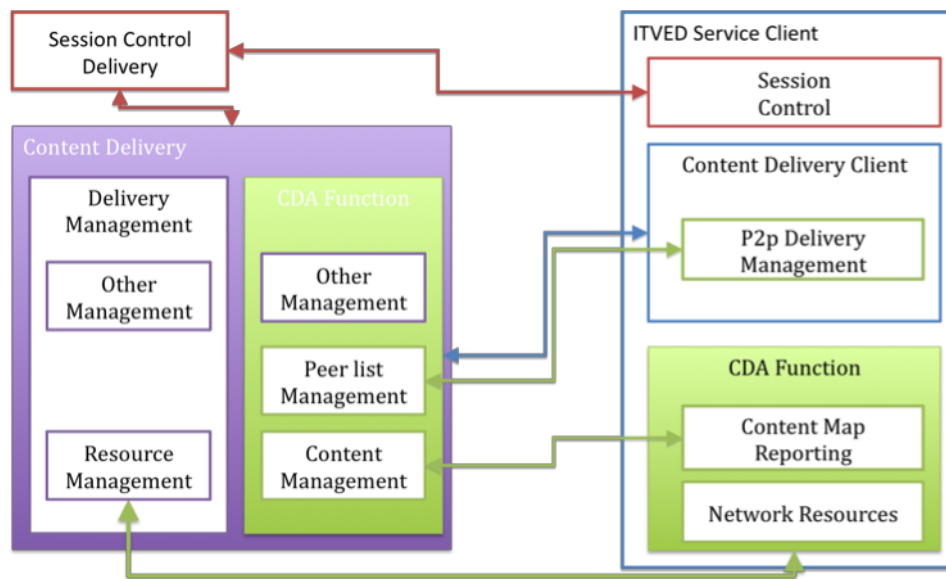


Figure 10 Example for decentralized P2P-based delivery

The architecture diagrams in this clause do not include details on QoS measurements and QoE reception reporting. These functions are relevant in Internet TV Services as the QoS support is limited and therefore, the quality of the service needs to be constantly monitored. However, Internet TV Services also provide the possibility, through their bi-directional setup, to constantly measure and monitor the service quality and send regular and frequent feedback. Reporting may happen on many different levels and time-scales. Some aspects have been discussed in clause 8.4.7. Reporting may occur on different levels, e.g. on service level, network level, event level, automated instrumentation, or user-driven feedback.

### 10.3.5 Hybrid CDN/P2P Delivery Architectures

Combining the above two content distribution approaches might also prove to be a possible option for content distributors, since a hybrid CDN/P2P-based may be able to exploit the benefits of each of the two distinct approaches.

One approach mentioned previously may involve an ITVSP relying on pure P2P content distribution and, in order to maximize its contents availability, to deploy additional network infrastructure, e.g. super-peers. Such super-peers still host CDA functions, but may be deployed within a CDN network in order to enable the fast transfer of data among them. In this case CDN-based scalability is provided among a small numbers of peers acting as super-peers, and the classical P2P content distribution scheme among the remaining peers.

An alternative straightforward approach use CDNs and P2P-based delivery in parallel, i.e. initially content is seeded through standard CDN-based distribution, and later, as the content becomes more and more widespread the content is distributed over P2P networks. As the content become more popular, the burden on the Origin Servers or on the CDN is actually reduced since the ITVEDs are able to obtain large portions of the content from other peers.

From the architectures presented in Figure 5 and Figure 7, it is observed that a hybrid CDN/P2P approach can be realized without any changes to the overall content distribution architecture. The Content Delivery Client may be served from cache servers from the CDN network and at the same time the content may be obtained from other ITVED CDA functions within to the P2P network. Such a flexible network architecture may be introduced progressively, initially deploying a CDN based approach, and later, in order to reduce the load of their CDN network adding CDA-Functions in ITVEDs. The introduction of CDA function may allow different business models for ITVCD service providers and ITVED manufacturers. This hybrid approach defines no new interfaces or components as the ones defined in Figure Figure 5 and Figure 7. A hybrid CDN/P2P example architecture is shown in Figure 11.

