How to architect an IPTV system

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Abstract

Today's Internet Protocol Television (IPTV) is being offered and taking off, driving radical changes in the way telecom networks are designed. Future consumers will look for unique, personalized services through multiple devices, including the television. On demand content, Interactive TV, Video and voice communications, photo, music, and home video sharing, and online gaming, all delivered seamlessly, are a few examples of the services that consumers could receive. This requires innovative changes in the entire end-to-end service delivery architect, quality of service and customer management, reliability and security.

1. Introduction

IPTV, also known as triple play, is a solution that offers customers voice, data, and video services on a single broadband access connection that can be Ethernet, PON, FTTH, or more typical nowadays DSL. The voice can be either POTS or VoIP; data service is typically a high speed Internet; and video includes all traditional services and advanced features that are significantly better then current cable and satellite offerings like Video on Demand, and converged services with the integration of voice, data, and video. Besides, the solution offers an intuitive and appealing interface with instant channel change and multiple pictures in picture for increased end-user satisfaction and less churn.

The driving factors to architect an IPTV solution are: Advances in Video Compression, Digital Rights Management technologies, open standards, IP Multicast protocol, IP Quality of Services (QoS) capabilities, and the evolution of broadband distribution networks based on Internet Protocols, increasing the bandwidth.

In this paper, we present a detailed description of what is IPTV, all critic aspects to architect a new IPTV solution, the key drivers and challenges for this emerging solution. The outline of the remaining part of this paper is as follows: Section II includes challenges to architect this solution. Section III involves MPEG Transport Stream, and IP Multicast. Section IV describes all components, and user services descriptions. Section V, we present our conclusions and inspiration for upcoming researches.

2. IPTV Challenges

Telcos will offer a significantly improved TV experience for a sustainable competitive advantage over Cable providers.

An important factor is the ability to integrate all this, including with the existing OSS/BSS (Operating Support System/Billing Support System).

Other crucial feature coming into play with IPTV is ensure high availability, scalability, and extensive security, specially to block paralyzing denial-of-service (DOS) attacks.

There are some critical challenges, but IPTV service has cracked them. The first is to compress video better than MPEG-2 does.

IPTV service is different from terrestrial, cable, or satellite broadcasting service in several points. In traditional broadcasting services the STB receives all of the channels. When user changes channels, the STB immediately reflects it and display the selected channel. On the contrary, IPTV service cannot transfer all of the channels simultaneously due to the lack of network bandwidth between Last Hop Router and home gateway.

The channel zapping time is critical problem to resolve for IPTV service. In general, channel change times depends on several parameters: command processing time, network delay time, STB layer delay time, STB jitter buffer delay time and MPEG decode time. Command processing time is the time interval between the remote control action and the transmission of the join message.

3. MPEG TS, and IP Multicast

Transport stream (MPEG-TS) is a format specified in MPEG-2 Part 1 standard. Its design goal is to allow multiplexing of digital video and audio and to synchronize the output. Transport stream offers features for error correction for transportation over unreliable media, and is used in broadcast applications such as DVB and ATSC. It is contrasted with program stream, designed for more reliable media.

This standard covers rules for: compressing audio and video content; transporting the multiplex across a network; and encapsulating data into the multiplex

MPEG-TS standard defines ways of multiplexing more than one stream (video, audio, and data) in order to produce one program. It simultaneously can carry many programs or services with audio, video and data all interlaced together. However, in IPTV the MPEG-TS will carry only one program.

In IPTV, a program consists of some elementary streams. It may have one video stream, one or more audio streams, one data stream, and zero or more subtitles streams as following:

- Data Stream: Program Specific Information (PSI) tables
- Video Stream: MPEG-1, MPEG-2, H.264, or VC-1
- Audio Stream: MPEG Layer II, AC-3, or Dolby
- Subtitle Stream: DVB bitmap

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A decoder must be able to sort through the transport stream, organizing the video, audio and data streams by program or service. It must also know when to present each part of the program or service to the viewer.

Program Specific Information (PSI tables) helps the decoder locate audio and video for each program in the transport stream and verify Conditional Access (CA) rights. The tables are repeated frequently in the stream to support random access required by a decoder turning on or switching channels. These information acts as a table of contents, allowing the decoder to quickly sort and access information in the transport stream.

