

IPTV: How it works?

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IPTV or IP Television is a process, a method of preparing and distributing Television signals over an IP based data network. Content streams are acquired, demodulated and decrypted if necessary, then re-encoded digitally for IP transport possibly with additional compression and new encryption. IPTV signals, or streams, are distributed on an IP based network and viewed on a IPTV capable viewing device, usually a Set Top Box.

Note: This article discusses building and operating a complete headend, for the purpose of competing with or replacing a traditional CATV service, to provide coverage to a metro or regional area. We are not discussing the deployment of pre-multiplexed content such as Comcast Corporation's "headend In the sky" offering or Satellite Master Antenna TV (SMATV) systems.

The key steps to delivering IPTV to the end user

- Acquiring the Programming – The vast majority of this content, will be received via satellite, requiring a headend facility. Additional content, local network affiliates, may be received off-air in either analog or digital off air format, or even terrestrially, as an ASI or SDI stream provided over fiber optic transport from a nearby broadcaster.
- Encoding the streams– The digital or analog content that has been received has to be re-encoded for multicast IP transport. This stage would also encompass the encryption that will be required by the programmers.
- IPTV Distribution Network – The distribution network obviously needs to be some kind of wide area network, as it needs to deliver IPTV services to the customers' homes. This network needs to have adequate bandwidth with the ability to implement Quality of Service (QoS) to the end users to deliver IPTV content. These requirements can be attained with the mixing and matching of many current technologies.
- Middleware – The end user, the television customer, expects a user friendly viewing experience. Typically presented in the form of an Electronic Program Guide. The middleware presents this to the viewer via the Set Top Box.
- IPTV Viewing Device – This is generally considered to be the Set Top Box, not too different in appearance from the STB provided by the cable company for their digital service tier, or the STB included with a home satellite package, which is also a satellite receiver. The IPTV STB works hand in hand with the middleware.

Overview of key steps to delivering IPTV

Acquiring the Programming

The content that the IPTV company delivers to its end user is owned or managed by some person or some entity (for example: in almost all cases, the leagues retain ownership of major league sports content). In this industry the entity that owns the rights to the content is called “The Programmer”. Once the IPTV Service Provider (IPTVSP) has acquired the rights to collect and redistribute this material, then the IPTVSP has to build a headend facility to process this content for distribution to the end user

The headend is the physical facility where the media streams are collected and de-coded/re-coded as Multicast IP for distribution. This is the core of the IPTVSP’s world. This facility is not dramatically different in principal from a traditional Community Access TV (CATV) or Cable Television headend. The IPTVSP headend can be broken into three distinct sections: satellite reception, encoding and encryption, and distribution. In this section we are primarily concerned with the reception of the streams via satellite.

The inside of this headend facility will be lined with rack after rack of commercial satellite receivers. Outside receiving the content that is coming down from many satellite transmitters will be a large multi-focal point c-band dish or a field of fixed single focal point dishes. This field is occasionally referred to as a “dish farm”.

The signals that are being broadcast from space are very weak by the time that they reach the earth and require the amplification of the large parabolic reflector (that is the recognizable part of the dish.) Most places in the United States can get by with the use of a five meter dish. There are places where more gain is required, or the headend designer may choose to engineer a larger dish for more margin, boosting the robustness of the system.

Inside the headend the individual signals captured by the dish will be split and shared by the many receivers that need to “look” at each of the satellites. An active splitter can be used which should provide Unity Gain on the outputs; it also delivers DC current on the input (back to the dish) to power the Low Noise Block amplifier (LNB). After splitting, the signal is run to the various receivers for demodulation.

Most headends being built today would be considered digital headends. This means that digital content is being delivered to and from the satellites, and stays digital all the way to the Set Top Box. Of course there are some exceptions, as there are a few streams not yet available digitally.

In the mostly digital environment, the receiver will be connected to an input from the satellite dish or splitter. The receiver will be tuned to a transponder, which represents a frequency or a channel. Other settings, such as symbol and forward error correction rates must be set, as well as other technical settings as per the requirements of the

programmer's uplink operations center. The receiver will demodulate the stream or streams, and it will decrypt the encryption that the programmers have used to protect their intellectual property for the trip to outer space and back. The programmers designate the type of encryption used, and this in turn dictates the receiver manufacturer and sometimes the model. The digital output of the receiver is the Asynchronous Serial Interface (ASI). ASI is a compressed format designed to carry multiple MPEG2 streams.