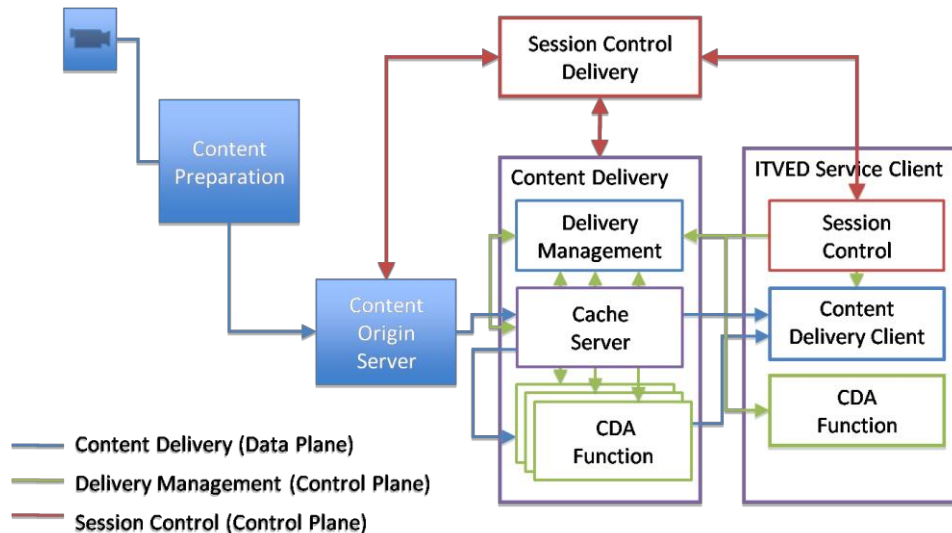


Figure 11 A Hybrid CDN/P2P based delivery architecture

## 10.4 Refined Example Architectures

### 10.4.1 Introduction

To verify the architectural examples as introduced in clause 10.2 and 10.3, this clause provides a mapping of architectures from submitted technologies to these example architectures. Only a selected set of technologies are presented, based on a best-effort basis during the Study Mission.

### 10.4.2 Example 1: Open IPTV Forum

The architecture included in the OIPF reply, and available in [4], Annex B.2 represents a client architecture (see Figure 12). Functions in the client, referred to as OITF, are:

- A browser module (based on CEA-2014) used for deploying applications and for service and content discovery.
- A metadata client (using DVB SD&S and BCG) receiving metadata for service and content discovery.
- A streaming client (using RTP, RTSP and HTTP) designed for receiving streamed content
- A content download client (using HTTP) receiving content for local storage from a “Content Delivery Function”
- A content and service protection function
- A content and service protection gateways (CSP-G)
- An application execution environment (based on GEM-IPTV)

