Internet Protocol Television (IPTV)

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Executive Summary

This technical report discusses on IPTV technology. Internet Protocol television (IPTV) is a system through which internet television services are delivered using an architecture and networking methods of the Internet Protocol Suite over a packet-switched network infrastructure. IPTV services may be classified into three main groups: live television, time-shifted programming, and video on demand.

IPTV works on the TV with a set-top box that accesses channels, subscription services, on demand and other interactive multimedia services over a secure, end-to-end operator managed broadband IP data network with desired QoS to the public with a broadband Internet connection

This report discusses the IPTV architecture, network technologies, implementation of IPTV, different types if STBs that are in use in New Zealand, The standards, different business models, hardware and software of IPTV are described.

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Chapter 1

1. Introduction

In the 21st century, the access with broadband internet and downstream data rates of several Megabit per second (Mbit/s) is making a steady progress. With the increasing number of households are getting used to video streaming and download, use of the Internet Protocol (IP) to enable interactive retrieval of video content from the Web. This type of IP based television service is known as WebTV [1]. However WebTV does not provide a guaranteed quality of service (QoS). Therefore now the telecommunication companies are making an attempt to overcome the deficiencies of WebTV and launched the so-called IPTV.

1.1 What is IPTV

Internet Protocol Television (IPTV) is a system where a digital television service is delivered over Internet Protocol network [2]. Werner [1] describes that "IPTV is not a well-defined term and may be a source or ambiguity and sometimes confusion".

IPTV works on the TV with a set-top box that accesses channels, subscription services, on demand and other interactive multimedia services over a secure, end-to-end operator managed broadband IP data network with desired QoS to the public with a broadband Internet connection.

IPTV system may also include Internet services such as Web access and VOIP where it may be called Triple Play and is typically supplied by a broadband operator using the same infrastructure. IPTV is not the Internet Video that simply allows users to watch videos, like movie previews and web-cams, over the Internet in a best effort fashion. IPTV technology offers revenue-generating opportunities for the telecom and cable service providers. For traditional telephone service providers, Triple Play is delivered using a combination of optical fibre and digital subscriber line (DSL) technologies to its residential base. Cable television operators use a similar architecture called hybrid fibre coaxial (HFC) to provide subscriber homes with broadband, but use the available coaxial cable rather than a twisted pair for the last mile transmission standard. Subscriber homes can be in a residential environment, multi-dwelling units, or even in business offices.

From the service provider's perspective, IPTV encompasses the acquisition, processing, and secure delivery of video content over an IP based networking infrastructure. The type of service providers involved in deploying IPTV services range from cable and satellite TV carriers to the large telephone companies and private network operators in different parts of the world.

The Figure 1 shows us a block diagram of simplified IPTV system.

