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COEN 332 (Wireless/Mobile Multimedia Networks)

Spring 2021

Mobile IPTV

Audience

This document covers the architecture, design and functioning of IPTV systems followed by architecture and design of mobile IPTV systems. The Quality of Service section discusses in detail video compression and channel zapping which are essential elements of IPTV services.

The reader is expected to have basic knowledge of networks to be able to understand the architecture and design of IPTV systems. Some background in the field of image/video compression is desired to have a better understanding of quality issues.

This document can be used by system architects, designers, developers, quality assurance analysts, business analysts, academicians, researchers and technical authors.

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1. Introduction

IPTV, or Internet Protocol Television, is the delivery of multimedia content which includes television, video, audio, graphics, text and data, over Internet Protocol (IP) based networks using logical IP signals as compared to the traditional terrestrial, satellite and cable television formats. These services are managed to support quality of service (Qos), quality of service, security, interactivity and reliability.

IPTV services fall in the following three categories:

- Live television
- Time shifted media
- Video on demand

Mobile IPTV is the extension of these services in the mobile domain. With mobile IPTV, mobile users can transmit and receive content (television signals, video, audio, graphics, text and data) through IP networks. Mobile IPTV provides the flexibility of mobility that IPTV lacks. It empowers users to use these services anywhere on earth.

This report is divided into four chapters. The first chapter covers the overview and architecture of IPTV services and how different it is from Internet TV.

The second chapter takes IPTV to mobile domain and explain the current and proposed architecture using NGN (Next Generation Network) and non NGN based architecture. The NGN based network using IMS (Internet Protocol Multimedia Subsystem) is the most promising but is still in development stage.

The third chapter is based on Quality of Service or QoS which is one of the most important features of IPTV. It describes various techniques used for maintaining quality of delivered content and also introduces basic concepts of video encoding and decoding process. There is always a trade-off between efficiency and quality in video compression and it is a major factor in QoS.

Finally, we discuss the conclusion of this study and the future aspects of mobile IPTV services.

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2. Understanding IPTV

2.1 IPTV and Internet TV

IPTV, as stated before is the distribution of content (audio/video/text) through controlled and regulated IP networks. The media content is received at the user end through a device known as set top box.

IPTV brought many new concepts to home television which made it so popular.

- Home television subscribers could now choose which particular channel they wish to watch. As opposed to terrestrial, cable and satellite television, where everything was broadcasted, IPTV allowed for selective transmission and reception as per user needs. IPTV is a point-to-point connection and thus makes users having their individual broadcast possible.
- Communication through IP networks provided a mechanism for two way communication, that is the user was now able to interact with service provider, for example, VoD (video on demand), which is essentially requesting a video (e.g. a movie) from the video library and the program is delivered.
- It opened new gates with possibilities of transactional applications (like TV shopping) and interactive applications.
- Features like Electronic Program Guide (EPG) and Personal Video Recorder (PVR) allowed for fully interactive experience along with video recording for viewing at a later time. User could now pause or rewind the current broadcast, something impossible in the past.
- Parental control of content to monitor television usage even when the parent is away.

This should not be confused with internet video steaming. Even though at a layman level the two sound similar, these two are in fact very different technologies with completely different objectives and implementations.

The differences between the two are summarized in the Table 1.

Table 1 - Differences between IPTV and internet video streaming

	Broadband TV	Internet video streaming
Footprint	Local (limited operator coverage)	Potentially supranational or worldwide
Users	Known customers with known IP addresses and known locations	Any users (generally unknown)
Video Quality	Controlled QoS, "broadcast" TV quality	Best effort quality, QoS not guaranteed
Connection bandwidth	Between 1 and 4 Mbit/s	Generally below 1 Mbit/s
Video format	MPEG-2 MPEG-4 Part 2 MPEG-4 Part 10 (AVC) Microsoft VC1	Windows Media RealNetworks QuickTime Flash, and others
Receiver device	Set-top box with a television display	PC
Resolution	Full TV display	QCIF/CIF
Reliability	Stable	Subject to contention
Security	Users are authenticated and protected	Unsafe
Copyright	Media is protected	Often unprotected
Other services	EPG, PVR (local or network)	
Customer relationship	Yes; onsite support	Generally no
Complementarity with cable, terrestrial and satellite broadcasting	Potentially common STB, complementary coverage, common metadata	Pre-view and low-quality on-demand services

(Source – IPTV the future of television – Eric Martinsson)

2.2 Architecture

The IPTV system includes four major domains.

1. The consumer domain – This is responsible for presenting IPTV services to the end user.
2. The network domain – This is responsible for allowing connection between the consumer domain and the service provider domain
3. The service provider domain – This is responsible for providing the end user with all IPTV services

4. The content provider domain - This is responsible for providing all content – audio/video/text/data – to the consumer through the service provider. The content provider is licensed to sell the content.

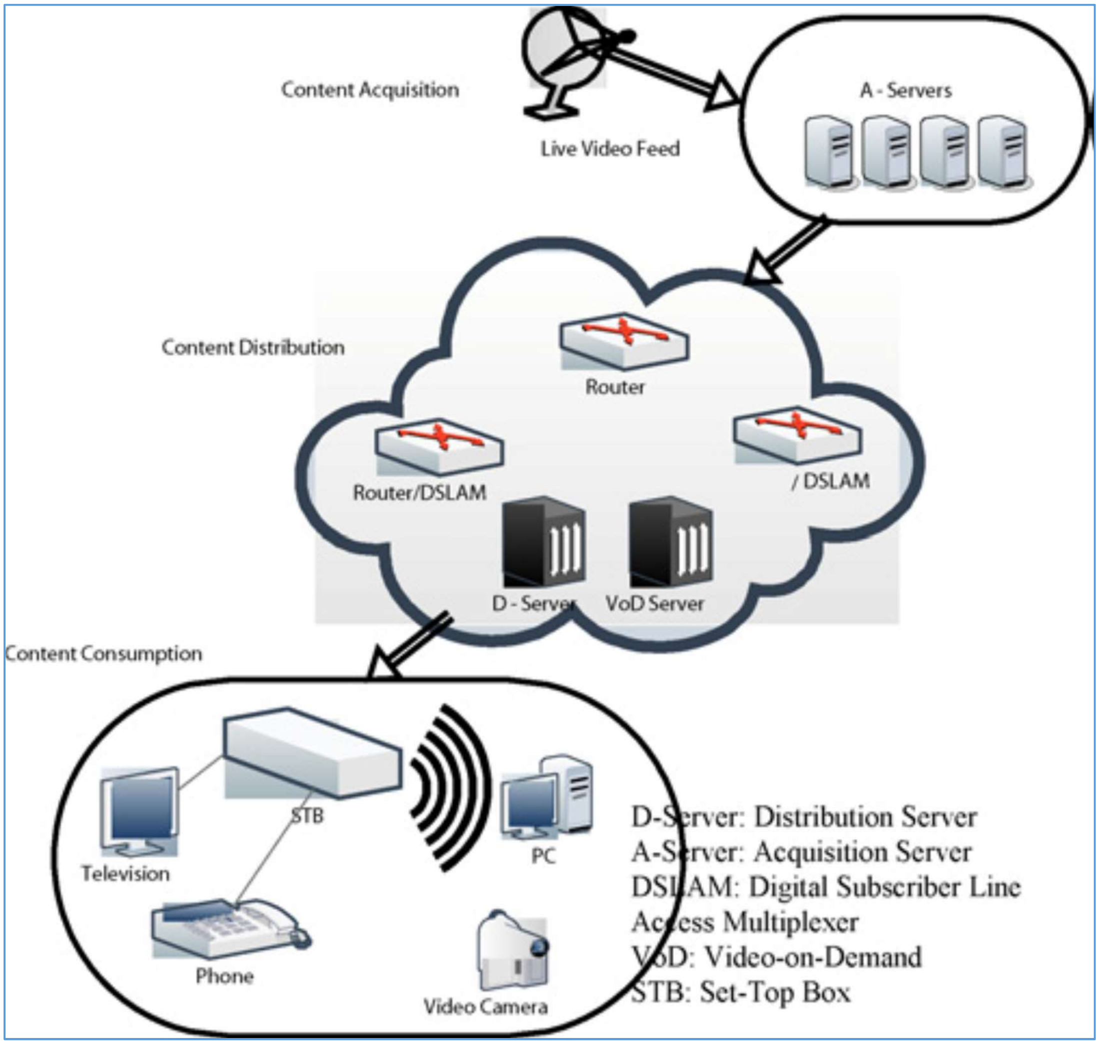

Figure 1 - A simplified architecture diagram for IPTV

(Source – IPTV – Architecture, Trends and Challenges by Zeadally, Mustafa)

Figure 1 shows a simplified diagram for an IPTV system. The basic building blocks of IPTV infrastructure consist of

1. Content acquisition
2. Content distribution
3. Content consumption

Each building block consist of different elements and should be scalable. Figure 1 describes the major components in an IPTV system. These are:

1. Acquisition servers or A-servers – These are used to encode audio/video and to add DRM metadata.
2. Distribution Servers or D-servers – These are used to provide QoS control and catching.
3. VoD creators and servers – These consist of a library of video content to be used to provide VoD services to consumers.
4. IP routers – Routers are used to route IP packers and in case of a failure should provide fast reroute as well.
5. Residential gateways – These are IP routers for bundled services at home
6. Set-top-boxes (STBs) – A set top box is a device on the consumer end that uses a DSL or cable wiring to interface with the user terminal such as TV or laptop.

