(IPTV) INTERNET PROTOCOL TELEVISION'S KEY BROADCAST BUILDING BLOCKS

Muhammad Asif[1], Zahid Farid[2], Muhammad Lal[3], Junaid Qayyum[4] and Fayyaz Gul[5]

**[1]Department of Information Technology and Media (ITM), Mid Sweden University
Sundsvall 85170, Sweden.**

**[2]School of Electrical and Electronics Engineering, Universiti Sains Malaysia (USM)
Penang 14300, Malaysia.**

**[3, 4, 5]Department of Information Technology, Gandhara University of Sciences
Peshawar 25000, Pakistan.**

Abstract

Telcos, in pursuit of the triple play (voice, video, and data), are investing heavily to compete with the cable companies in providing quality video content to the consumer. However, most telco infrastructures do not currently have the bandwidth to support high-quality video distribution. The telcos are updating their Internet protocol (IP) networks and using new encoding schemes such as MPEG4-Part 10 (also called H.264-AVC) to deliver video content to the consumer. This creates a huge opportunity for supplying telcos with updated equipment including the latest encoders and decoders. This paper will investigate the technology that is fueling this new Internet protocol television (IPTV) infrastructure. The first portion will be looking at the video encoding method and the second portion will focus on the video-over-IP network design that is being used for IPTV.

Keywords Telco, Internet Protocol (IP), MPEG4-Part 10, H.264-AVC, Internet Protocol Television (IPTV), Encoder, Decoder.

1. Introduction

The telcos are on the offensive to gain a big piece of the video market share from the cable TV providers. Cable multiple service operators (MSOs) have made great progress in delivering a "triple play" of voice, video, and data services to the consumer in the last few years. Now the telcos are responding in a big way to provide the same triple play by offering not only voice and data, but also high-quality digital TV video via a new technology called IPTV. IPTV is an emerging technology that allows consumers to watch high-quality digital TV over the Internet via an IPTV set-top box or a PC. The traditional cable companies use a RF signal to carry the digital video by means of QAM. Technology advancements have made it possible for telcos to bring the same quality of video via the Internet. The key building blocks on the transmission side are advanced video encoding and video over IP. Advanced video encoding is the most critical building block. The availability of high-definition (HD) content along with standard definition (SD) content have created a challenge for the telcos, since telcos still rely on bandwidth-limited twisted copper pair of wires and usually do not have the luxury of cable's broadband capability. A typical HD channel requires 20 Mbps and a SD channel requires 4 Mbps. Therefore, a bandwidth-efficient video transport mechanism is needed. The H.264 format of MPEG4 Part 10 and Microsoft's VC-1 encoder can offer 2.5 to 3 times more bandwidth-efficient improvement over the popular MPEG2 encoding. Most broadcasters are adapting the H.264 standard rather than the VC-1 standard. The other building block of IPTV transmission is video over IP, which maps or bridges the encoded video data onto the Internet for delivery.

2. Building Blocks for IPTV and Broadcasting

2.1 Broadband and Telephone Networks

IPTV is gathering momentum. One main driver is the technical developments taking place in telephone networks. That can be illustrated by the sharply increasing downstream data rates becoming available on twisted-pair copper lines *(see Fig. 1)*. In the past, with an analogue modem or narrow-band ISDN connection, the last mile to the home was the bottleneck for high bandwidth applications. DSL (Digital Subscriber Line) technology has provided the breakthrough for broadband telephone networks in recent years. With ADSL, and its variants ADSL2 and ADSL2+, downstream data rates of several Mbit/s are now common in many households. In the future, with VDSL, the data rates will extend well into the two-digit Mbit/s range.