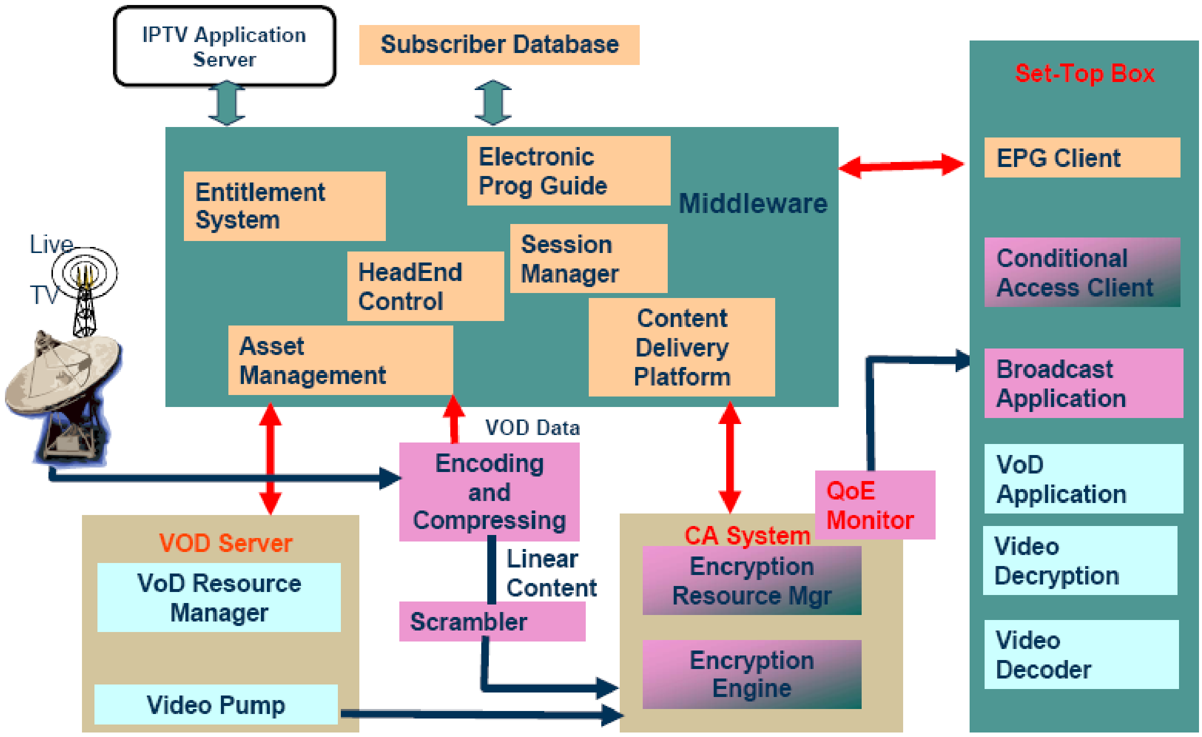

Figure 1: Simplified IPTV system [3]

1.2 IPTV Features

IPTV has number of features. According to [4], these features are:

- ***Support for interactive TV:*** The two-way capabilities of IPTV systems allow service providers to deliver a whole raft of interactive TV applications such as standard live TV, high definition TV (HDTV), interactive games, and high speed Internet browsing.
- ***Time shifting:*** IPTV in combination with a digital video recorder permits the time shifting of programming content.
- ***Personalization:*** An end-to-end IPTV system supports bidirectional communications and allows end users personalize their TV viewing habits by allowing them to decide what they want to watch and when they want to watch it.
- ***Low bandwidth requirements:*** Instead of delivering every channel to every end user, IPTV technologies allow service providers to only stream the channel that the end user has requested. This attractive feature allows network operators to conserve bandwidth on their networks.
- ***Accessible on multiple devices:*** Viewing of IPTV content is not limited to televisions. Consumers often use their PCs and mobile devices to access IPTV services.

1.3 IPTV Advantages

- IPTV signals are 100% digital, so the days of analogue TV are fast becoming a thing of past.
- IPTV works on any existing internet connection. So we just need to install the set-top-box and power it on.
- IPTV doesn’t require to wires to get its signal. The newest IPTV set-top-boxes work on wireless signals.
- Programs can be stored on servers and ready to view with the click of a button on IPTV remote (in contrast to linear broadcast TV).

1.4 Video on Demand

The idea of this to allow viewers to watch any programme they desire whenever they want to watch [5]. But as the technology advances and costs come down, video on demand (VOD) becomes more and more attractive to service providers.

The basic concept of VOD is based on video programming that is stored and then delivered to a viewer when it is required. This storage can take the form of a centralised server that is equipped to send programming simultaneously to a hundreds of viewers, or it can take the form of more distributed storage throughout the network. At the limit, individual storage devices for each viewer can be located in individual STBs [5].

Unicast connection is set up between the customers’ STB and the delivering streaming server. The signalling for the trick play functionalities (pause, wind, and rewind) is assured by Real Time Streaming Protocol (RTSP). The most common codecs used for VOD are MPEG-2 and MPEG-4.

1.5 Triple / Quadruple Play

Triple play refers to multiple services being delivered by a single service provider, such as voice (telephony), data (internet access) and television services. Quadruple play adds mobile telephony to the mix [5].

From a service provider perspective, triple play services offer the combined cash flow from three separate services that can be used to pay for a common network that is capable of delivering all of them. Service providers usually offer discounts to customers who buy more than one service, which has proven to be a successful marketing ploy.

Triple play focus on a combined business model rather than solving technical issues or a common standard. Quadruple play is often supported by dual-mode GSM plus WiFi cell phones that shift from GSM to WiFi when they come in range of home wired for triple play service.

Chapter 2

2. Current IPTV and Its Evolution

2.1 IPTV Deployment

IPTV is a system of delivering television content to consumers over the infrastructure of the Internet. With the proliferation of broadband networks set up by telephone companies to offer broadband Internet to consumers, IPTV has overcome the problem of having limited bandwidth that was once a major barrier to deployment [6].

Currently there are two different ways consumers can get IPTV. They can buy a "set top box" which will convert an IPTV signal and play it on their television. The other option is to watch on a PC. Many IPTV service providers also offer voice and data capabilities with the IPTV service, making it a true "triple play" use of the broadband network. In the market of broadband applications IPTV is a major upset. With the advent of IPTV, many cable television companies are being expelled from the market of providing low cost television, data and voice broadband applications to consumers.