3.1 Video Compression

The new video coding scheme called H.264 also know as MPEG-4 part 10, or MPEG-4 Advanced Video Compression (AVC) significantly improves the quality of codec video signals, at a given data rate when compared to the existing MPEG-2 standard, there is a considerable interest in the consumer industry for devices supporting H.264. The new content format AVC may reduce the service bit rate by as much as a factor of two and it is based on next-generation coding techniques.

Windows Media 9 also know as VC-1, is Microsoft's compression and proprietary technology that competes with MPEG-4 AVC.

The video compression rate for MPEG-2, H.264, and Windows Media 9 for a Standard Definition Channel and a High Definition Channel is showed in the table 1.

TABLE I
VIDEO COMPRESSION RATES

	SDTV	HDTV
MPEG-2	2 - 4 Mbps	16 - 19 Mbps
H.264	1.5 - 2 Mbps	6 - 8 Mbps
WM9 (VC-1)	1.5 - 2 Mbps	6 - 8 Mbps

3.2 IP Multicast

When data is broadcast, a single copy of the data is sent to all clients on the network. Unicast wastes bandwidths by sending multiple copies of the data. Broadcast wastes bandwidth by sending the data to the whole network whether or not the data is wanted. Broadcasting can also needlessly slow the performance of client machines. Each client must process the broadcast data whether or not the broadcast is of interest.

Multicast takes the strengths of both of these approaches and avoids their weakness. Multicasting sends a single copy of the data to those clients who request it.

Multicasting can dramatically reduce the network bandwidth that multimedia applications require.

Multicast groups provide several advantages. Groups are dynamic: clients can join or leave at any time. No elaborate scheme is required to create or disband a group. When a group has no members, it ceases to exist on the network. Groups also scale upward easily because as more clients join a multicast, it becomes more likely that the multicast is already being routed close to them.

The Internet Group Multicast Protocol (IGMP) is a protocol of IPv4 systems used to manage IP multicast membership to an intermediate multicast router.

In IPTV the MPEG-TS is encapsulated by multicast on Ethernet. Ethernet networks' low cost and ease operation relative to other metropolitan network technologies make it appealing to enterprise that wants to extend their LANs across a metropolitan or wide area.

Video channels and Pay-Per-View (PPV) in IP Video use Multicast, while Video on Demand (VOD) and Music on Demand (MOD) uses Unicast.

Obviously, when using IP-multicast, trick modes like "pause", "fast rewind", and "fast forward" cannot be used. However, on demand content, delivered over IP-unicast, supports trick modes.

IP-Multicast is a proven way to efficiently transmit multimedia content to a selected set of receivers. An IPTV stream (channel) consists of video, one or more audio stream, and additional information. However the video part of the stream is dominating.

3.3 Quality of Service (QoS)

QoS includes consideration of availability, accuracy, priority, and delay. QoS evaluates the availability of bandwidth. If a customer wants fewer delays on video and voice they need the option for selecting a quality of service, which has greater bit rate and fewer delays.

Voice, Video and Data traffic require different QoS treatment and need to be differentiating according to their priority level. For example, the premium channel of IPTV should have a higher priority than free-charged multimedia stream.

4. IPTV components and end user services

The major functional parts of the IPTV architecture are Head-End, where you have content acquisition, integrated with encoders and content-packing tools; Middleware responsible for service management, delivery and consumption; Content Protection, with real time encryption and Digital Rights Management (DRM); and Customer premise.

Head-end, Middleware, VOD servers, Transport and Access Network, Conditional Access, Digital Rights Management, and Set Top Box are the key elements of an IPTV network and are situated in figure 1 and described below.

4.1 Head End

The head-end is the primary point at which content is introduced to the IPTV network and thus it performs a number of functions.