There are two approaches to designing an IPTV infrastructure - NGN-based and non-NGN based architecture.

The non-NGN based IPTV architecture is based on the existing infrastructure i.e. the current network components as well as the protocols and interfaces presently in use. It requires, generally, a separate service control setup and an IPTV specific application layer.

The NGN based architecture, on the other hand can be NGN non-IMS based and NGN IMS based. The NGN non-IMS based takes advantage of the NGN framework architecture to support IPTV services along with other NGN services. It is, as the name suggests, not IMS based. There is a dedicated IPTV subsystem within the NGN infrastructure. The NGN IMS based architecture utilizes the NGN architecture components while using IMS to provide IPTC services along with other IMS based services.

There are a number of advantages of using IMS based architecture. These include better user subscription management, QoS offered to every session, unified billing services, application servers have open interfaces, mobility support and service personalization among others.

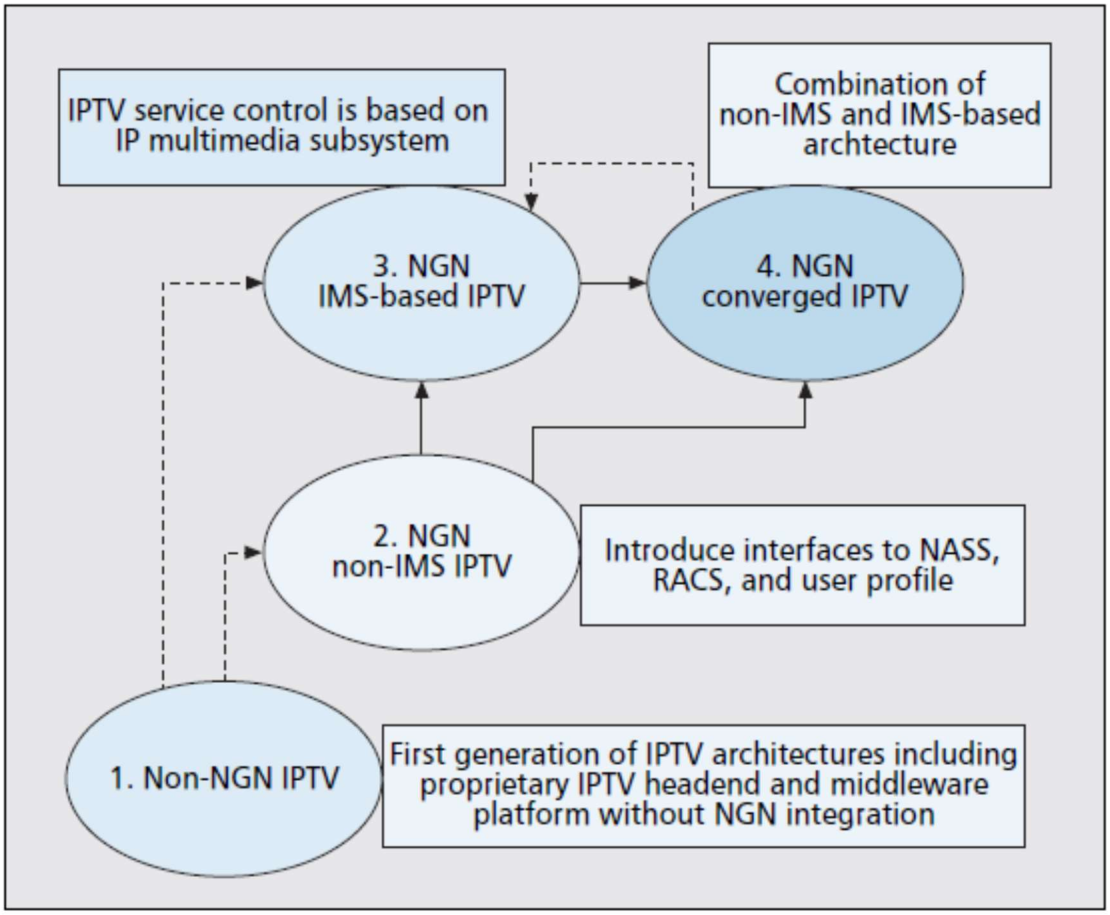

Figure 2 - IPTV evolution steps

2.3 IPTV Services

IPTV services can be broadly classified into three categories:

1. **Basic channel services** – these comprise of audio and video channels, audio channels and A/V with data channels and are broadcasted very similar to the traditional television broadcast.
2. **Enhanced selective services** – These are advanced services aimed at improving user experience and the problems associated with basic channel transmission. These include, but are not limited to VoD (video on demand), Electronic program guide (EPG), personal video recorder (PVR), business to business services and customers to customer services.
3. **Interactive data services** – These consist of T-communication (mail, video phone, messaging), T-information (news, weather, traffic), T-commerce (banking, shopping,

auction), T-entertainment (gaming, blog), and T-learning (education centric programs for elementary to high school).

A major component of IPTV system is the video head end. This is the component where the audio video content for broadcast services and VoD services is captured, digitized and compressed for transmission and distribution over IP networks. Video encoders and VoD servers constitute of the major sources of video content for these IPTV services. The broadcast national feeds use satellite and some other feeds are ingested using terrestrial fiber based networks. The video head end, in turn, consist of the following major components:

1. Video encoder – Encodes raw video analog signals from a content provider or a live video source into a compressed digital format. The compression technology may differ but is usually MPEG2 or MPEG4.
2. Live video broadcast server – this encapsulates the compressed digital video received from different sources to be broadcasted. This also has an interface to the core network and hence broadcasts the video content to the core network towards access network.
3. Vod server – this has a large storage capacity to store all VoD video content to be ordered on demand.

As described above encoding converts analog signals into digital compressed video content which is then encapsulated into IP packets to be transmitted over the network. The network consist of two parts.

- Core network
- Access network

The core network is used to connect the access network to the customer premises. It could be made of gigabit Ethernet national distribution network or one running IP multi protocol label switching, along with many regional distribution networks. Access networks, on the other hand, are the broadband connections between the service provider and the household. Access network could be implemented using varying technologies such as xDSL, coaxial hybrid fibre cable, among others.

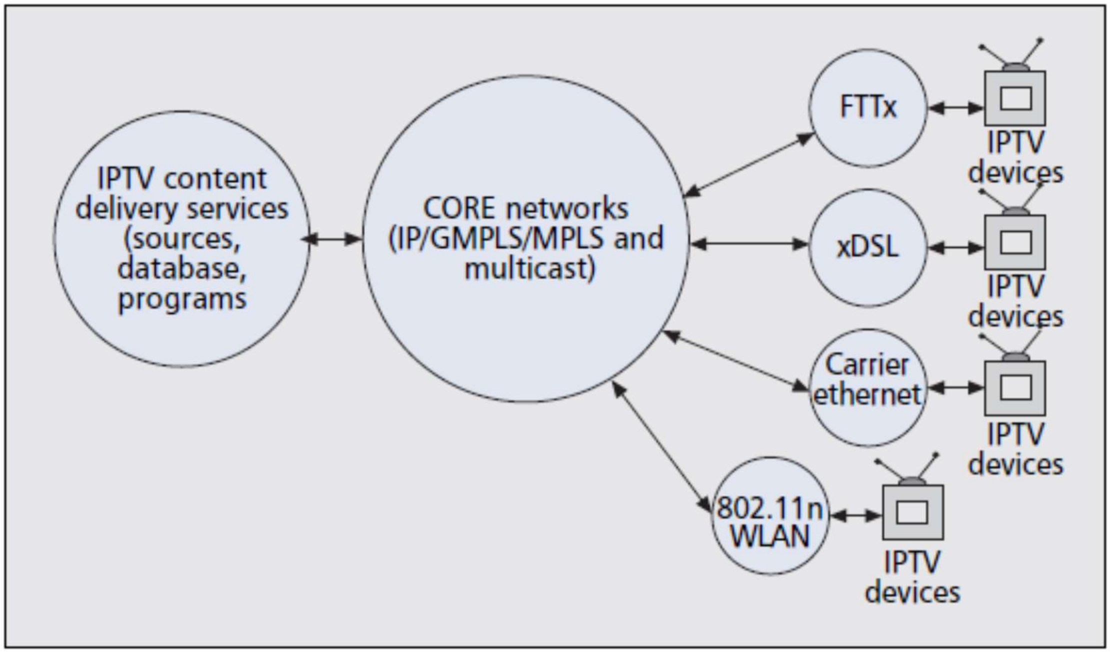

Figure 3 - IPTV services

IPTV services are provided using IP multicast. The bandwidth of access networks are generally limited and to provide TV broadcast access to all customers simultaneously the IP multicast system has a feature of scalable video data delivery.