Business applications are also in development. Services such as streaming video are widely available on IPTV due to the scalability of the medium. The categories within IPTV are still gel, but possibilities are still wide open as to which of the many versions of IPTV will become standard. Companies are in the initial struggle to become leaders of the market, but at this point it is anyone's game. There is no doubt that IPTV is the next generation for television content, but it has yet to be determined which companies will be the benefactors of the innovations that are now taking place [6].

2.2 Global Growth of IPTV

Worldwide subscriber base for IPTV services is expected to expand more than 26 times from 2005 to 2010 [7]. According to the Al-khatib and Alams' research [7] global IPTV subscribers are expected to grow from 2.4 million in 2005 to over 63 million in 2010. Figure 1 shows the expected rate of growth of IPTV subscribers.

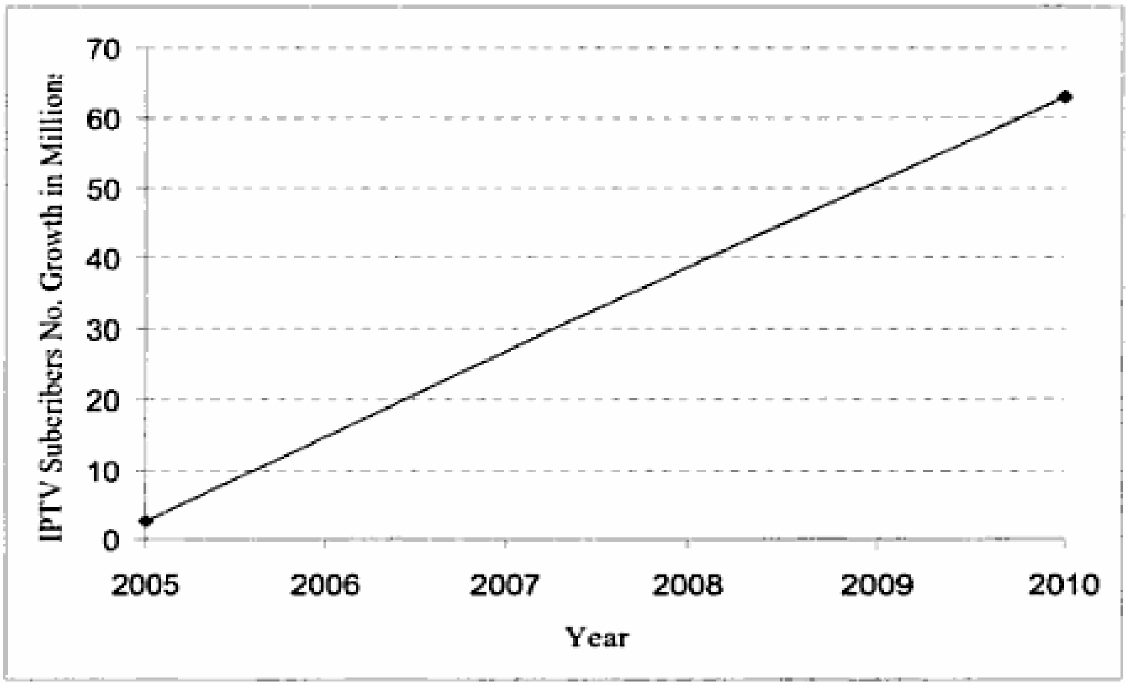

Figure 2: Expected growth of IPTV subscriber base [7]

The IPTV subscriber base is expected to generate more than $27 billion in revenue for all IPTV services in 2010 [7]. IPTV subscriptions are poised to grow from over 30 million in 2010 to 68 million by the end of 2014, according to forecasts from analyst form Strategy Analytics.

Chapter 3

3. IPTV Building Blocks

The figure 3 shows the basic building blocks that are required for implementing IPTV. The home gateway has to have powerful processing power and enough network bandwidth to provide networking service and to cope with various customers. In order for a system operator to deliver IPTV, it would require encoding, broadcast, and do the appropriate management before the end user can connect their set-top-box.