In the analog environment the receiver gets input from the satellite, which it tunes and decrypts similarly to the digital example, but then the video and audio exit the receiver on separate analog connectors for analog to digital conversion.

Encoding the content

These digital outputs from the various receivers will be injected into an encoding device to be assigned a multicast IP address. In a standard definition environment, these streams can be encoded in MPEG2 format or in MPEG4 format. The higher cost of MPEG4 encoding equipment encourages the encoding as MPEG2 if sufficient bandwidth on the distribution network is available. We will discuss this in detail later on. If the content in question is High Definition (HD), then without question it will need to be encoded in MPEG4 not to overwhelm the distribution network. (A typical HD MPEG2 stream consumes about 20 Megabits per Second.)

The process of converting analog SD to MPEG2 or MPEG4 includes the single extra step of analog to digital conversion before being assigned a Multicast IP address. This extra step normally requires different, encoding equipment that tends to be less efficient. As more and more content streams are becoming available on the same ASI connection, the size of the digital headend is being compressed through the application of modern processing power. The limiting factor is the space required for the ports. A single analog stream consuming an entire port on the input of the encoding equipment seems wasteful in this day of the digital headend.

Please note, we do not cover the concept of analog HD because there just isn't the need, HD comes out of the receiver only on the ASI (or rarely on the serial digital interface/SDI) port. There is no video signal available on the traditional analog or NTSC interface when receiving an HD stream.

Once all the received streams are demodulated and Multicast IP encoded, encryption still needs to be applied to specified streams. The sub-system in IPTV responsible for encrypting content is known as the Digital Rights Management (DRM) package. This package consists of one or more servers, which behave as a two-port function on a block diagram. Unencrypted multicast IP content goes in, encrypted multicast content comes out.

Due to the above mentioned in/out methodology, the headend engineer needs to know, for design purposes, early on which streams will require encryption, as these streams and

their associated encoding equipment need to be segregated. Specifically, the encoder outputs need to be directed onto different segments on the headend's internal network. Content that needs encryption has to be isolated from the distribution network until such time as the encryption has been added. Only then can these streams be merged with the streams not requiring encryption for transport out on the distribution network.

While the big piece of DRM is the encryption of the content, it would not be very much use if there was no way to decrypt the signal at the far end. This requires some additional puzzle pieces to fall into place.

The first is that depending on how the DRM is implemented the headend may require an additional database server in the form of a Key Management Server. This server delivers and keeps track of rotating decryption keys for the STBs to be able to decrypt content. This vital task homogeneously belongs with the family of boot servers and DHCP servers, therefore it is usually grouped with those devices rather than the DRM package.

The second is that the DRM provider has to support and ensure full compatibility with the Set Top Box manufacturer, the STB operating system vendor, and the STB video presenting software vendor so that the STB can be made to accept the key and decrypt the encrypted content. This integration is usually version dependant and requires code changes on multiple architectures when any one participant makes a change.

IPTV Distribution Network

Building an IPTV distribution Network can be attained with the mixing and matching of many current technologies. As emerging technologies become available to deliver more bandwidth to the home, they will certainly be incorporated and used by the IPTVSP's network engineers as they see fit to utilize these new technologies most efficiently.

The IPTV distribution network needs to have adequate bandwidth and quality of service to the end users to deliver your content, and it needs to be capable of transporting IP Multicast based communications. Additionally, the network needs a small amount of bandwidth to deliver other revenue generating opportunities.

The most prevalent types of networks for IPTV distribution are Fiber To The Home (FTTH/FTTx), Ethernet Passive Optical Networks(PONs), or a Hybrid network using fiber optic distribution throughout a metro area coupled with a Digital Subscriber Line (DSL) technology for the "last mile" transport. The typical DSL types that have been used for IPTV are VDSL or ADSL2. Although these high capacity DSL technologies at first glance seem to be ideal to deliver this "new technology" the probability of building out a new IPTV system employing DSL is decreasing rather quickly, as customer demands quickly exhaust the maximum capabilities of these technologies.

For the IPTVSP to stay ahead of or even be competitive with the traditional cable company, the IPTVSP has to offer compressive high definition packages and on-demand

video services. These two features make extreme demands on network design that did not exist just a few years ago. Review the sample bandwidth calculations in appendix A where we show some simple examples of how this has impacted network design.