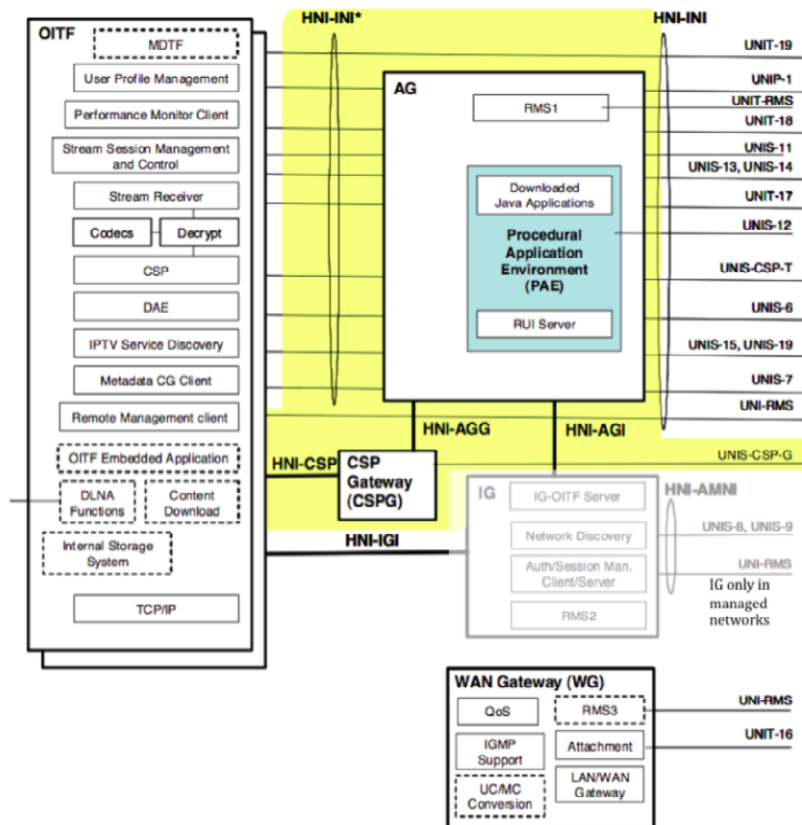


Figure 12 Open IPTV Architecture

Corresponding functions are available on network side, but not explicitly depicted in the architecture diagram.

The architecture maps well to the generic architecture presented in Figure 3 and to the CDN-based content delivery architecture according to Figure 5. According to the included diagram the OIPF architecture supports the following services:

- Content and Service Protection
- Service Discovery
- Streaming CoD
- Download

The delivery of the services may be done either entirely over the Open Internet, or have parts of the services delivered over managed networks.

Service Discovery is mapped on service and content discovery using browsers (based on CEA-2014) or metadata client (using DVB SD&S and BCG). The Content Origin Server is realized by a Streaming Server using either RTP/RTSP or HTTP interfaces or a Download Server using HTTP as delivery protocol. Scalable content delivery is not defined in detail but it is mentioned that a CDN-based delivery can be used for this purpose. The ITVED Client contains a Streaming Client (with RTP/RTSP and HTTP protocol support) and a Download Client (with HTTP support).

Worthwhile to mention that the GEM-IPTV, MHEG-5 IC, ZDF Mediathek and HBBTV architectures are similar to the Open IPTV forum, namely they all rely on CDN-based delivery as presented in clause 10.3.3.

### 10.4.3 Example 2: DVB-IPTV CDS

The architecture presented in the DVB-IPTV CDS reply in [4], Annex B.20 represents a simplified logical service and delivery architecture focusing on the interfaces to the client (see Figure 13). The functions in DVB-IPTV CDS architecture are:

- Content Storage

- CDS Management
- Delivery Function
  - Multicast Delivery (+ File Repair, Completion Polling)
  - Unicast Delivery (+ Redirection Management)
  - Reception Reporting
- CDS Service Announcement
- Storage Management Function