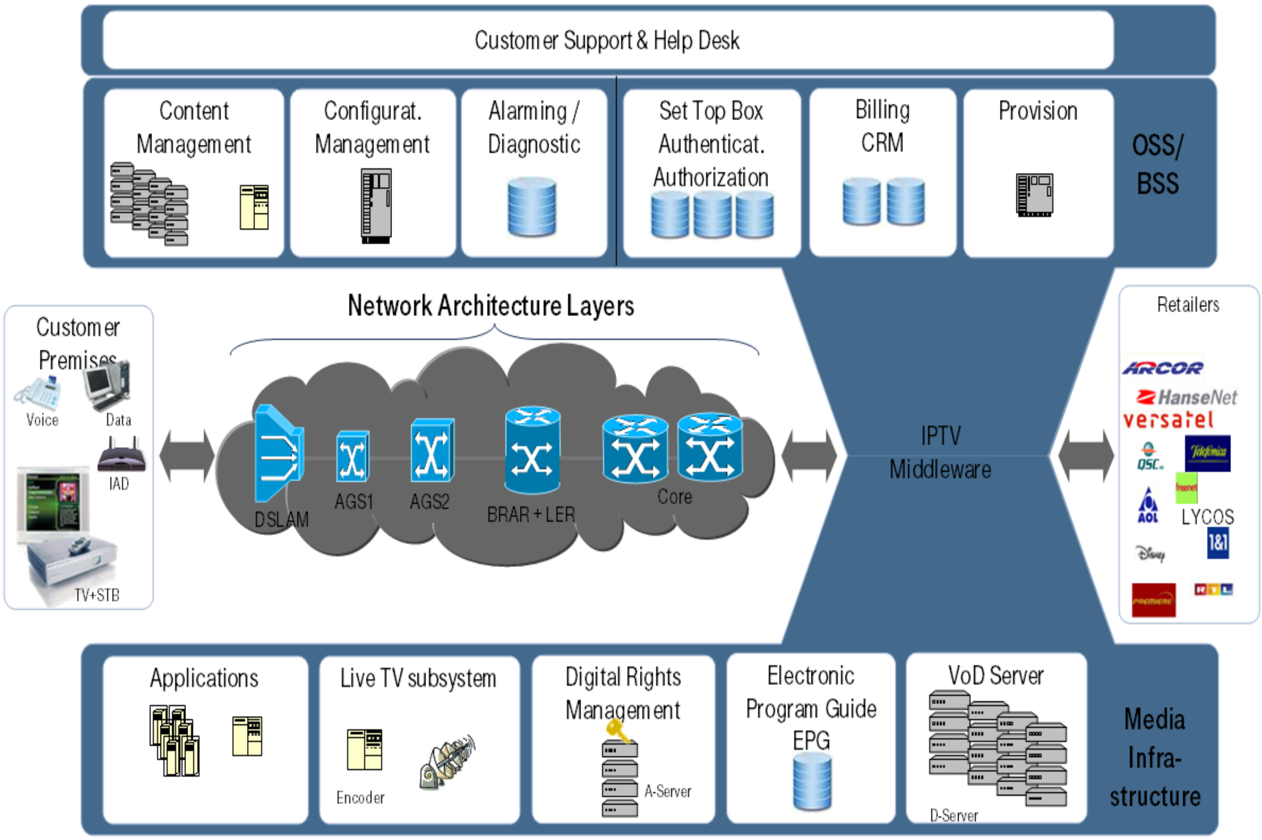

Figure 3: IPTV Basic Building Blocks [8]

Chapter 4

4. IPTV Architecture

A typical IPTV architecture is comprised of the following ***functional blocks***:

- Super head-end: Where most of the IPTV channels enter the network from national broadcasters
- Core network: Usually an IP/MPLS network transporting traffic to the access network
- Access network: Distributes the IPTV streams to the DSLAMs
- Regional head-end: Where local content is added to the network
- Customer premises: Where the IPTV stream is terminated and viewed