Wide area high bandwidth networks can be so diverse in both components and capabilities only a small fraction of possibilities could be addressed here. While the network acts as the plumbing through which the content flows, it is just a conduit and is effectively interchangeable; the available infrastructure will often times dictate how the IPTVSP chooses to deliver its content streams.

Middleware

Middleware is the glue that holds the IPTVSP together. Without the middleware the IPTVSP has a lot of expensive but useless equipment. It may have been noticed that up until this point in this series all reference to content has been identified as streams, not channels. This effort not to address streams as channels was directed toward this purpose; without middleware there are no channels, just streams.

Setting aside for a moment the very real existence of encryption, the technically savvy could connect a PC to the distribution network and, using a web browser with the correct plug-in installed, or other multicast capable application, could access the content by going to the address and port number of the multicast stream, for example `igmp://<ipaddress>:<port>` or `igmp://233.34.56.78:1234` (note: this is a randomly selected address within the designated multicast IP range). This method of viewing the content is not what the viewing public would consider an acceptable viewing experience. This is where middleware comes in.

Middleware manages input and output to or from several databases, generates the presentation to the TV viewer in the form of the Electronic Program Guide (EPG), facilitates navigation in the EPG and, of course, channel surfing. The following list highlights these interactions:

- The middleware must access and possibly manage the database of what content stream is on what multicast IP address and port number.
- The middleware must access and possibly manage the database of what channel number the IPTVSP wants assigned to each content stream.
- The middleware must access and usually manage the database of what “package” each channel is a member of.
- The middleware must access and possibly manage the database of subscribers, their associated Set Top Boxes, and what packages or individual channels they are subscribed to.

- The middleware must access the database which has the 1/2 hour by 1/2 hour programming for each stream that the IPTVSP has redistribution rights for. This database is usually purchased, via subscription, from some third party aggregator of this information.
- The middleware must keep track of VOD purchases and have the ability to interact with the billing system to ensure that those VOD purchases are properly reflected on the subscriber's bill.
- The middleware must be able to generate and distribute a functioning, navigable guide to the STB that enables the end-user to view the EPG select and watch a program, as well as to navigate up and down within their subscribed channels using the up and down "CH" arrows on the remote (to surf).

For example: when a user switches on their Set Top Box, the middleware has first to determine whether the unique identifier of that STB is assigned to a subscriber whose accounts are up to date. Then the middleware delivers to the STB for presentation the list of channels that this user is subscribed to; consequently this is what the STB is authorized to display. When the user presses the guide button on the remote, the middleware has to dynamically generate or have deliverable the Electronic Program Guide (EPG) that displays all the program titles and descriptions for content to which this user is subscribed. Typically this guide is navigable up and down, representing all programs showing now. Additionally, the guide also displays programming that is upcoming in the next few hours. The guide is usually navigable forward in time for at least one or more days, as well as back in time a day or more so the user can see what they have missed.

The middleware needs to be as or more robust than the most durable of any of the IPTVSP's systems. Consider that a serious network segment outage will only affect a portion of the subscribed customers, and likewise a receiver or satellite dish/LNB failure will only lose some of the streams; a middleware outage causes 100% of subscribers to be without 100% of the content.

IPTV Viewing Device, the STB

The Viewing Device or Set Top Box is the adapter, which connects to the user's television. It is similar in appearance to the STB provided by the cable or satellite company for their digital services.

The STB is the hardware item that the user associates with the IPTVSP, but it is useless without a middleware solution. Set Top boxes need also be affordable and disposable, as one or more will deploy to each subscribing home and some will be lost or receive wear and tear beyond where the IPTVSP can reasonably re-deploy it to a new customer.

While discussing middleware previously, it was mentioned that a PC with the right software could view multicast IP streams. The modern STB is in fact an embedded PC

with a customized operating system highly optimized to do what it is supposed to do, do it well, and to do nothing else.

An STB typically is an embedded PC with a processor and memory capable of decoding MPEG2 or MPEG4 encoded video, plus simultaneously dealing with the processor overhead that enforced encryption adds to its burden. The duty of presenting the guide and acting on input events from the user with the remote are small in light of its real duties, digital signal processing.