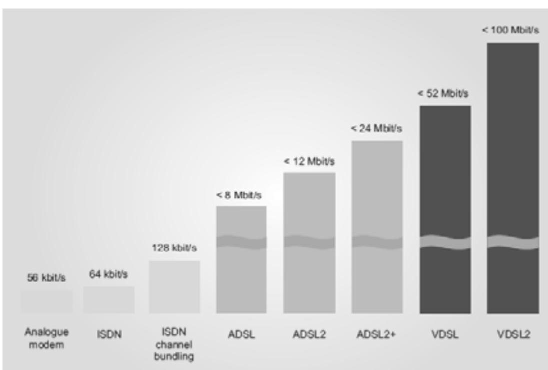

Figure 1: Downstream data rates on twisted-pair copper lines

DSL technology is based on sophisticated multi-carrier modulation schemes for physical transmission. The nature of the traffic at the consumer end suggests an asymmetric split with a broadband downstream data rate into the home and a relatively narrow-band upstream data rate from the home to the DSL provider. The multi-carrier approach of discrete multi-tone (DMT) splits the frequency band in a number of subchannels, each addressed by a carrier frequency. For example, 256 subchannels can be used in ***ADSL*** [2]. Physically, ADSL uses frequencies up to 1.1 MHz on a twisted-pair copper line. The length and the diameter of the twisted-pair copper line determine the attenuation of the ADSL signal. Line-noise and crosstalk between lines can significantly impair the signal-to-noise ratio. Under ideal conditions, the maximum downstream data rate is in the region of 8 Mbit/s and the upstream data rate is up to 1 Mbit/s. However, if the length of the line approaches the limit of about four to five kilometers, for example in rural areas, the downstream data rate may be just 1-2 Mbit/s or even lower. **ADSL2** [3] extends the maximum downstream data rate to about 12 Mbit/s. **ADSL2+** [4] doubles the upper frequency limit from 1.1 to 2.2 MHz. The maximum downstream data rate is in the region of 24 Mbit/s. **VDSL1** [5] uses frequencies up to 12 MHz on a twisted-pair copper line and **VDSL2** [6] up to 30 MHz. The resulting downstream data rates are in the region of 52 and 100 Mbit/s, respectively. However, in order to achieve the maximum data rates, the length of the line has to be reduced from several kilometers down to about 150 - 300 meters. Additionally, in order to maintain the very high data rates to and from the provider backbone, typically a ***fiber optic network*** is needed up to the point where the last mile starts with VDSL transmission. Thus, VDSL requires a major investment. The focus will be on selected urban areas to reach as many households as possible for a given capital investment and operational expenditure. At present it is not clear how fast the telephone companies are going to upgrade their networks to accommodate VDSL and for how long they will stick with ADSL and the variants thereof, for the vast majority of households.

2.2. Advanced Source Coding for Data Compression

Advanced source coding for data compression enables full-quality television on DSL networks. The transition from the ISO-MPEG-2 standard to MPEG-4 Advanced Video Coding (AVC) [7] reduces the data rates required for the picture signal. Using MPEG-4 AVC, the data rates required for high quality television in standard definition (SDTV) are in the region of 2 to 4 Mbit/s depending on the source signal. The data rates of MPEG-4 AVC streams are thus quite commensurate with the data rates available over ADSL. VDSL lends itself even to HDTV. Source coding is not performed using only the MPEG open standards. On the Web, proprietary codecs that are integrated in downloadable software players are also used. In the case of

IPTV, there is notably Microsoft IPTV edition as a platform with integrated data compression, based on Windows Media 9 / VC-1.

2.3. IPTV and Physical Transmission

Technically, IPTV is not a well-defined term. In a layered communication model, the Internet Protocol (IP) resides at the network layer and television (TV) at the application layer. Nothing is said about the physical transmission. Three simplified examples are shown in *Fig. 2*. After source coding, the compressed video bit-stream is packetized at the network layer with the Internet Protocol. The resulting IPTV packets are then physically transmitted with a transmission scheme that provides a guaranteed quality of service for digital television – in terms of bandwidth, error rate and delay. For example, as shown on the left in *Fig. 2*, DSL is used for physical transmission over twisted-pair copper lines. In the home, the DSL modem contains a so-called Integrated Access Device (IAD) which is connected to an IPTV set-top-box, using a cat-5 (Ethernet) cable. Alternatively, a wireless LAN (WLAN) can be used for connecting the IPTV set-top-box to the IAD.