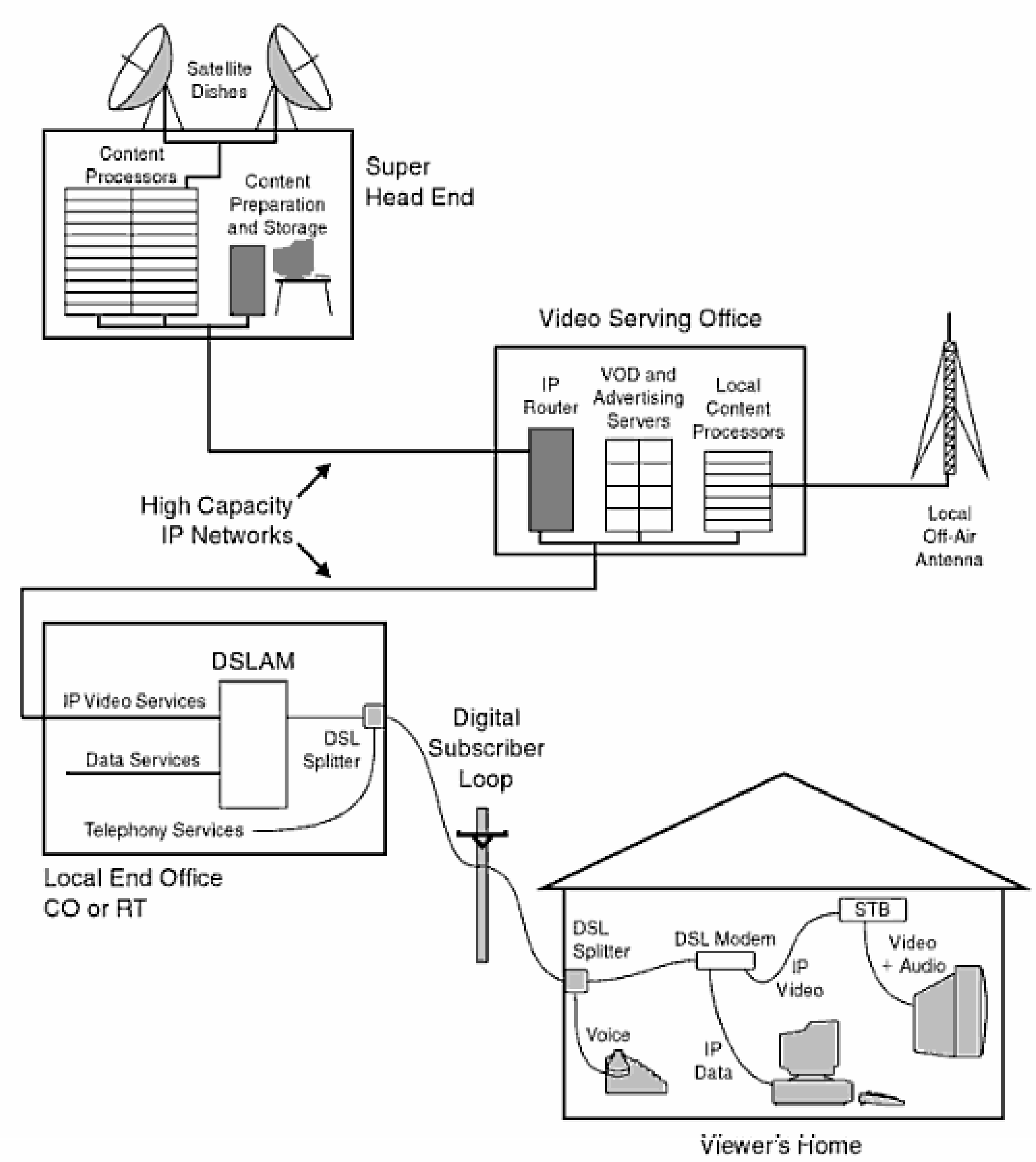

Figure 4: Typical IPTV System Architecture [5]

For a very large IPTV delivery system, there is often a hierarchy of facilities constructed to deliver video signals across a large expanse of territory. One Super Head-end can serve millions of customers by processing the video channels that are common to all subscribers across the serving area. A Video Serving Office is located in each region as required to handle local programming and channels specific to a single city or geographic area. The Remote Terminal can serve as a Regional Head-end that contains the equipment needed to actually deliver the programming to customers in local area.

Broadcast information coming from an antenna or a satellite dish at the Super Head-end is mainly distributed using MPEG-2 multi-program transport stream (MPTS) to the video service node. The distribution of the actual SDTV or HDTV channel content is performed using various devices on the access network, such as digital subscriber line access multiplexers (DSLAM) and other technologies like fibre-to-the-home (FTTH) can be used to interface with the user's STB. For IPTV, each channel is distributed using a multicast IP address.

Chapter 5

5. IPTV Networking Technologies

IPTV technology is part of a new breed of services designed to facilitate access to video entertainment. It provides access to digital TV over the IP transport medium from a head-end device to the end user's TV set-top box (STB). Most service providers use a dedicated transport network to support IPTV.

5.1 IP Distribution to the STB via DVB IPI

DVB has had a technical ad-hoc committee (TM-IPI) dedicated to IP distribution to the STB since 2000. It has a responsibility to provide a standard for the IP interface connected to the STB. The special feature about this technology in contract to the other standard bodies and traditional broadcast methodology is that it starts at the STB and then works to outwards [9]. The standards bodies of TM-IPI are shown in figure below.