Given the above criteria, the IPTVSP is looking for little more in the STB, particularly as features have real costs and when deploying these items in the tens to hundreds of thousands, even pennies add up.

IPTV signals can also be viewed on a PC; many software media players can play Multicast streaming content. However, to be a legitimate IPTV client a media player would have to interact with the Digital Rights Management package. Only a minuscule fraction currently does - those developed in-house, jointly by middleware and DRM companies. The protection of the programmer's intellectual property always has to stay at the forefront of thought at every step of the IPTV company design and build. Without the satisfaction and sanction of the programmers the IPTVSP and the IPTV industry has no product.

Coming soon, part 3: IPTV; Features & Benefits

Appendix A: Sample Bandwidth Calculations

Bandwidth calculations, part 1: How much bandwidth capacity to the home?

Working backwards from the home, the IPTVSP needs to put a set top box at every TV, as there is no cable ready/basic package that can be hooked up for limited reception. This means that for standard definition content to be delivered to four TVs in a home, encoded as MPEG2, encoded at 3.5Mb/s, plus overhead, a minimum of Sixteen Megabits per second reliable connection must be available. Using ADSL2+, speeds of this capacity are only available within the first few thousand feet from the Central Office (CO), practically within sight of the CO. If those four TVs are HD capable and the end-user wishes to subscribe to an HD package for each one, those four streams must be encoded as MPEG4, encoded at 11Mb/s, plus overhead, consequently a minimum of Fifty Megabits per second must be available. Note, it is also good practice to have the additional bandwidth of an entire stream plus overhead available at all times to accommodate certain settings within the Internet Group Management Protocol(IGMP) snooping to allow fine tuning of the network for fast channel changes. You can already see how 100

megabits per second fiber to the home looks like your minimum connectivity standard and may be insufficient in just a few years.

Bandwidth calculations, part 2: IPTV Channel Lineup 2007/2009

We start at the headend and consider the streams available, or the streams that the IPTVSP wishes to make available. More than 150 SD content streams at 3.5Mb/s, plus 25 HD content streams at 11Mb/s, plus overhead immediately requires a distribution network from the headend to the COs or equivalent location with a 920 Megabit second capacity. But the IPTVSP cannot design and build for today. Looking forward just a few years, it is expected that those ratios will be reversed, with most of the content being available in HD. That calculation looks significantly different. With 25 SD content streams at 3.5Mb/s, Plus 150 HD content streams at 11Mb/s, plus overhead the distribution network now needs to be at a minimum two Gigabits per second, this assumes there has been no additional content streams added. This estimate also hasn't taken into consideration... On Demand Video Services

Bandwidth calculations, part 3: On Demand Video Services or Video On Demand (VOD)

With modern storage capabilities, it is not expensive or difficult for the IPTVSP to store hundreds of popular movie titles for their VOD offerings. The bandwidth required to deliver VOD services is a function of the VOD "take rate" rather than the offerings, though the take rate will depend on the desirability of the content offerings. Even if two subscribers are watching the same offering, unless they subscribed to that offering simultaneously the distribution network needs to deliver two 3.5Mb/s for SD, or 11Mb/s streams. Of course the IPTVSP could choose to have a poor selection of content to discourage subscribership in the VOD offerings, but we are not here to discuss bad business plans. Lets look at a hypothetical IPTV deployment: regardless of the size of the city, lets assume that the IPTVSP has deployed 100,000 Set Top boxes to some number of residences. If one percent of STBs simultaneously subscribe to a VOD offering, and half of the offerings are HD we have a bandwidth consumption as follows: 500 SD content streams at 3.5Mb/s, plus 500 HD content streams at 11Mb/s, plus overhead the capacity of the distribution network dedicated to VOD which must have at least 8.4 Gigabits per second. Remember, this 8.4 Gb/s is just an estimate: as the VOD take rate is dependant on many factors. The obvious simple percent of subscribers is one factor, but high quality content , or even inclement weather can dramatically increase the subscribership drastically increasing the network load.

The astute reader will note that the bandwidth requirements derived in this hypothetical example added to our year 2009 channel lineup above exceeds the capacity of a 10 Gigabit network for the IPTVSP's metro distribution. This forces the IPTVSP to consider preparations for implementing 10 Gigabit link aggregation models or move to a 60 Gigabit distribution network.

Link to original web document:

<http://www.worleyconsulting.com/publications/2007/IPTVhow.html>