Encoding is a complicated process with the trade-off between coding efficiency (hence bandwidth) and the quality of reconstructed video. When streams are transmitted over a network, there are issues with varying bandwidth availability as per changes /congestion in the network. Hence an encoding system capable of varying bit rate is highly desired in such circumstances. Scalable video encoding is one solution.

Scalable video encoding is when the video content is encoded in such a way that it can be transmitted according to varying bandwidth availability. When high bandwidth is available, full encoded video is transmitted. However in case of low bandwidth availability selected frames are dropped to match the available bandwidth at the cost of video quality of regenerated video. H.264 video format is typically used for scalable video coding to improve coding efficiency while efficiently using bandwidth.

Another solution is the newly developed and researched topic of rate optimization. In this case the encoding parameters are changed at real time as per the bandwidth availability by a feedback mechanism provided in the system. In case of a congestion a feedback informs about congestion in the system and the encoding parameters are changed to lower the bit rate of the encoded video. When the congestion is resolved, encoding parameters are changed to match the allowable bit rate.

IPTV services are distributed by the home network to the end user. The end point of a home network is the set top box, which receives transmitted signals, the program guide data, and decodes the MPEG2 or MPEG4/H.264 A/V stream to display on a screen. A set top box can be stand alone or could be integrated with DSL or even cable modem.

3

3. Mobile IPTV

Mobile IPTV takes IPTV to the whole new level, much desired in this era of ever increasing mobility and portable devices all around. The mobile IPTV technology lets the users transmit and receive, on their mobile devices, multimedia traffic such as TV signals, video, audio, text, data and graphics through IP based networks and with the support of excellent QoS (quality of service) and QoE (Quality of experience), security, mobility and interactivity.

The ITU-T classifies the mobile IPTV architecture into NGN-based (next generation network) and non-NGN-based networks. The following section describes the non-NGN based network for mobile IPTV services. Currently only non-NGN based architecture has been standardized and the work and research is going on for NGN based architecture.

3.1 Non-NGN based architecture

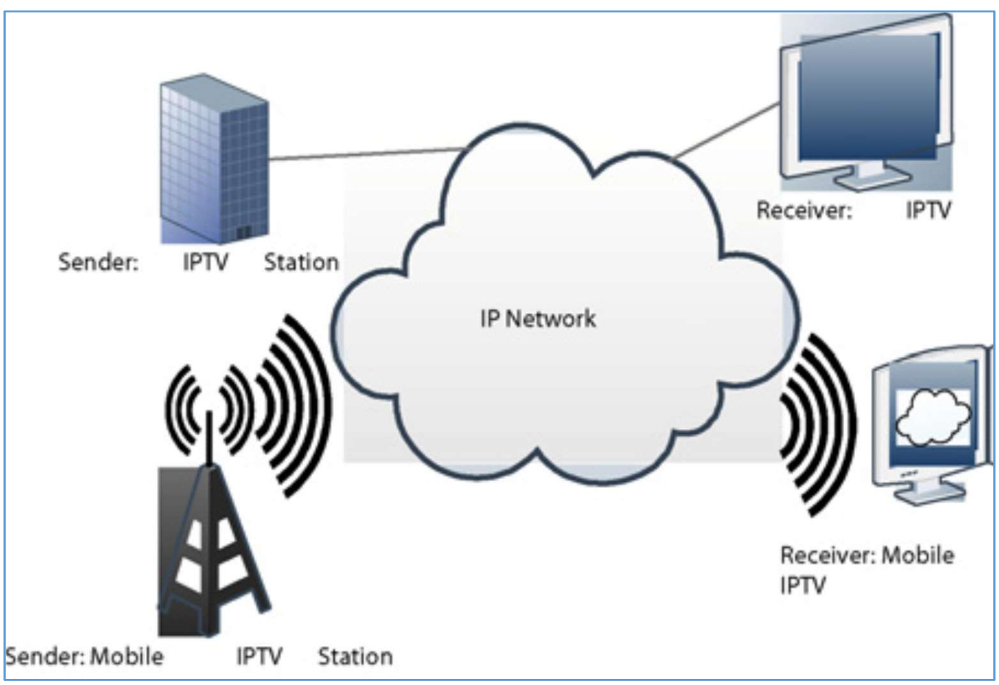

Figure 4 - Mobile IPTV system

Figure 4 shows a typical mobile IPTV architecture. The first stage of mobile IPTV is when the receiver is able to receive services through a wireless interface between the access network and the receiver. Various access networks can exist there such as wireless LAN (WLAN), WiMAX, and cellular networks. Each of these access networks has its own properties and characteristics which should be considered by the IPTV service provider for deployment of mobile IPTV services.

In the second stage of mobile IPTV the sender is also wirelessly connected to the access network so that both sender and receiver devices can be mobile. In this scenario any sender is able to create content and share with another user via mobile IPTV services.

There are two main approaches to mobile IPTV services in the non NGN based architecture, which are quite similar from the perspective of the user but the underlying technologies differ considerably.

1. Mobile TV plus IP
2. IPTV plus mobile

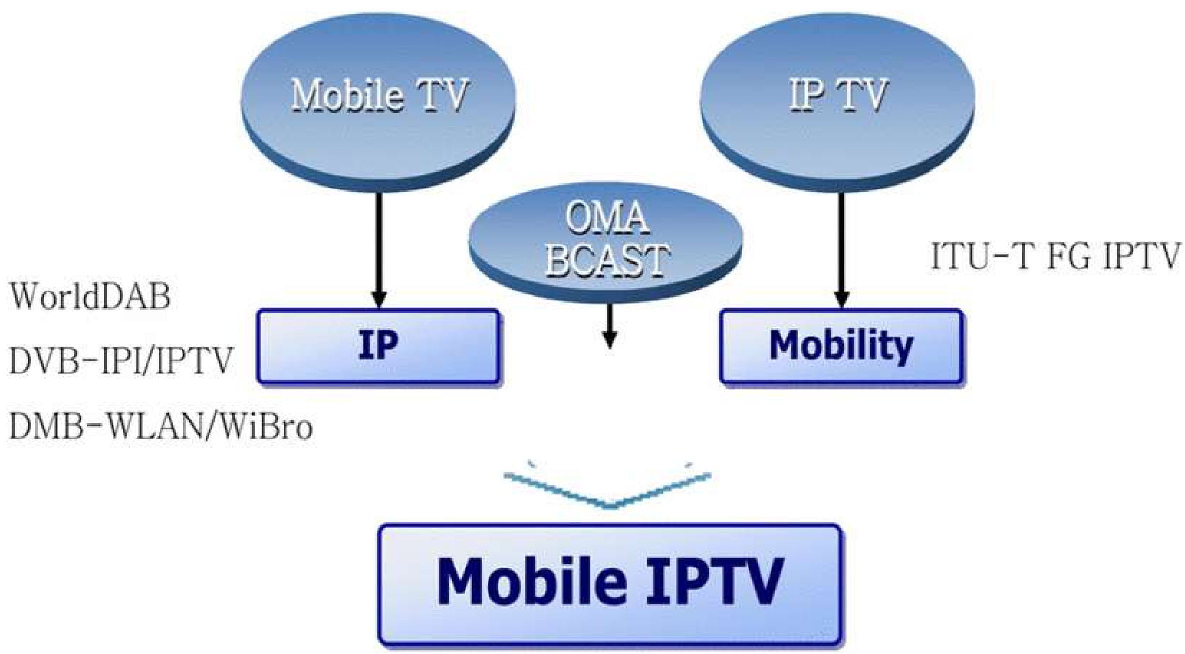

Figure 5- Two approaches for mobile IPTV services

3.1.1 Mobile TV plus IP

This approach uses the traditional digital video broadcast services (DVB) to deliver IPTV services to a mobile user. It is a merger of the stability and reliability of the broadcasting services with the diversity of multimedia services offered through internet. Wireless networks like cellular networks are a part of it to support mobility and interactivity. The key standards in this area are DVB-CBMS (Digital Video Broadcast - Convergence of Broadcasting and Mobile Services) and World Dab (dab refers to digital audio broadcasting). This approach, even though is technically called mobile IPTV, but the inclusion of broadcasting services it may cause loss of IP individuality such as personalized services and point to point interactive communication.