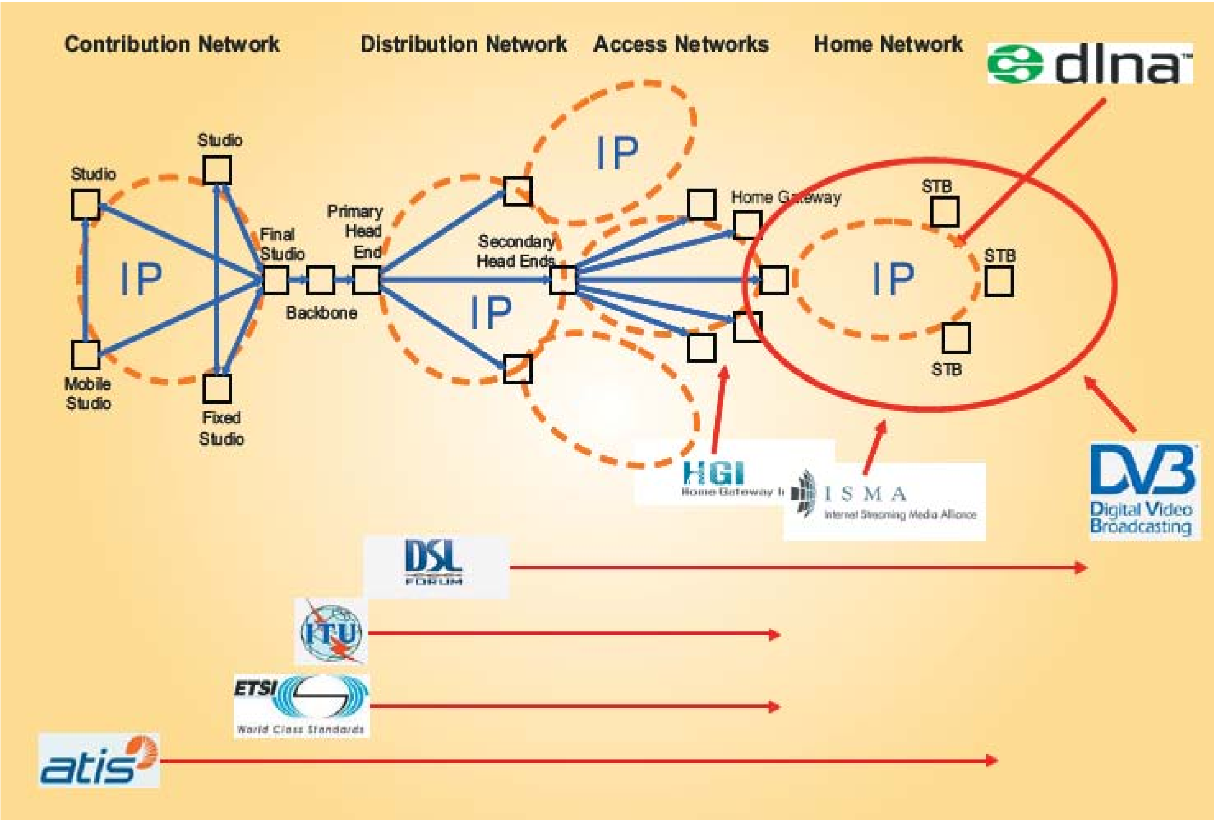

Figure 5: IPTV related activities of selected standardisation bodies [9]

- **DLNA** (Digital Living Network Alliance) for the home network
- **HGI** (The Home Gateway Initiative) for the standards surrounding the residential gateway between the broadband connection and the in-home network
- **ISMA** (The Internet Streaming Media Alliance) for the transmission of AVC video over IP
- **DSL Forum** for the standards surrounding DSL and remote management of in-home devices including STBs and residential gateways
- **ITU** which, via the IPTV Focus Group, is standardizing the distribution and access network architecture
- **ETSI** which, via the NGN initiative, is standardizing the IP network carrying the IPTV
- **ATIS** which, via the ATIS IPTV Interoperability Forum (ATIS-IIF), is standardizing the end-to-end IPTV architecture including contribution and distribution.

5.2 IPTV over DSL versus DVB over satellite and cable

In contrast to other technologies, the difference in IPTV over DSL is that the client-server architecture used for IPTV sit between the provider backbone and the IPTV home. The difference here is that not a single programme goes automatically into the IPTV home. A simplified comparison of IPTV over DSL with the DVB-S and DVB-C is shown in Figure 6.