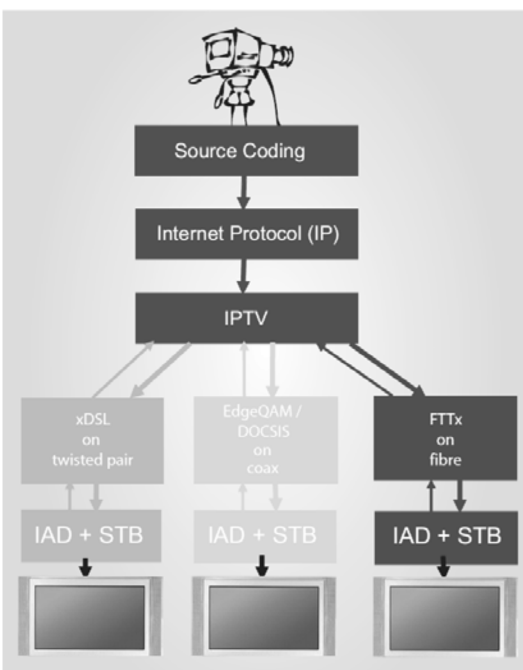

Figure 2: IPTV and physical transmission

IPTV is not bound to telephone networks and can be physically transmitted on broadband cable networks as well. One needs a transmission scheme which matches the physical properties of coax cable, e.g. EdgeQAM/ Docsis [8]. A similar reasoning applies to IPTV transmission on fiber-optic networks, e.g. fibreto- the-curb (FTTC) or fiber-tothe-home (FTTH). Actually, VDSL networks are typically a combination of FTTC to get to the point where the last mile starts and, from there, VDSL over twisted-pair copper lines to the home. For example, Deutsche Telekom is planning a fiber-optic network in Ten German Cities which, in combination with VDSL2, aims to provide downstream data rates of 25 Mbit/s over the last mile. At a national and European regulatory level, there is much debate about whether competitors of Deutsche Telekom should also have bit-stream access to this new network. Why is there IP? It is because IP fits in well with the existing infrastructure of the telecom-munications industry. IP is a bidirectional protocol with source and destination addresses in the IP header. One can address packets using **IP unicast** to a single household for video or television ondemand and, for greater efficiency, use seamless switching to **IP multicast** [9] for addressing packets to a group when live broadcasts attract a large audience. It is not strictly a "must" but typically, as shown in *Fig. 2*, an IPTV system comprises at least a narrow-band return channel to complement the broadband forward channel. Within this asymmetric structure, usually a client server architecture is implemented for IPTV. In that respect, IPTV is interactive from the very start which makes an important difference when compared with one-way digital television such as DTT.

2.4. WEBTV and IPTV

IPTV, as outlined in this article, should not be confused with WebTV. While WebTV is also based on IP and compressed TV signals, it provides for live video streaming or video-on-demand over the worldwide web. Downloadable software players for a PC or Laptop are common. The quality of
service relies on the "best effort" principle. The IP unicast traffic of WebTV can lead to significant distribution costs for the broadcaster, depending on the number of users. In contrast, IPTV is implemented in fully-managed networks similar to broadband cable networks. The quality of service is
guaranteed. The IPTV technology is under the control of the provider. Specific provider-defined

settop boxes were common in the early days of IPTV, but open standards should be a requirement and are being developed by DVB. For retransmission of live broadcast signals as IPTV, thanks to IP multicast, the distribution costs on the provider's backbone network do not scale with the number of users. Moving away from fixed networks for a moment, a similar difference between WebTV and IPTV can be found in the case of terrestrial networks for mobile reception.

WebTV over 3G networks is an approach already being followed by the mobile network operators (MNOs). In contrast to mobile WebTV, **mobile IPTV** can be physically transmitted over a broadband terrestrial forward channel. A suitable broadcast transmission scheme, such as DAB-IP, DMB-DXB or DVB-H, provides a guaranteed quality of service that is independent of the number of users receiving the signal. It is that proposition – in combination with a 3G return channel to deliver IPTV services to battery-powered handheld devices with small displays and integrated antennas *(Fig. 3)* – that is attracting the imagination of MNOs for creating new revenue streams.