3.1.2 IPTV plus mobile

The development of mobile IPTV standardization is at a very early stage and a lot of research is required in the field. IPTV was originally developed to target fixed terminals such as set-top-boxes at the television unit. However, mobile devices are dominating day by day and in coming years will become the major entertainment source of a majority of customers. This is leading to slow death of fixed terminal devices like television and desktop computer systems and thus driving towards technological advancements in the area of mobile entertainment. IPTV is currently dominated by Telco giants. The Open IPTV forum is working on mobile IPTV systems based on IMS (IP based Multimedia system).

3.2 NGN based architecture (IMS based)

The standardization process for NGN based architecture for mobile IPTV is still in research phase and is an ongoing process. This approach will incorporate the IMS (IP based multimedia system) architecture within the mobile IPTV system. Since the IMS based mobile IPTV system is still in development stage, we will study IMS based IPTV system in this section.

Internet Protocol Multimedia Subsystem (IMS) is defined as the global, access independent and standard based IP connectivity and service control architecture that enables various types of multimedia services to end users using common internet based protocols. IMS uses SIP language (Session Initiation Protocol) while supporting various access modes like GPS, GPRS, WCDMA, WLAN and broadband.

Figure 6 below shows the typical IMS network architecture. It has three layers namely

1. Connectivity layer
2. Control layer
3. Service layer

The connectivity layer supports various Access network technologies such as UMTS, GPRS, WCDMA, WLAN, xDSL among many more.

The control layer consists of all the CSCF's (Call Session Control Functions) which are used to set up, maintain and modify, and release a session.

The Service layer consist of the Application Servers (AS's) to host IMS services, and the HSS (Home Subscriber Server) which stores the subscribers location and other information to be needed for security purposes.

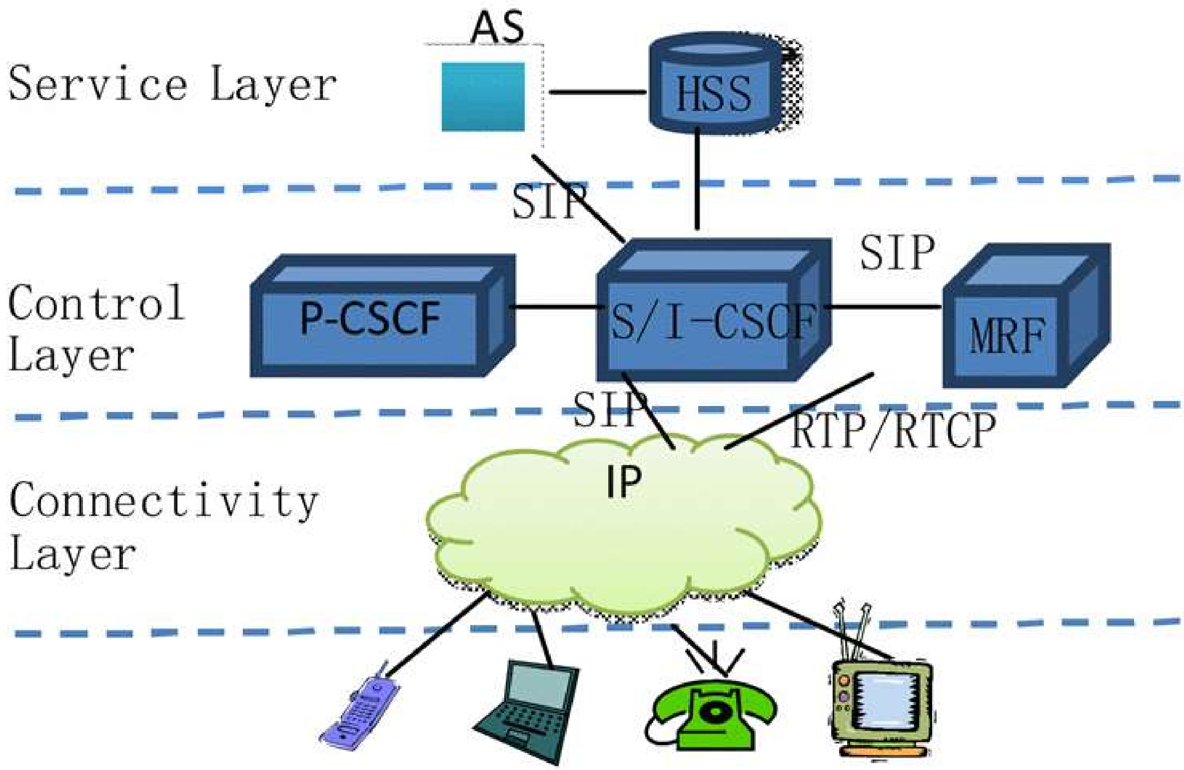

Figure 6 - IMS Network Architecture

The IMS has features which make it a great choice for IPTV services.

1. The platform is using layered architecture and hence the control layer is separated from the application layer.
2. The signaling protocol used is SIP (Session Initiation Protocol)
3. IMS is access network independent

4. It supports mobility of terminals (for mobile IPTV)
5. Provides specifications for network infrastructure, billing, authentication, security and QoS.

3.2.1 IPTV Network Architecture Based on IMS

The Figure 7 below shows the IPTV architecture implementation using IMS infrastructure.

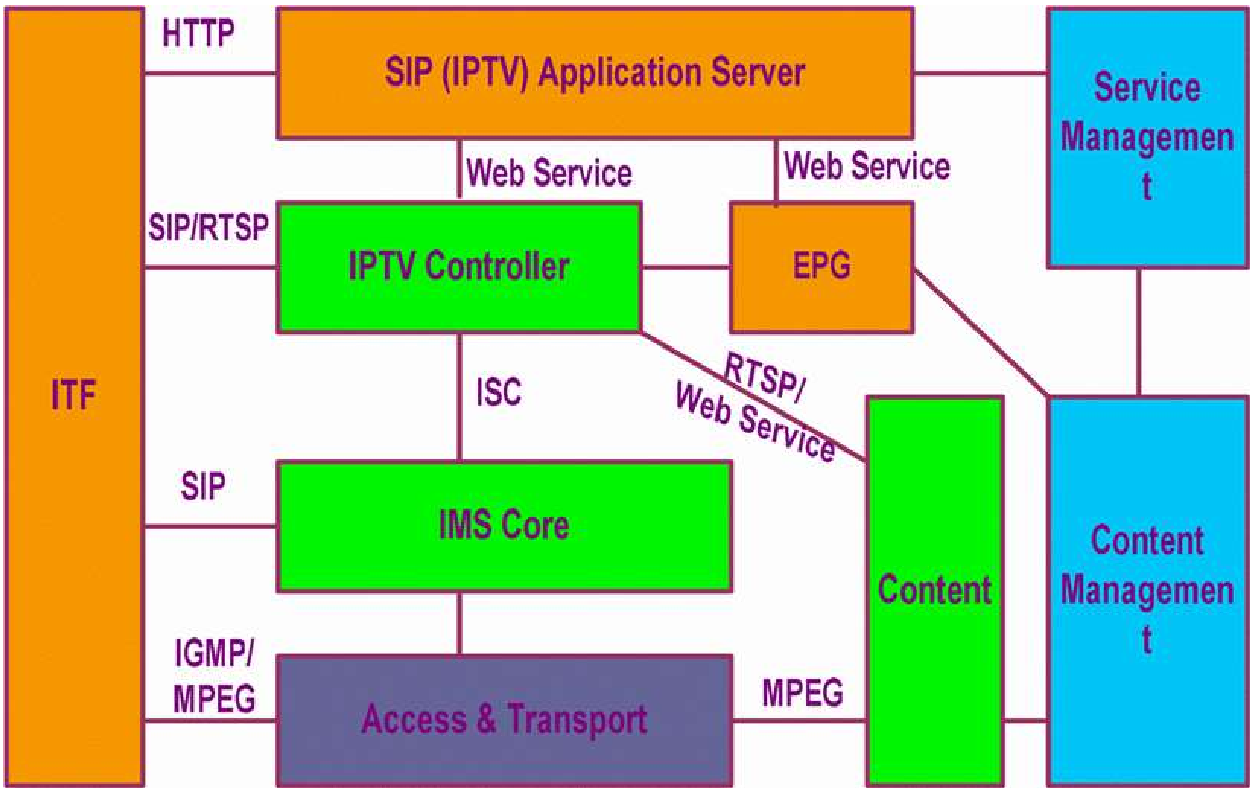

Figure 7 - IMS based IPTV architecture

The IPTV services are provided by the main application server called SIP Application Server or SAS. It works on Session Initiation Protocol (SIP). It implements some service logics so that the user can interact and request for IPTV services like television channels, VoD, and other multimedia services. These are implemented in a very intelligent way. Some special services like EPG (Electronic Program Guide) and PVR (Personal Video Recorder) are given focus and implemented separately for faster and effective service deployment.