As with a digital cable or digital satellite television system, an IPTV service requires a video head end. This is the point in

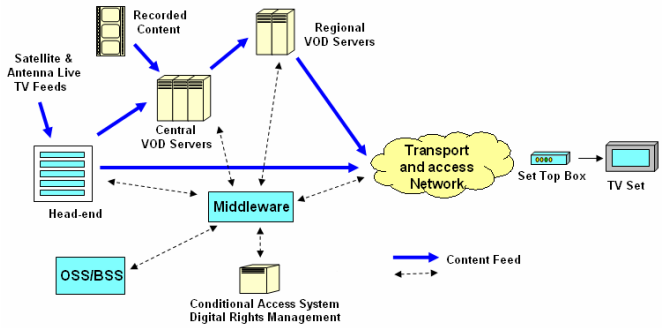

Fig. 1. Key Elements of an IPTV Network

the network at which broadcast TV and on-demand content is acquired and formatted for distribution over IP network.

Head-end can be identified by two types: Broadcast TV Head-end and VOD Head-end. The Broadcast TV Head-end system receives video stream in various formats, reformats and encapsulates the video streams, interfaces the core network and transmits the video signal over the core network towards the access network.

In addition to the main head-end, an IPTV system might be equipped with local head-end stations to capture local TV and radio signals.

The Head-end is comprised of many components including the encoders, middleware, VOD server, Broadcast TV server, subscriber manager, resource manager, session manager, and application manager.

Satellite signals are descrambled, the content is sent to an encoder, which compress and multiplex combined video and audio signals into MPEG-TS and stream it in a real time using multicast protocol (live streaming). It might also be streamed to and stored on on-demand servers.

4.2 Middleware

Middleware is responsible for undertaking the tasks required to provide an IPTV service, such as managing customer navigation and viewing; content packaging and service management; and interaction with authorization, operations support system (OSS), and billing support systems (BSS).

It includes web servers, application servers, content management systems, and similar tools that support application development and delivery.

Part of middleware software, Web Cache eliminates the need to repeatedly process URL requests for Application Server (AS) an Database (DB) servers by caching both static and dynamically generated content from one or more application Web servers. It also provides optimal performance by greatly reducing the load on AS and DB layers.

Summarizing: middleware offer central management of IPTV value-chain components Video server, STB, Conditional Access, and Content delivery. Responsible for creating the business management: pricing, payment, bundling, discount and spending limits; subscriber administration; content protection and Integrated with CRM and billing.

Some middleware vendors also offer the ability to create business reports.

Enable interactive television service providers to monitor their performance in terms of revenue and subscriptions and are designed to assist managers in decision-making and provide operational information in providing information as the most or least purchased movies and subscription trends.

Another very attractive feature offered by an IPTV is the real time Audience Meter, which reports TV channels usage.

IPTV platform permits a complete knowledge about customer preferences and behaviors in a non-intrusive way.

It is possible to obtain data from all users, an exact calculation of usage based on IGMP SYSLOG messages coming from DSLAM (Digital Subscriber Line Access Multiplexer). Whenever a user changes a channel, an IGMP leave command will be sent to a DSLAM followed by an IGMP join. So the DSLAM will collect all zapping changes from all users. The DSLAM location can be seen on figure 2.

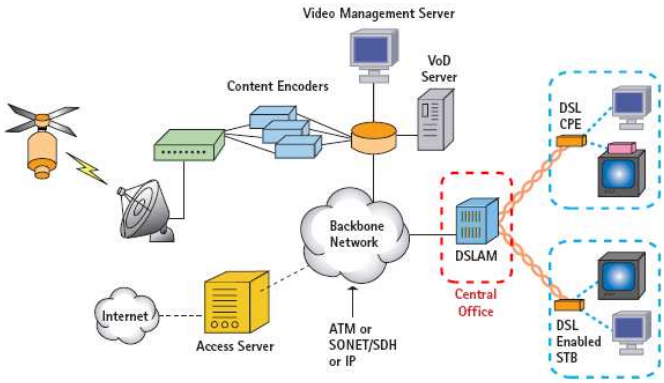

Fig. 2. Content receiver and DSLAM Location.

4.3 Video Server

Managed by the middleware, streaming Video Server, or Video On Demand (VOD) Server is a dedicated hardware with a great capacity of storage and stream.

VOD Server sends streaming data (MPEG-TS) to clients across the network using standard Real-Time Streaming Protocol, RTSP (Unicast transmission).

4.4 Content Protection: CAS/DRM

Considered number one issue facing content providers and mandatory on IPTV and handled by Middleware, content protection is the ability to protect the revenue capability of content owners and service providers by disabling illegal copies of digital content - Digital Rights Management (DRM) and ensuring payment for usage - Conditional Access System (CAS).