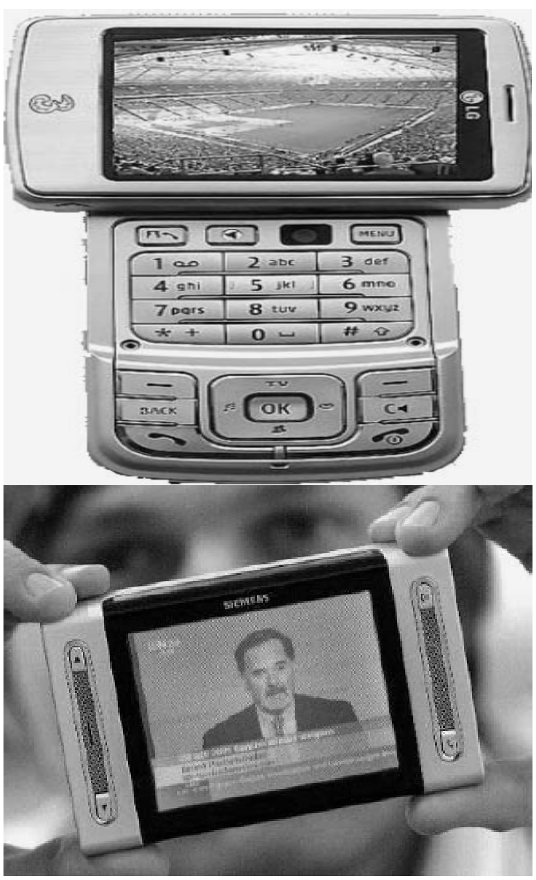

Figure 3: IPTV for mobiles

2.5. IPTV Over DSL Versus DVB Over Satellite and Cable

Returning to IPTV over DSL again, a simplified comparison with the DVB transmission schemes for satellite (DVB-S) and cable (DVB-C) is shown in Fig. 4. The colored lines are the different television programs of a digital bouquet that are bundled together in one or more multiplexes, each carrying a multi-programme transport stream (MPTS). Similar to a broadband cable head-end, a DSL headend picks up the satellite signals and converts them to IPTV signals. The difference here though is the client-server architecture used for IPTV, which sits between the provider backbone and the IPTV home. In contrast to DVB-S and DVB-C, however, not a single programme goes automatically into the IPTV home. Instead, the press of a button on the remote control is communicated back via the return channel to a server of the provider. The server then routes the requested programme, typically as a single programme transport stream (SPTS), over the backbone to the last mile which, in Fig. 4, starts behind the point of presence (PoP) at the DSL access multiplex (DSLAM). In this context, a technical challenge for IPTV is the short time delay during channel hopping (i.e. the zapping time).

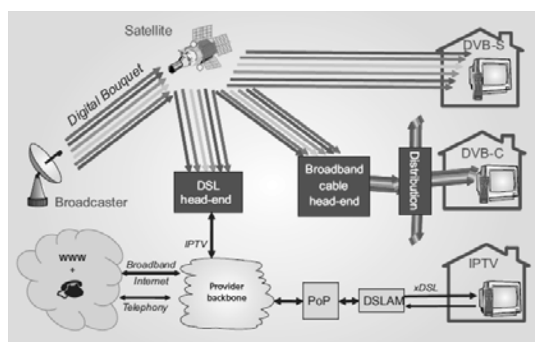

Figure 4: Simplified comparison between IPTV over DSL and DVB-S / DVB-C

Theoretically, every command on the remote control at home can be registered at the back-end system of the provider. This permits the ratings of a television programme for every single home to be measured very accurately and opens up a new dimension for personalized and individualized services on the TV screen. Equally, the client server architecture poses a new challenge to the data protection act and to privacy, quite different from anonymous free-to-air reception in one-way digital television systems. Different IPTV providers may use different DSL head-end structures, different backbones and different client server architectures including the settop-boxes. Under regulatory terms, market competition among telephone companies in Germany is enabled through bit-stream access at the point of presence (PoP) or at the DSLAM *(Fig. 4)*. Thus, a telephone household can choose from several IPTV providers, unlike subscribers to existing coax broadband networks for cable television. The activities of IPTV providers in Germany are, however, still very much in the start-up phase. To summarize this section, IPTV can be regarded as a new variant of interactive cable television which at present, in Germany, is implemented primarily for DSL transmission over fixed line telephone networks in urban areas *(Fig. 5)*.