The SAS interacts with the ITF (IPTV Terminal Functionality) which handles and displays the interactivity functions for viewers. This is also responsible for audio/video encoding and decoding for all streams. It thus interacts with the IMS core using SIP and also interacts with the transport layer by sending the encoding media content to be transmitted.

There are content management services for handling the audio/video/text content. The IPTV controller sits between SAS and IMS core.

3.2.2 Mobile IPTV user profile

The IPTV services for mobile are personalized services and hence every user has his own IPTV profile. This ensures each user has personalized EPG's and PVR's along with his video library, personalized advertisements and communication services. There should be a home gateway, which provides a relationship between the IMS user profile and the IPTV profile. It usually has an ISIM card reader attached to it, which is used to read user data and it can be deployed in the residential gateway or any other networked consumer equipment. This gateway is used to translate home signaling to IMS signaling. The home signaling could be SIP, UPnP, or even pure HTTP. If the home signaling is SIP, there is no need for translation as IMS is SIP based. This gateway is also responsible for traversing the NAT and securing a connection with the P-CSCF within IMS domain. In the home domain, the gateway takes care of identity, device subscription and management.

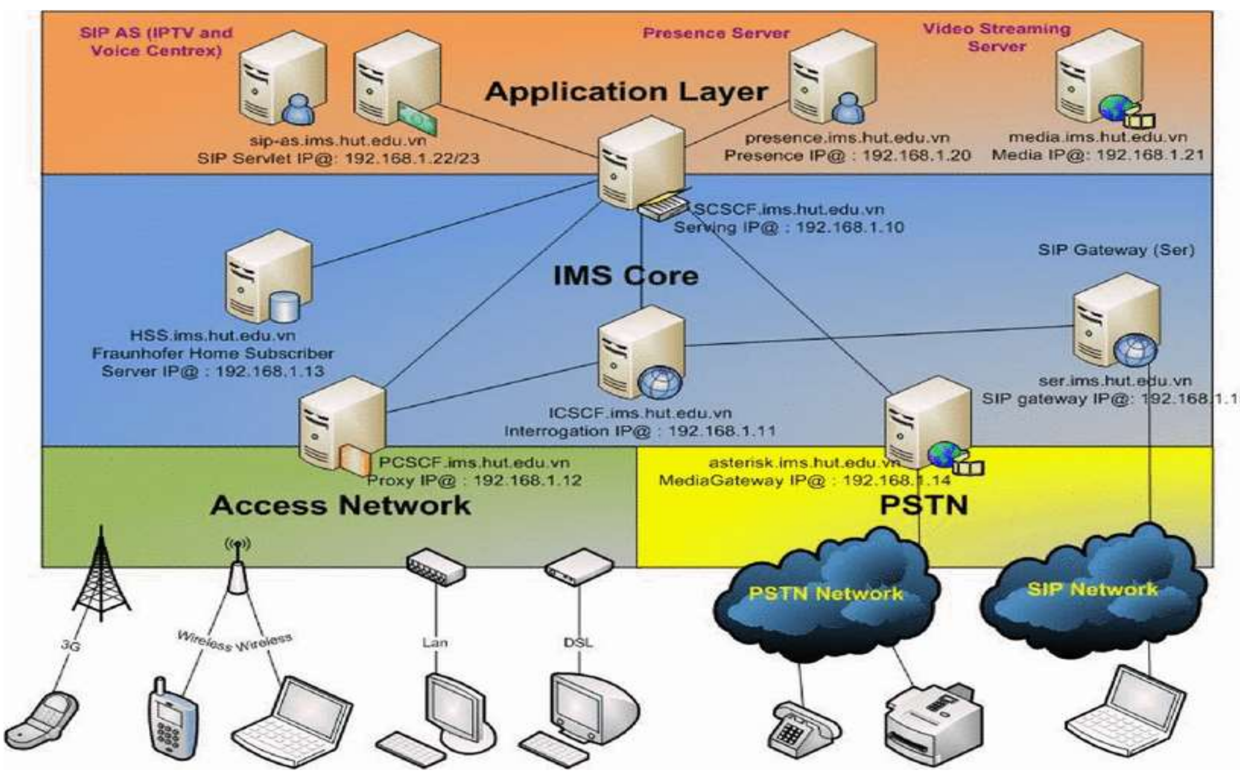

Figure 8 - The test bed set up by HUT (Hanoi University of Technology) for IPTV using IMS

3.2.3 Parental Control feature

Parents can now control the type of content their children are viewing easily using IPTV services. The scenario is explained in Figure 9. When the child (Peter) initiates a request for a specific content (a movie or a channel for which parental control is desired), the request is forwarded to the IPTV AS through IMS Core. The IPTV AS, through the “Sh” link checks for user registration information stored in the HSS. The HSS tells AS the user requires permission to view this specific content. The AS now checks the status of the parent (Alice) using Presence services (whether online or not) and if available asks for permission using the Message method. If the request is denied by the parent a denial response is sent to the child (603 decline) and if it is accepted the request is proxied to the media server which will send an RTP media stream to the child.

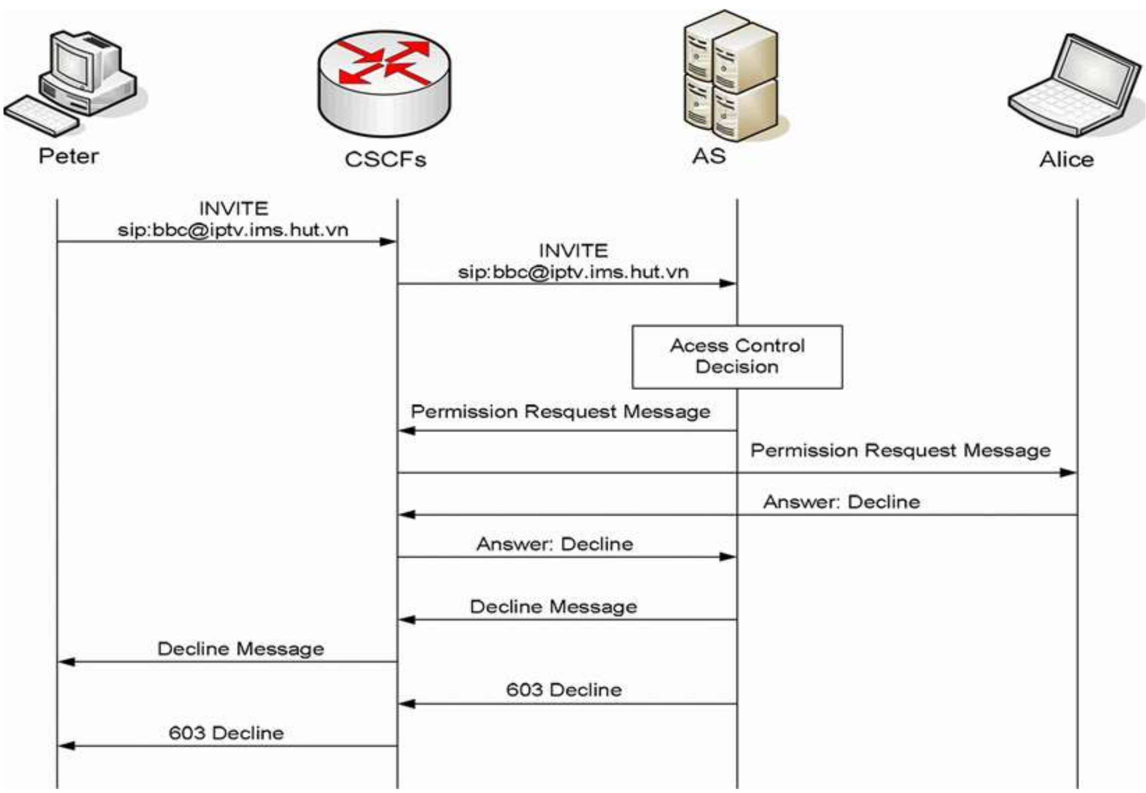

Figure 9 - IPTV parental control feature

3.2.4 Enhanced EPG

Since IPTV services are personalized services, each user has a profile which is stored in the HSS. This leads to another intelligent feature it can support which is called enhanced EPG services. IN this case the users are classified into different groups based on their subscription level. The user with no access control are grouped into one group and those who need access control are grouped to another. The AS queries the HS for profile of each user and intelligently groups them. The EPG (Electronic Program Guide) for each user is delivered according to the access control the user has. For example, the child having no access to some particular channels will not even be able to view those channels in his device. This will be especially useful in case of mobile IPTV since each user has his mobile phone and controlling access would become very difficult otherwise.