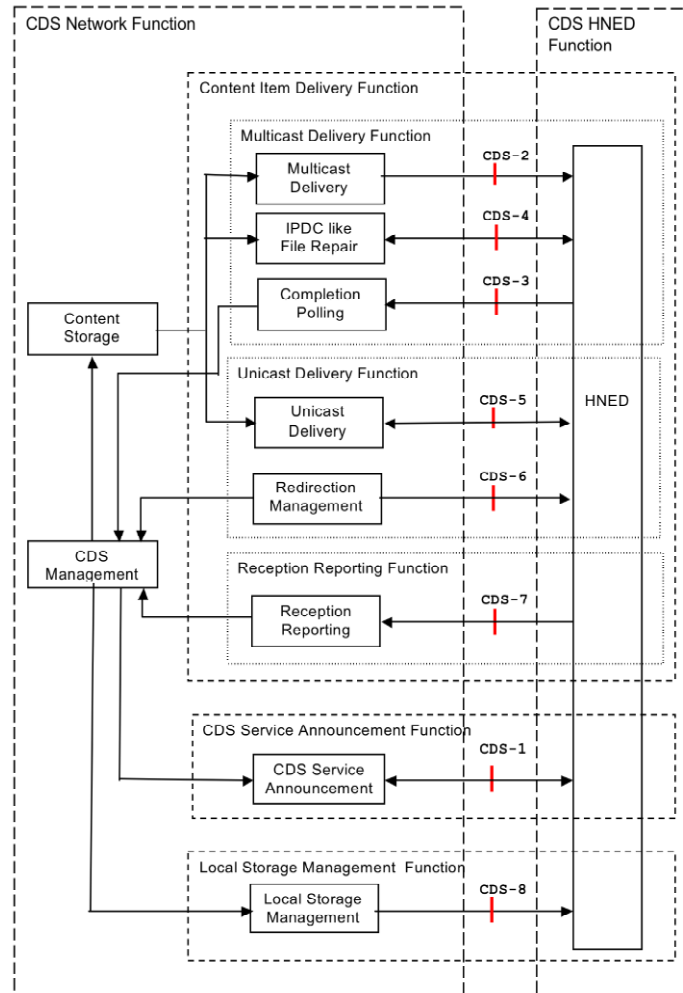


Figure 13 DVB-IPTV CDS Architecture

The architecture maps well to the generic architecture presented in Figure 3 and to the client-server architecture with CDA functionality presented in Figure 6. According to the diagram the DVB-IPTV CDS architecture supports the following services:

- Service Discovery
- Content Download Services

As before, the delivery of the services may be done either over http-based Open Internet, or have parts of the services delivered also managed networks using multicast. The Service Discovery Function is realized by the CDS Service Announcement relying on SD&S and BCG. The Unicast Server maps to the Content Origin Server and the ITVED Service Client maps the CDS HNED Function. Additional Content Delivery Management Functions are mapped as Storage Management and Reception reporting.

#### 10.4.4 Example 3: Microsoft IIS Smooth Streaming

The architecture presented in the reply Microsoft IIS Smooth Streaming in [4], Annex B.21 represents a Delivery Platform based on an HTTP-CDN (see Figure 14). The architecture maps well to the generic architec-

ture presented in Figure 3 and the CDN-based content delivery architecture according to Figure 5. Services supported by the IIS Smooth Streaming architecture are

- content delivery for LMB,
- content delivery for CoD and
- content delivery for Content Download services.

The relevant functions that are adequately addressed in the Microsoft IIS Smooth Streaming architecture are:

- Content Preparation,
- Content Origin Servers,
- Content Delivery
- ITVED clients.