Figure 5: Examples of xDSL networks for IPTV in Germany

3. H.264 Encoder

The H.264 is also known as MPEG-4 ISO/IEC14496-10 or MPEG-4/AVC. This standard was co-developed by a JVT group composed by MPEG-ISO/IEC members and VCEG-ITU-T members. Three profiles (main, baseline, and high) have been defined, each with several levels. The main profile is required for broadcast video quality, while the baseline profile is typically used for mobile and video conferencing applications. The H.264 encoder system block diagram (Figure 6) includes two dataflow paths, a "forward" path and a "reconstruction" or feedback path.

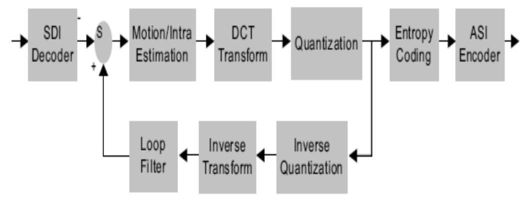

Figure 6: H.264 Encoder Block Diagram

H.264 encoding is ten times more complex than the MPEG2 encoding. For the motion estimation and compensation
section, H.264 employs blocks of different sizes and shapes, multiple reference frame selection, and multiple bi-directional mode selection. For the transform section, H.264 uses an integer-based transform that roughly approximates the discrete cosine transform (DCT) used in previous MPEG standards, but does not have the mismatch problem in the inverse transform. Entropy coding can be performed using either a combination of a single universal variable-length codes (UVLC) table with context adaptive variable-length codes (CAVLC) for the transform coefficients, or using context-based adaptive binary arithmetic coding (CABAC). The H.264 design is very complex, computing-hungry, and requires parallel processing. If a general-purpose processor is used, it will be limited by its internal architecture (i.e., if it has eight internal multipliers, it can perform eight multiplications per cycle). A programmable logic device (PLD) is flexible and highly scalable: if an algorithm needs 100 multiplications per cycle, then the PLD can be programmed to perform the required task. Figure 2 shows a single-chip main profile H.264 encoder PLD implementation using an Altera® Stratix® II device.

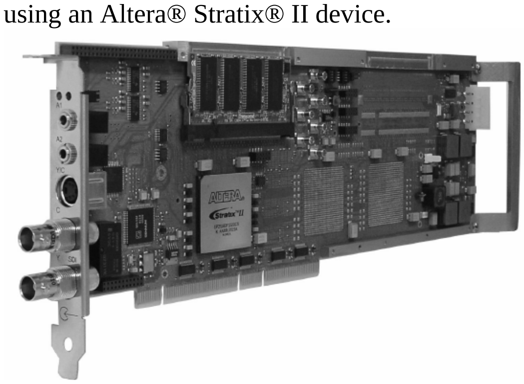

Figure 7: Single Chip H.264 Encoder

4. Video Over IP

Video over IP is the transmission of encoded video transport stream (TS) data over IP-based networks. It bridges between one or more encoded video streams and IP packets carried over 100 Mbps or 1 Gbps Ethernet. Video over IP accepts TS data and encapsulates it for transmission over Ethernet. Various standards define video over IP: real-time transport protocol (RTP), RTP payload format for MPEG video, UDP/IP, Pro MPEG code of Practice #3, and DVB-IPI. The TS input to video over IP is either a DVB-ASI or uncompressed SDI video data that will be mapped onto the Ethernet protocol layer. Figure 8 shows a video-over-IP reference design block diagram that receives a DVB-ASI TS and then converts the TS to IP. The design includes the following main blocks: TS input logic, frame buffer, queue system, Ethernet-receive DMA, encapsulator, transmits channel information, receive channel information, timestamp, media access control (MAC) interface, and host processor interface.