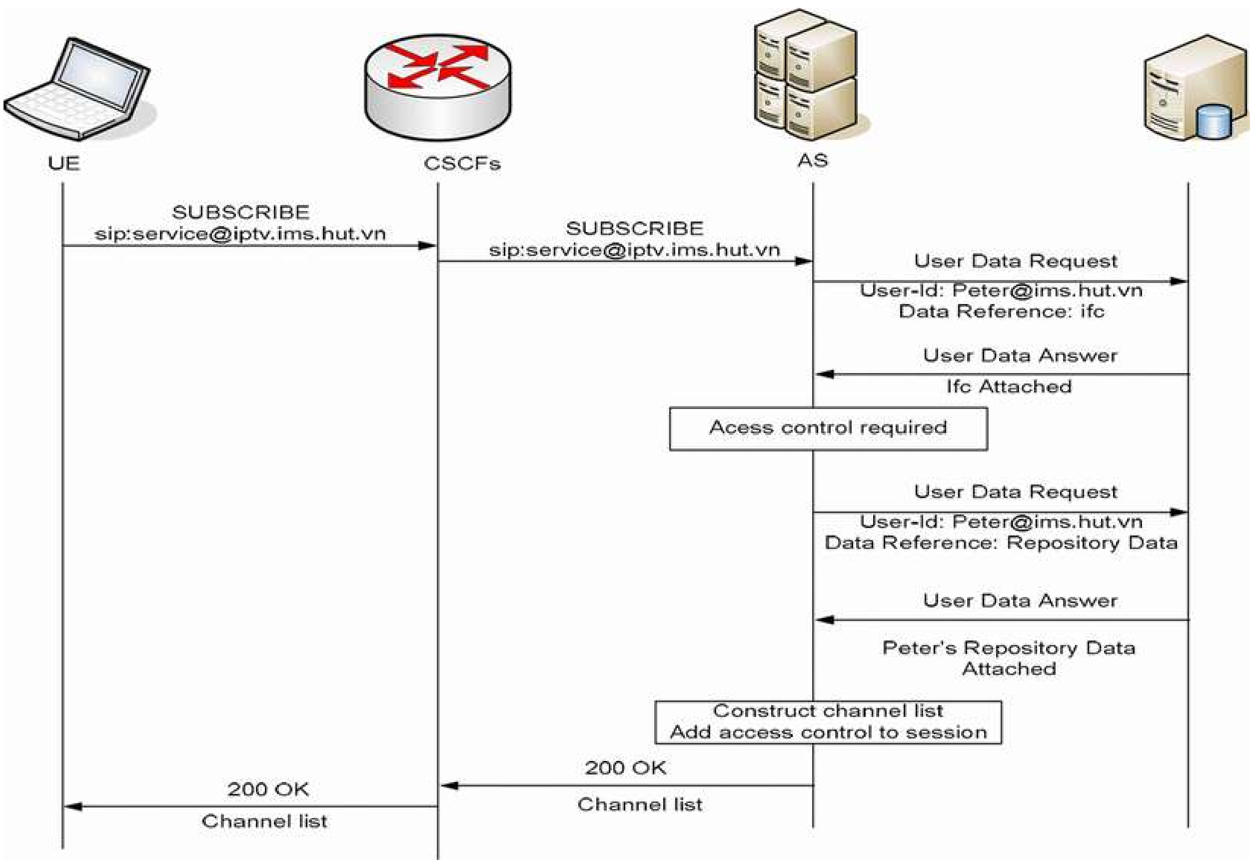

Figure 10 - Message flow for enhanced EPG services

IMS (with SIP signaling), thus, can be used to implement intelligent features in the mobile IPTV system focusing on personalization of video on demand, EPG, PVR allowing parental remote control and session handover without interruption, among other interactive features.

4

4. QoS (Quality of Service)

A major component of mobile IPTV services is the QoS or Quality of Service guaranteed to the consumer. Excellent QoS is crucial successful delivery of mobile IPTV services for video, audio and data. In a real mobile environment for mobile IPTV services there are possibilities of unreliable mobile network connection and bandwidth. The utmost important aspect would be of course service continuity, but also quality service. The services could face many errors like shadowing, fading, jitter, blockiness in video, frame loss, audio-video synchronization issues, voice blurriness, voice packet loss, delay and many others.

The mobile IPTV system must be designed in such a way so as to handle all these errors and correct some of them if possible.

Some of the QoS metrics characterized by services are listed in the table below:

Table 2 - QoS metrics characterized by services

Service	QoS Metric
Video	jitter, number of out of sequence packets, delay, network fault probability, multicast join time, packet loss probability etc.
Audio	MOS (mean opinion score), jitter, delay, voice packet loss rate etc
IPTV services	channel availability, start time and change time of channel, channel change failure rate and so on

There are many ways to ensure QoS. Seamless video transmission is the most challenging of them all. Some of the techniques used for ensuring uninterrupted video transmission are

1. Scalable video coding
2. Rate distortion optimization
3. Deblocking filters

Since video consist of a majority of content deployed through IPTV services, and since it is the biggest of big data today, it is important to understand the process of video compression in a little detail. The next section focusses on video compression techniques and how the QoS is achieved, along with the challenges.

4.1 Video Compression

Video compression is the process of reducing the amount of data required to represent a video sequence to be stored or transmitted in the network. This process is also called encoding. The complementary process of reconstructing original audio or video sequence to be displayed on screen is called decoding.

Digital data, especially video, takes up a very large amount of space, and without compression it is almost impossible to store and transmit such large data with limited storage and bandwidth availability. This makes video encoding-decoding an essential part of the mobile IPTV system.

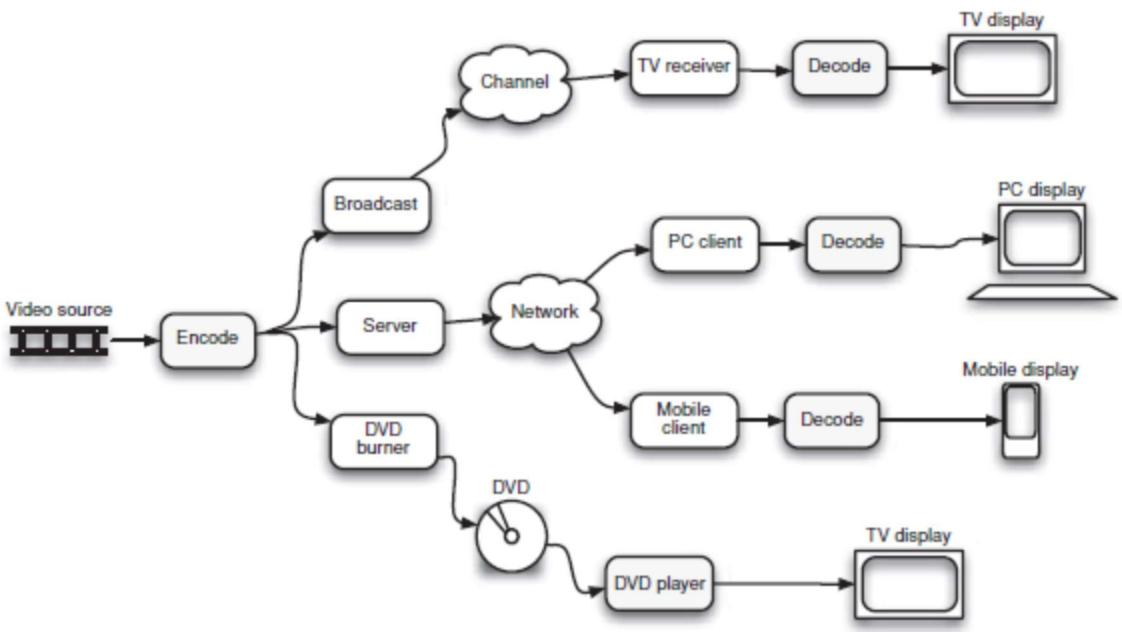

Figure 11 - Video Coding Scenarios, one-way

The video compression technique takes advantage of the spatial and temporal similarity in a sequence. Spatial similarity is the similarity between pixels in a video frame. Since pixels are so small more often than not the neighboring pixel is of the same or very similar value. This is called intra frame coding. Temporal similarity is the similarity between two consecutive frames in a video sequence. This is called inter frame coding. Much of the compression comes from inter frame coding since the difference between two frame is very small value. This is illustrated in Figure 12.