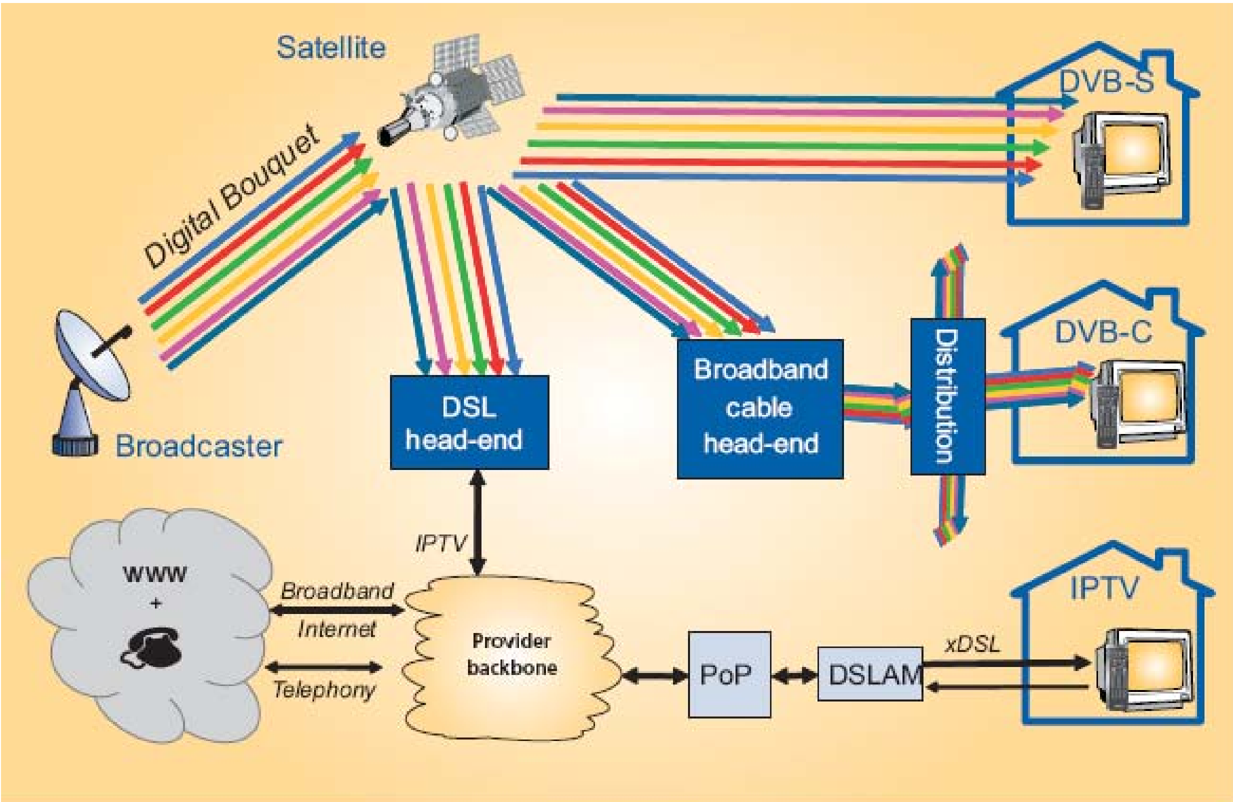

Figure 6: Comparison between IPTV over DSL with the DVB-S and DVB-C [1]

The coloured lines represent the different television programmes of a digital bouquet that are bundled together in one or more multiplexes. Each of these carries a multi-programme transport stream (MPTS) [1]. Similar to Broadband cable head-end, the DSL head-end picks up the satellite signals and converts them to IPTV signals. But the difference is that when we press the button of an IPTV remote control, it is communicate back via the return channel to the service provider. Then the server routes the requested programme as a single programme transport stream (SPTS), over the backbone to the point of presence (PoP) at the DSL access multiplex (DSLAM). The technical challenge for IPTV is the short time delay during channel hopping [1].

Chapter 6

6. IPTV Standards and Solutions

Setting standards for IPTV would be difficult at best. There are multiple areas to cover, as IPTV is very broad subject, and the medium was not intended to transport audio and video when it was created. Moreover, some specific features of this medium allow some services while outdating some of the former schemes based on broadcast [10]

Standardization is important in the telecommunications industry. Especially when talking about such a complex and large system as IPTV. So it requires many standards for the user's vote to be securely recorded when pressing the red button on the remote control. The main standards body for IPTV has emerged to be ETSI (European Telecommunications Standardization Institute), through the branch that develops standards for the "next generation networks", which many telecom operators are deploying.