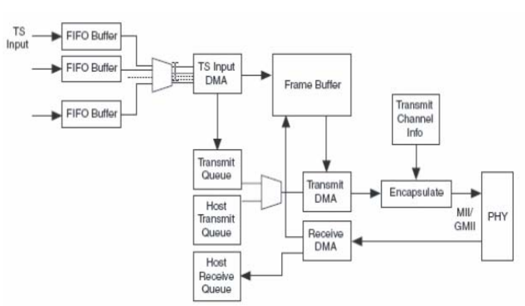

Figure 8: Video-Over-IP Reference Design Block Diagram

Conclusion

In summary, in order to provide quality video over IP, the latest H.264 video encoding technology is used to conserve bandwidth for delivery. Figure 9 shows the overall IPTV transmission system block diagram. The video content can be either SD or HD, uncompressed video, or previous MPEG2 TS. All these formats will be converted to H.264 video format before transmitting. All the key pieces can be implemented efficiently using PLDs for system upgradeability and flexibility.

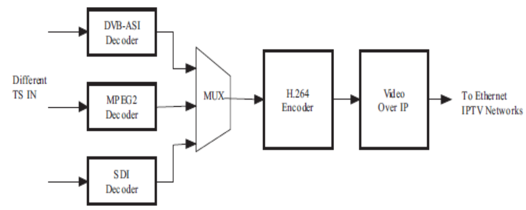

Figure 9: IPTV Core Block Diagram

5. Requirements

For the system outlined in Fig. 4, we will now concentrate on the requirements for IPTV over DSL networks. The business model is key. Obviously, Pay-TV and Free-To-Air (FTA) broadcasting are different models. We will focus on the latter for defining the requirements.

5.1. Retransmission of Live Broadcast Signals

If one regards IPTV as a new variant of interactive cable television, the general requirements for one-way digital cable television can be carried over. For example, broadcasters wish to provide a guaranteed quality of service with short signal delay, high picture and sound quality and lip sync. If transcoding of compressed source signals is involved at the DSL head-end, for example from MPEG-2 video received from a DVB-S signal to MPEG-4 AVC for IPTV retransmission, special attention has to be paid. The transcoding parameters have to be carefully chosen and adjusted in order to maintain a high picture quality and to make sure that the processed video does not lose the lip sync by delaying the unprocessed audio. The client-server architecture of a two-way IPTV system leads to additional requirements. Guidelines for programme listings in the navigator and interactive functions have to be revisited. The syntax and semantic for the related metadata server at the provider's back end system is a new component beyond the traditional broadcasting model. For example, a solution is required for the mapping of DVB service information (DVB SI data) that is carried in the transport stream of a DVB-S signal onto the client-server architecture and to identify what additional data is needed for the metadata server in order to get the electronic programme guide (EPG) or broadband content guide (BCG) fully functional and operational. In order to avoid expensive multi-platform authoring for the IPTV systems of different providers, standard data formats are very helpful, e.g. XML. In particular, if DVB transport streams feed the DSL head-end as shown in Fig. 4, one solution is the mechanism of Service Discovery and Selection (SD&S) defined in the DVB-IP (Internet Protocol) recommendation for the transport of DVB services over IP networks [10]. In that case, every DVB-IP receiver, no matter what brand, can access the services and that can be quite relevant for free-to-air broadcasting. In the IPTV system, the return channel is always on. Therefore, requirements have to address in general what user- and service-related data is or can be collected on the return channel. Broadcasters want access to the interactive network functions, because this adds a new layer of functions for enhancing existing services or creating new ones. For copyright reasons, there should be no redistribution of IPTV content over the worldwide web. On the other hand, if a broadcaster does unicast live streaming over the worldwide web and in parallel the same content is distributed as multicast IPTV, then synergies through clever routing might be possible. An IPTV system can carry IP-Radio as well and therefore the radio requirements have to be negotiated between the broadcaster and the provider where appropriate. Free-to-air broadcasting, in its strict meaning, relies on unencrypted transmission of all service and bouquet components, not just picture signal and stereo sound but also multi-channel sound, teletext, interactive applications, etc. In terms of signalling, free-to-air means open standards for retransmission and coding such as DVB-IP [10] and MPEG-4 AVC [7]. If a digital rights management (DRM) system is used by the IPTV provider, the functions should be switched off by default for FTA services unless specified otherwise by the broadcaster. The EBU requirements, summarized in the content protection and copy management (CPCM) guidelines, provide a yardstick [11]. The users should have non-discriminatory access to all FTA services through the navigator and EPG/BCG. For the FTA services of public service broadcasters, the IPTV provider should not impose an extra fee on the user, related to content that is already covered through the license fee.