Figure 12 - Spatial and temporal correlation in a video sequence

To explain further the encoder consists of three main models – the **prediction model**, the **spatial model** and the **entropy coder**. The prediction model utilizes the temporal similarity explained above. Its input is the raw uncompressed video and it tries to reduce the temporal redundancy in neighboring frames. This is done by dividing a frame into blocks of pixels and predicting each block from the previously coded block. If a reasonable match is found, the encoder simply encodes the motion vector to that particular block in the previous frame along with the difference in pixel data (residual entropy). This is significantly smaller value than the actual coded block. This is called motion compensated prediction and is the most complicated aspect as well as the greatest contributor to video compression.

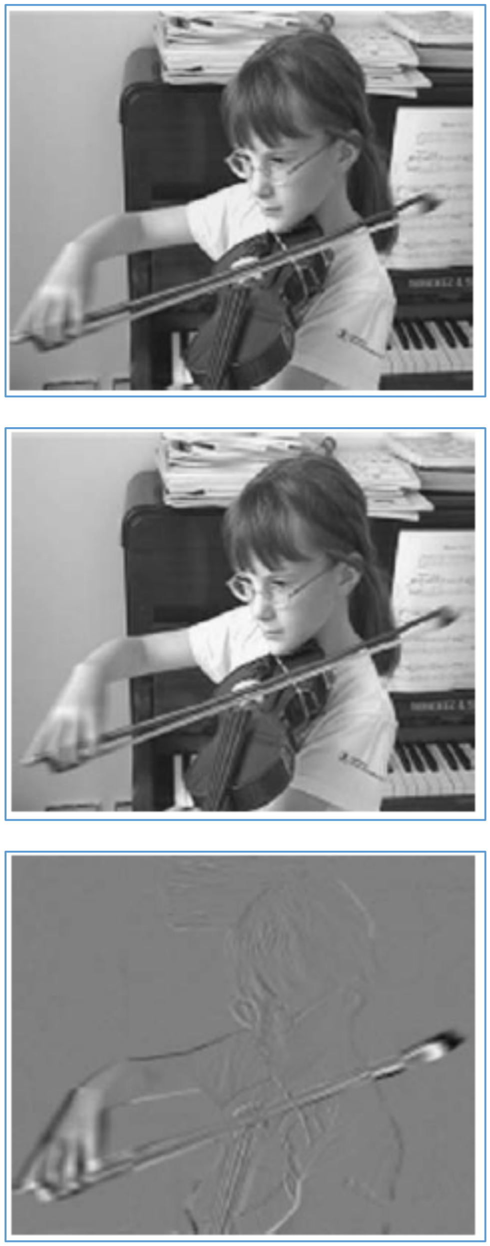

Figure 13 - Frame 1; Frame 2; Difference

The spatial model takes input the residual frame from the temporal model. It is basically the residue left after motion estimation and subtracting the current frame from the previous frame. It tries to utilize the spatial redundancy within an image or frame in this case. After the spatial redundancy has been exploited, the entropy model codes the final residual entropy. In H.265 and HEVC standards this is done by applying a transform on the data and quantizing the results. These, along with the motion vectors are finally coded by an entropy coder and a bitstream is formed.

The decoder decodes and reconstructs a video frame based on the encoded data in an exact reverse order to the encoding process. However, the quantization step is an error introducing step and hence a reverse quantization does not reveal an exact copy of the input signal.

4.2 Scalable Video Coding

Scalable Video Coding is an extension of the H.264 video compression standard. A video bitstream, when encoded using H.264 can have multiple subset video bitstream. These substreams are derived by selectively dropping certain packets or frames from the original bitstream so that the resulting video is still reconstructable, but with a lower quality and lower bandwidth requirement. Hence scalable video coding is the ability to recover an acceptable image or video by decoding only parts of bitstream.

The substream can also be used in case a lower spatial resolution is desired (smaller screen) or a lower frame rate is desired.

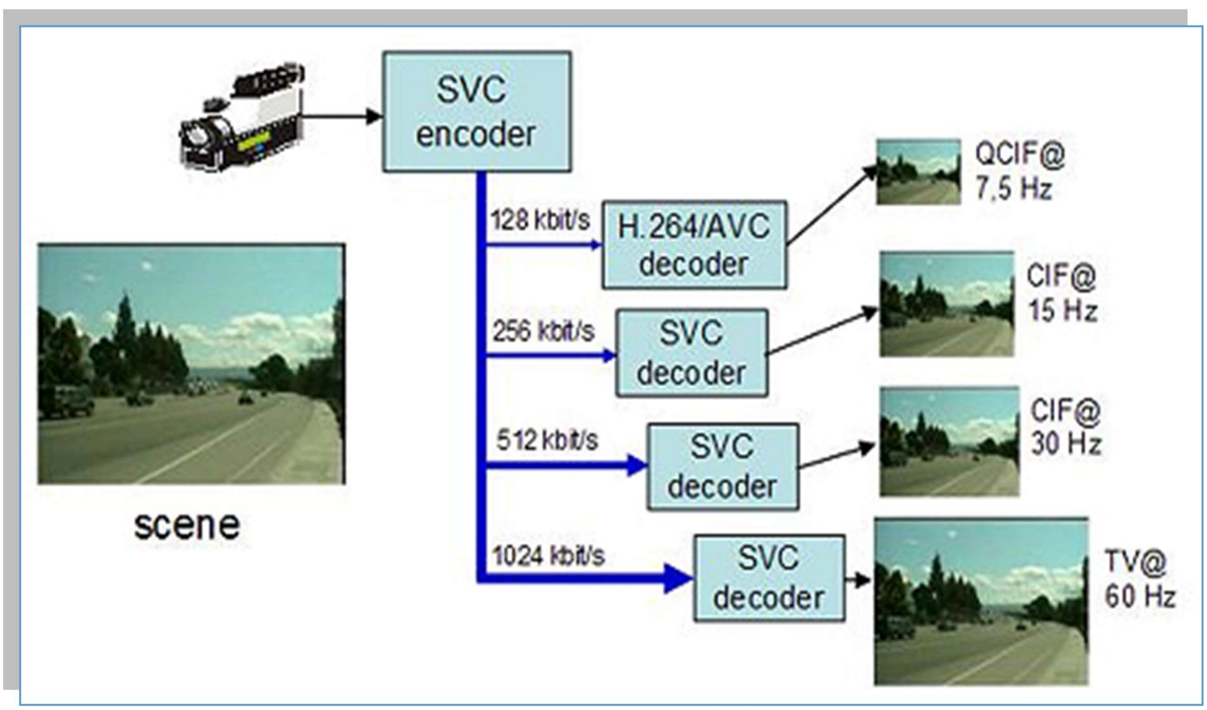

Figure 14 - Scalable Video Coding

There are two concepts in scalable video coding – simulcast and transcoding. Simulcast can compress video once for each client. It is used to support a range of client capabilities. Transcoding, on the other hand, compresses video once and transcodes it to lower bit rates as required.

4.3 MOS or Mean Opinion Score

It is gradually evolving as the most trusted metric for video and audio quality. Volunteers are asked to rank the quality (of audio and video) and then a mean score is computed which is used as a quality metric. It is a subjective quality metric.

Measuring visual quality is a very difficult art and a subject of constant research. The human visual system does not perceive certain errors in an image or video sequence but is sensitive to other errors. Visual quality is often a subjective measurement and not objective. It is influenced by many subjective factors.

4.4 PSNR or Peak Signal to Noise Ratio

It is the ratio of the square of peak signal to mean square errors (MSE), taken on a logarithmic scale. It is the most reliable objective quality metric for measurement of "error" in the channel.

$$PSNR_{dB} = 10 \log_{10} \frac{(2^n - 1)^2}{MSE}$$

It is quite popular since it can be calculated quickly and very easily.

However, recent research in the area of visual quality demonstrates that simply the value of error in a signal does not signify the visual quality perceived by humans. The human visual system is very complex and certain errors are more visible than some other kinds of errors. However, calculating MOS is time consuming and very expensive. The industry still prefers PSNR, but the new video standard HEVC (High Efficiency Video Compression) or H.265 has MOS as a parameter and likely it will become the new primary video quality metric.

Even though PSNR is not an actual measure of perceived visual quality they do serve a very important purpose of quantifying the signal error which is needed in case of QA and monitoring changes in received signal. A PSNR of 35dB is considered good enough. Any value below 30 is not acceptable.

Figure 15 - PSNR examples (a) original; (b) 30.6dB; (c) 28.3dB

4.5 Structural Similarity (SSIM)

There is another approach to video quality known as Structural Similarity (SSIM). It is based on the property of the HVS (human visual system) to extract structural information from the image.

With PSNR, it is very hard to describe why contrast stretched images have high perceptual quality than JPEG compressed and blurred images all with the same value of PSNR. It can, however, be explained if the image degradation is considered as perceived changes due to structural information variation.