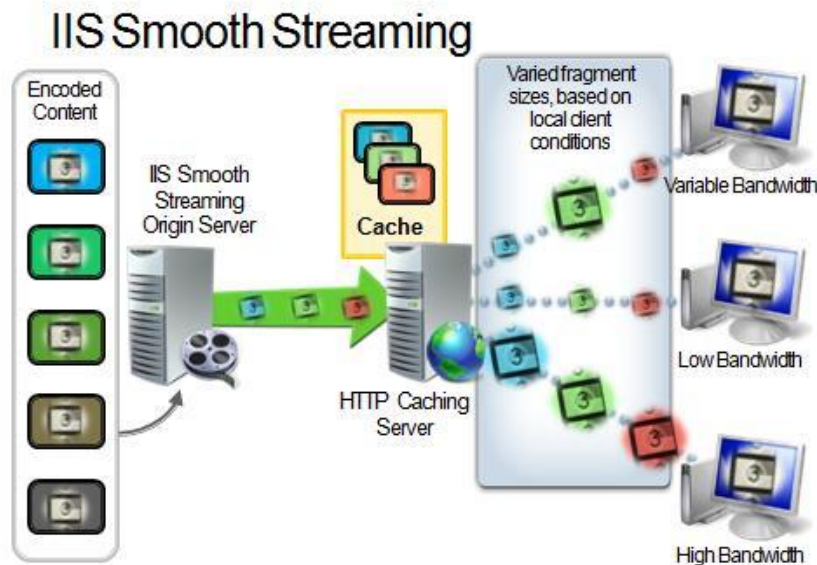


Figure 14 Microsoft IIS-Smooth Streaming Architecture

#### 10.4.5 Example 4: BitTorrent

The architecture presented in the reply BitTorrent in [4], Annex B.4 represents a centrally managed P2P-based delivery platform (see Figure 15). The architecture provides content delivery services as well as some auxiliary measurement and analytic functions. The other services and functions presented in Figure 15 are examples only. The architecture of BitTorrent maps well to the generic architecture presented in Figure 3 as well as the centrally managed P2P architecture in Figure 9. The delivery in case of BitTorrent is exclusively over the Open Internet. Content Discovery may for example be done by a web browser. The ITVED Client may also contain a browser, a player functionality and importantly a content delivery assistance (CDA) function referred to in this case as DNA downloader.

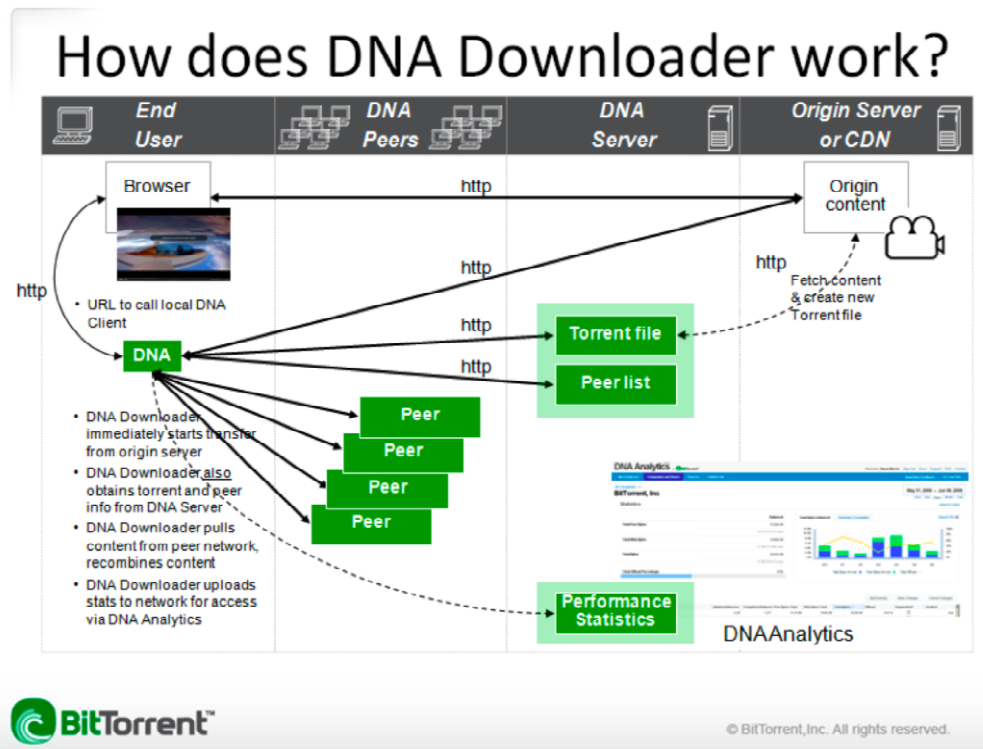


Figure 15 BitTorrent DNA Architecture

The DNA downloader fulfills P2P delivery and management functions: It connects to the server, discovers the P2P resources, combines the downloaded content in the client and provides statistical and network awareness data. The centralized content delivery management, referred to as DNA Server, provides different functionalities, such as torrent servers (for the purpose of discovering resources), torrent generators for content ingest, trackers and statistics repository and analytics servers. Since in BitTorrent DNA, the content is initially acquired from a content origin server or a CDN-based server and later enhanced with content delivered over a P2P delivery network, the architecture maps well to a typical hybrid CDN/P2P deployment as shown in Figure 11.