5.2. On-Demand IPTV Services

For on-demand services, another set of requirements relates to the time-shifted or time-independent use of content. Clearing of copyrights can be difficult. Broadcasters may not have the relevant rights for each programme or item in the archive because, at the time of acquisition, the television on-demand proposition was unknown and therefore not covered in the copyright contract. This brings up the problem of contemplating new and unknown forms of use for repurposed content that will be available in the future through advances in technology. Not an easy task. For rights acquisition today, the aspect of on-demand should be considered from the start alongside live broadcast. The take-up of hard disk video recording, be it on a server at the provider's back-end system (Network PVR) or at home (PVR) and more recent developments such as pod casting, are merely the tip of the iceberg. For on-demand it can make a difference whether one deals with (i) streaming and one-off time-independent viewing or (ii) file download yielding a permanent digital copy or, more precisely, a digital clone. Sophisticated DRM systems aim at refining the access rights for maximizing the income of commercial broadcasters and content owners. In this setting for an IPTV system, very careful thinking is needed when on-demand services are considered for programs that are originally made for free-to-air public service broadcasting. Nondiscriminatory and fair access to the interactive network functions that are relevant for on-demand services is a clear requirement. The IPTV on-demand system has to comply with the national copyright regime. For fully user-controlled personal video recorders (PVRs) that are combined with the IPTV set-top box, similar requirements apply as for PVRs with an integrated DVB-S, DVB-T or DVBC tuner. For example, a copy for private use must be possible. In the case of a provider-controlled Network PVR or PVR, the terms and conditions have to be negotiated between the broadcaster and the IPTV provider, e.g. unencrypted transmission or the marketing model by which the content is advertised and made available to the user. The best quality on-demand content is useless if it cannot be searched, located and referenced to others by the user. Metadata is the key to enable podcast-like functions and to facilitate sophisticated navigation tools. The syntax and semantic of relevant metadata should be agreed on between the broadcaster and the IPTV provider. The efficient generation of metadata for search engines and navigation tools is getting increasingly important in the media production process. In passing, we should note that synergies between on-demand video services for the worldwide web and for IPTV networks could be an interesting follow-up.

6. Meeting the Requirements

In order to meet the requirements for IPTV, a look back at DVB and at the worldwide web is instructive. The DVB project was created for digital television. It brought together the broadcast industry, i.e. broadcasters, broadcast network operators and manufacturers. Out came mandatory forward transmission schemes for terrestrial, cable and satellite, now commonly used in the European broadcast markets. On the consumer side there is specific hardware, i.e. DVB receivers with mandatory and fixed integrated decoding functions. On top of the mandatory part there are options, e.g. for encryption or the MHP application programming interface. At the birth of the worldwide web, the Internet Engineering Task Force (IETF) defined the real-time streaming protocol (RTSP) without involving the traditional broadcast industry. Building on RTP/ RTSP and other mechanisms defined by the IETF, proprietary audio and video streaming schemes are not uncommon and are even used by broadcasters for WebTV. Proprietary schemes and widespread availability co-habitat through using general-purpose IT consumer hardware (PCs, Laptops) along with proprietary downloadable software players. Recent developments such as podcasting, and related RSS feeds, were originated for user-generated content and again rely on downloadable software. Pod casting is now increasingly used in the broadcast industry, even though it was not code signed by incumbent broadcasters. IPTV stands at the crossroads of these two examples, WWW and DVB. There is the content provider model as followed by WebTV and pod casting, and the broadcaster model of DVB. In the content-provider model, one concentrates on the generation of content. For distribution of the content, the necessary functions are specified at a rather abstract level and one does not really care about the specifics of the transmission scheme and the receiver technology. The content-provider model is agnostic to a specific IPTV technology. The IPTV system is a black box. The IPTV technology is left to the IPTV provider who has to make sure that the requirements of the broadcaster are met. For example, abstract requirements include (i) avoiding multi-platform authoring and (ii) ensuring a high quality of service with a free-to-air experience for the user. But how can a broadcaster be sure that such requirements are really met in cases of dispute, when no parameters are defined that could be metered, measured and quantified. The broadcaster model goes one step further and cares about certain specifics of the transmission scheme and the receiver technology. The business functions are developed into a set of technical requirements. The FTA principle, the avoidance of multi-platform authoring and the benefit of the economies of scale are promoted through technical requirements for open standards such as DVBIP for transmission and MPEG-4 AVC for source coding. However, the policy of intellectual property rights (IPR) and the conditions for obtaining a license to apply open standards is getting more difficult as the example of MHP highlights. The IPR policy and the license conditions for DVB and other standards relevant to IPTV should be clear upfront. Of course, IPR can be an even more important issue in the content-provider model when proprietary systems are involved.