4.5 Ad Insertion

IPTV Solution offers the ability for the Service Provider to insert, create, replace and schedule advertising content in its negotiated channel line up. This functionality is known as Ad Insertion. This is a very attractive feature and enables a powerful source of revenue and marketing and revenue to Service Provider.

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In order to architect an ad-insertion solution additional equipment are required. Typically content providers send cue tones (DTMF signals) embedded in the left audio channel to mark the beginning and the end of a commercial. A very new technology called SCTE-35 can also be used as a trigger.

So, if the splicer receives this trigger, it will replace the original content by the commercial stored in the ad-server.

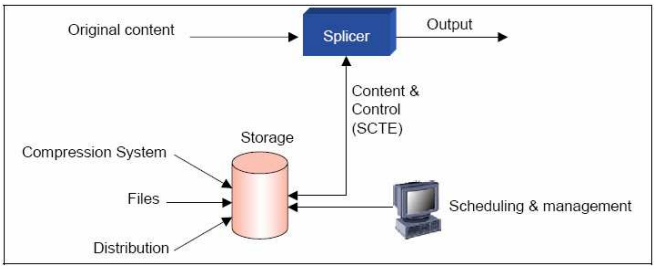

Fig. 3. Ad-insertion block diagram.

4.6 Transport and Access Network

The transport network can be made up three parts: core, edge and access.

The grouping of encoded video streams, representing the channel line up, is transported over the core network. These networks can be a mix of well-engineered existing IP networks and purpose-built IP networks for video transport.

The access network is the link from the transport network to the customer premise. Access networks can use variants of Asymmetrical Digital Subscriber Lines 2+ (ADSL2+), and Very High Speed Digital Subscriber Line (VDSL) to provide the required bandwidth to run an IPTV service to the customer premise. They can also use fiber technology like Passive Optical Networking (PON), or Fiber to the Home (FTTH) that is emerging as a new trend to reach homes. The access could also be a wireless connection, like WiMAX.

4.7 Customer Premises

Customer Premise is the location providing the broadband network termination functionality, using DSL modem. The IPTV receiver, Set Top Box (STB), may access a service using either IGMP or RTSP. Live Broadcast services are delivered over IP Multicast; they are streamed continuously and do not need to be initiated by the receiver. A STB can join or leave such a service by issuing the appropriate IGMP commands. VoD services, however, are delivered to a specific user via IP unicast and need to be initiated explicitly by the STB.

STBs enable customers to navigate, select, and receive content, and provide format conversion for presentation on TV. Typically is a client running HTML and relays subscriber transactions to middleware server providing access to services.

4.8 IPTV End User Services

Typically an IPTV solution support a full range of easy-to-use services that lead to a superior TV experience though a very intuitive Subscriber User Interface, including: Broadcast Television that is the multicast transmission of real time broadcast of live or prerecorded TV content. Many end-user services are already in use and many others are being created. Below, you can see the description of some end user services.

The Electronic Program Guide (EPG) is an interactive portal allowing an easy navigation to a list of all of the video and audio content available to the end user through the service provider, besides of an advanced program search.

Pay Per View (PPV) allows the Service Provider to offer live or pre-recorded programming to their subscribers at scheduled times (multicast), and accessible only through additional and specific purchase.

Video on Demand (VOD) enables an individual customer to demand a movie from a video library, with video categorization, to enable browsing by looking at DVD covers.

Network Personal Video Recording (NPVR) allows the ability to record broadcast content using carrier's network resources for a later unicast transmission including total trick plays functionality.

Web Access/Walled Garden allows the users to browse over the Internet or Portal via their TV sets.

Finally, IPTV has support for innovative applications by an architecture based on the IP Multimedia Subsystem (IMS).

5. Conclusion

More and more consumers are eager to have new services that cater above various digital devices anywhere and anytime.

The TV industry as a whole is being dragged, kicking and screaming, into the next generation of digital programming: High Definition Television (HDTV). And HDTV, with its vastly greater resolution, needs massively higher rates.

For future researches we would suggest emerging access technologies like VDSL2, and IPTV as an IMS application which would allow IPTV contents to mobile phones or pocket PCs.

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