### 10.4.6 Example 5: Samsung P2P-TV

The architecture presented in the Samsung P2P-TV reply in [4], Annex B.9 represents a centrally managed P2P-based service and delivery platform (see Figure 16). The architecture presentation in Figure 16 represents mainly a logical network architecture, embedding some physical components for facilitating the understanding of the later deployment. The architecture supports different services such as service discovery as well as CoD and LMB services. Service discovery is achieved by a web portal, origin servers map on source servers and the track server maps on a centralized P2P-delivery management. The ITVED module contains CDA-functions to support the content delivery.



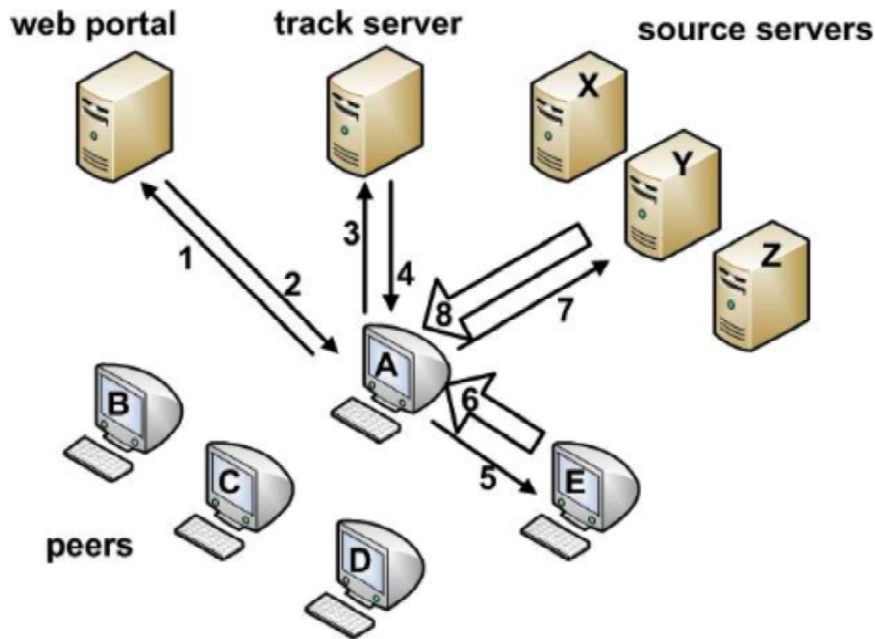


Figure 16 Samsung P2P-TV Architecture

### 10.4.7 Example 6: NextShare

The architecture presented in the reply NextShare in [4], Annex B.15 represents a de-centrally managed P2P-based delivery platform. NextShare is flexibly enough to also provide the central management, but the architecture strongly emphasizes on decentralized management. NextShare provides content delivery services for LMB, CoD and Content Download Services. Other services such as service discovery, etc are only example functions and may be realized in different manners.

The architecture of NextShare maps well on the generic service architecture in Figure 3 and the P2P-based delivery architecture in Figure 10. Content Origin Servers may permit a progressive download of VoD file using torrent-files. In LMB services, the content origin server is realized by a live ingest from any source via standard interface like HTTP or UDP stream location (referred to as tstream). For service discovery functions no specific restrictions are present, the service is discovered by accessing a torrent or tstream URL. NextShare clients contain a CDA function in order to support P2P-delivery and to create an overlay network. NextShare also permits the use of network CDA functions by the use of super-peers. Since NextShare makes no functional difference between the network-based CDA-functions and client-based CDA-function, it is obvious that super-peers are generally just high powered and highly resourced peers. Super-peers are high powered and highly resourced peers. The content origin servers referred to as ingest peer in NextShare, can report pieces proactively to super-peers in order to help seed the overlay, and so ensure that they remain unchoked.