7. Conclusion

IPTV can be regarded as a new variant of interactive cable television. IPTV brings together telephone companies and broadcasters. Partnerships are needed for carrying the concept of free-to-air public service broadcasting forward to IPTV. The implementation of a broadcaster model with broadcast-centric requirements and open technical standards as a base for fair and non-discriminatory access is a worthwhile goal, of benefit of the audience. The high-quality content and the specific know-how of public service broadcasters is a valuable asset for building strategic partnerships with IPTV providers, relevant software and hardware manufacturers and other broadcasters. The short term effects of IPTV should not be overestimated. In Germany, IPTV is still in its infancy. In the long run, IPTV could have a lasting effect and bring profound changes to the broadcast business. IPTV combines the traditional concept of live broadcast with on-demand and interactive viewing. That combination is most likely to prevail because it is an attractive proposition that appeals to a large audience. With ever-increasing bandwidth on the worldwide web, the differences between WebTV and IPTV will eventually vanish. But this will take some time, and the guaranteed quality of service of IPTV is an advantage for the time being.

Abbreviations

ADSL Asynchronous Digital Subscriber Line
AVC (MPEG-4) Advanced Video Coding
BCG (DVB) Broadband Content Guide
CPCM (DVB) Content Protection and Copy Management
DAB Digital Audio Broadcasting (Eureka-147)
http://www.worlddab.org/
DMB Digital Multimedia Broadcasting
http://www.t-dmb.org/
DMT Discrete Multi-Tone
DRM Digital Rights Management
DSL Digital Subscriber Line
DSLAM DSL Access Multiplexer
DTT Digital Terrestrial Television
DVB Digital Video Broadcasting
http://www.dvb.org/
DVB-H DVB - Handheld
DxB Combination of DAB and DVB-T/DVB-H
EPG Electronic Programme Guide
FTA Free-To-Air
FTTC Fiber To The Curb
FTTH Fiber To The Home
IAD Integrated Access Device
IEC International Electro technical Commission
http://www.iec.ch/
IETF Internet Engineering Task Force
http://www.ietf.org/
IP Internet Protocol
IPI (DVB) Internet Protocol Infrastructure
IPR Intellectual Property Rights
IPTV Internet Protocol Television
ISDN Integrated Services Digital Network
ISO International Organization for Standardization
http://www.iso.org
MHP (DVB) Multimedia Home Platform
MPEG Moving Picture Experts Group
http://www.chiariglione.org/mpeg/
MPTS Multi-Programme Transport Stream
MSO Mobile Service Operator
PoP Point Of Presence
PVR Personal Video Recorder
RSS Really Simple Syndication
RTSP Real-Time Streaming Protocol
SD&S (DVB) Service Discovery & Selection
SDTV Standard-Definition Television
SPTS Single Programme Transport Stream
STB Set-Top Box
VDSL Very high bit-rate Digital Subscriber Line
WLAN Wireless Local Area Network
xDSL *(Different variants of)* Digital Subscriber Line

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