4.6 Just Noticeable Difference (JND)

JND is defined as the visibility threshold below which any changes cannot be detected by the human visual system. It is based on the principle that slight differences between original signal and received signal are not noticeable to the user. Hence by mathematical modeling and calculations the rate by which a signal can be compressed so that the error is less than or equal to JND is calculated and applied in the compression algorithm. The resultant encoded signal is one which is compressed but with same visual quality as the uncompressed raw sequence.

4.7 Channel Zapping Time

4.7.1 Channel Zapping Time as QoS metric

Channel zapping time is another very important quality metric for mobile IPTV services. It is defined as the time delay between the currently watched channel and the first frame displayed of the new channel requested by the user. In mobile IPTV systems all the channels are not transmitted at the same time to all the customers due to bandwidth limitations (there are thousands of channels). Hence reliable and quick channel zapping is crucial to the performance of mobile IPTV services.

Fig 8 shows the typical channel zapping process from the currently viewed channel "CH1" to the newly selected channel "CH2", which is used in mobile IPTV systems.

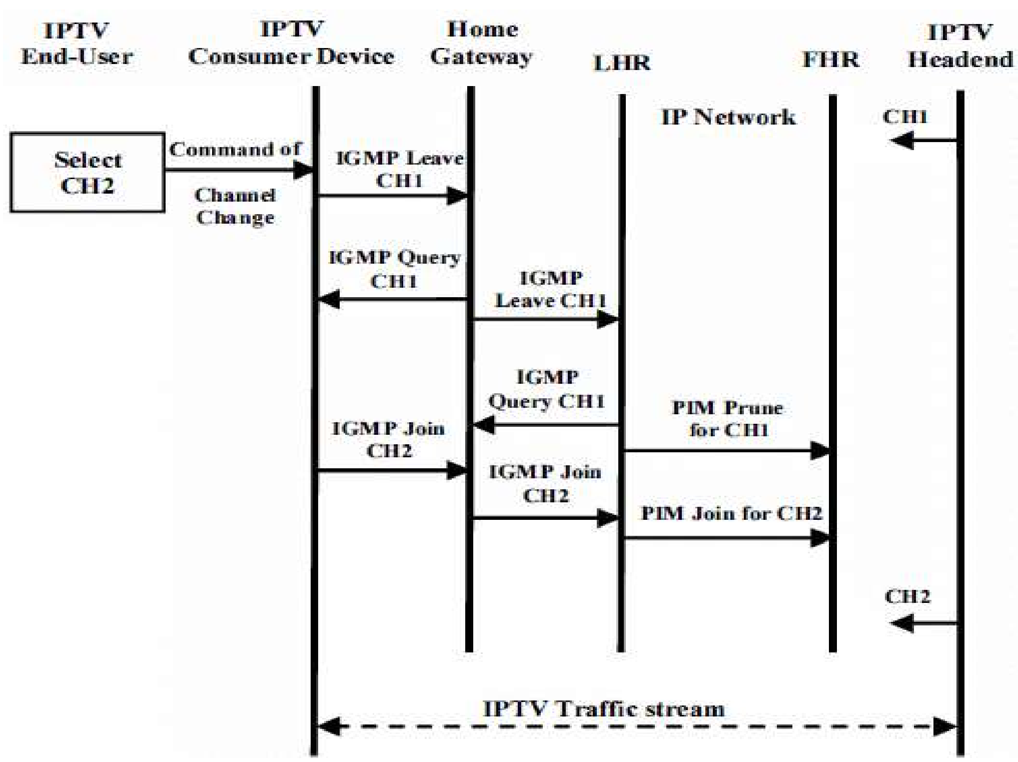

Figure 16 - Channel Zapping Process from CH1 to CH2

When the user is watching channel 1 and send a request to watch channel 2 on his device, an IGMP leave message is sent to the home gateway. The home gateway respond with an IGMP query for channel 1 to the home network and if no response is received it send an IGMP leave message to LHR. Now the device send an IGMP join message for channel 2 which is propagated to the upper level routers and finally channel 2 media is delivered to the requesting device.

4.7.2 Factors Effecting Channel Zapping Time

Channel zapping time depends on the following factors which contribute to delay in the system

1. Multicast leave and join command processing time
2. Access network delay
3. Jitter buffer delay
4. Video decoding delay
5. CA/DRM system delay
6. Device processing time
7. IR (Infra Red) remote control delay time

A typical example of latency introduced by these factors is shown in the table below.

Table 3 - Channel zapping latency for various factors

Channel Change Latency	
Channel Change Latency Factors	***Latency (ms)***
Remote control delay	25
Multicast leave old channel	50
Delay for stream to stop	150
Multicast join for new channel	50
Jitter buffer fill	200
CAS/DRM delay	0-2000
I-frame decoding delay	500-2000
Device processing rime	100-200

The table clearly shows the maximum delay comes from two major factors – video decoding and CAS/DRM delay.

There are many approaching aimed at reducing the channel zapping time in multicast mobile IPTV systems.

1. **Small GOP size**
   This approach takes into consideration the video decoding time and aims at reducing the GOP or group of pictures in a video bitstream. A group of pictures is a closed unit which can be fully decoded without any outside reference. The start of a GOP is an I frame which is a random access point. We know that the one of the main causes of delay is to wait for the random access point. Thus by reducing the GOP size it is possible to reduce the delay time.

2. **Reducing channel buffering time**
   The initial buffering time is also a major contributor to the delay propagated in channel switching. This can be reduced at the encoder end to significantly reduce the channel switching time but it comes with a trade off in quality If the transport bitrate is fixed. IF the maximum allowed buffer is very small, the quality of video suffers especially in fast moving scenes which are required to be predicted from a couple frames back and thus require a large buffer. A large buffer offers the encoder the flexibility of algorithm choice as per the content of the stream allowing for more optimized compression.

3. **Predictive tuning**
   This is a machine learning approach and aims to predict the behavior of user by predicting the channel used most. Some channels are pre-joined which are expected to be viewed by the user and then these are selected without much delay.

4. **Using multiple streams**
   The idea of this method is to top pipe as many channels at user end as possible. This is, of course, limited by the bandwidth availability in the access network.

5. **Using adjacent multicast joins**
   This is similar to the previous approach and exploits the fact that adjacent channels are going to be viewed frequently by the user and makes them available.

5

5. Future of Mobile IPTV

The standardization for mobile IPTV is still in progress for NGN based architecture. IMS based architecture for mobile IPTV services is especially very promising.

IMS can provide intelligent features for mobile IPTV like parental control even with individual devices, video on demand, session handover without interruption and enhanced EPG. We discussed how SIP can be used to provide these intelligent services.

Some of the technical limitations faced by mobile IPTV development are:

1. Bandwidth limitation
   This is one of the major issues faced as mobile IPTV would require a lot of bandwidth from the cellular network provider.
2. Coverage implication
   Inspite of ever improving mobile networks, there are still issues faced with the coverage of networks in certain areas. Dense building structures also block network signals.
3. Capability limiatations
4. Vulnerable wireless links

Other than technical difficulties, there are certain business issues which is slowing the growth rate of mobile IPTV standardization process, such as low consumer demand for mobile IPTV viewing due to smaller mobile screens. However, with improved user interface and excellent screen resolution available in the mobile devices the users are being driven to the idea of personal portable entertainment device.

To conclude, irrespective of technical difficulties faced in development of mobile IPTV, the future looks promising with ever improving technologies. The development would of course be on the lines of IPTV, including intelligent IMS infrastructure. Ensuring QoS is one of the most important aspect of IPTV and will be a challenge in case of mobile IPTV due to bandwidth/real time limitations.

Acronyms

A/V	Audio/Video
AS	Application Server
CBMS	Convergence of Broadcasting and Mobile Services
CSCF	Call Session Control Function
DAB	Digital Audio Broadcasting
DSL	Digital Subscriber Loop
DVB	Digital Video Broadcasting
EPG	Electronic Program Guide
GOP	Group Of Pictures
HSS	Home Subscriber Server
IMS	IP based Multimedia SubSystem
IP	Internet Protocol
IPTV	Internet Protocol Television
JND	Just Noticeable Difference
LAN	Local Area Network
MOS	Mean Opinion Score
MPEG	Moving Pictures Expert Group
NAT	Network Address Translation
NGN	Next Generation Network
PSNR	Peak Signal-to-Noise Ratio
PVR	Personal Video Recorder
QoE	Quality of Experience
QoS	Quality of Service
RTP	Real Time Protocol
SIP	Session Initiation Protocol
SSIM	Structural Similarity
STB	Set Top Box
SVC	Scalable Video Coding
VoD	Video on Demand
WCDMA	Wideband Code Division Multiple Access
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

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