Table 1: The standards organisations driving IPTV [11]

Name	Focus	Type of organization	Primary industry
Open IPTV Forum	End-to-end IPTV service, including interaction and quality of service	Industry consortium	Telecom
ITU-T	IPTV Focus Group	Formal standards organization	Telecom
ETSI TISPAN	IPTV based on IMS, and referencing relevant standards for the transport layer	Formal standards organization	Telecom
ATIS	IPTV for cable TV providers	Membership organization	Cable-TV
SCTE (Society of Telecommunications Engineers)	Technologies related to digital cable television	Industry association	Cable-TV
DVB Forum	IPTV and interactive television, primarily for broadcasters	Industry consortium	Broadcasting

Chapter 7

7. Set-top Boxes

An IP set-top box is a dedicated computing device that serves as an interface between a television set and a broadband network. In addition to decoding and rendering broadcast live TV signals, a set-top box provides functionality that includes video-on-demand (VOD), electronic program guide (EPG), digital rights management (DRM), and a variety of interactive and multimedia services. Set-top boxes can support additional features such as Web browsing, e-mail and viewing e-mail attachments, advanced multimedia codecs, home networking and PC connectivity including playback and rendering of content stored on the PC (photos, music, and personal videos), gateway functionality, instant messaging (IM), and real-time voice over IP (VoIP). These types of advanced functionality are in demand by end-users, enable incremental network operator service opportunities, and allow set-top box manufacturers to easily offer a large range of differentiated devices [12].

Also to provide secure delivery of satellite data in IPTV systems, service providers charge subscribing fee by scrambling the program in conditional access system using control words. At the receiver end, smart card is used to decrypt the control words and transfer them back to set-top box to descramble the scrambled program. Therefore, secure communication between set-top box and smart card is closely related with the benefit of service providers and the legal rights of users [13].

Current set-top box development is driven by service provider requirements and customer demand for new features. Priorities for service providers include the capacity to deploy, using minimal capital expenditures, new revenue-generating services and multimedia and entertainment-oriented applications on a set-top box to meet changing customer requirements over time. Service providers also need to ensure that copyrighted content is protected from unauthorized distribution. To accommodate these expectations, the set-top box operating system platform must be extensible and remotely upgradeable, and include both rich multimedia technologies and fundamental security features, such as access control.

7.1 Basic Functions

The main job of the STB is to receive the incoming IPTV signal and convert it to a video signal that can be displayed on the viewer's television. This also provides the user interface that allows viewers to select the video programming to be viewed. To do these tasks STB has the following ***functional elements*** [5]:

- Network Interface, to receive the IPTV signals and transmit user commands
- Video and audio outputs, which are connected to the viewer's video display and speaker system

- User interface, both on the front panel of the STB and by way of an on-screen display and remote control
- Conditional access hardware/software, to support secure viewing of valuable content
- Hard disk drive, for recording video programs.

7.2 TiVO Set-top-box

Telecom New Zealand and Hybrid TV has the exclusive rights of TiVo products and only its broadband customers can have the access to TiVo internet features [14].

A TiVo box acts like a digital tuner, giving the access to Freeview HD channels and the ability to record them. It will also provide internet access to pay-per-view movies and TV shows.

Figure 7: TiVo Set-top-Box, wireless adopter and remote controller [15]

Some of the TiVo STB features are summarised below.

- Vital statistics: The TiVo box is 42cm long, 32cm wide and 7.5cm tall
- Hard disk: 320 GB (up to 250 hours Standard Definition or 120 hours of High Definition, dependent on station broadcast formats recorded).
- Composite video and stereo out

TiVo features for Telecom customers [16]

- The HD DVR allows viewer to play, pause or rewind live TV and record two programmes at once.
- The 14-day on-screen TV Guide makes it easy to schedule the recording of free-to-air programmes and see what's coming up on the box.
- The Now Playing list shows all the programmes that viewer have already recorded.
- The Season Pass Manager automatically records every episode of the favourite series for the whole season.

- The WishList search finds and records programmes that feature viewers' favourite actor, director, team or topic.
- Viewer can restrict programmes, lock channels or set ratings to shows that are unsuitable for children with TiVo KidZone.
- Using the remote scheduling tool via the internet, viewer can set their TiVo to record when they are away from home.

7.3 My Sky HDI Set-top-box

The MySky HDi is a Personal Video Recorder (PVR), just like the original MySky box. The "i" in MySky HDi refers to interactive offerings; ie: the box is allowed to receive internet-delivered television (IPTV) from Sky [17]. Another feature that differs from the old Sky box is that the stunning High Definition output delivers to HDMI-capable TV sets.

The new box has twice the theoretical capacity of the original MySky (320 gigabytes vs 160 GB). However,in practice, consumers can only access 160GB to store recorded programmes and the remainder is for operating system software and to store pay-per-view programming downloaded to the box.

The MySky HDi comes with four tuners, but only two are enabled in the first release. So initially you'll be able to record two Sky channels at once, just as the existing box offers [17].

The My Sky HDI Set-top-Box shown in figure 8 has the resolution of 1080i and Sound of 5.1 Dolby [18].

Figure 8: My Sky HDI Set-top-Box and the remote controller [18]

7.4 TelstraClear Set top box

According to [19] TiVo STB has the following features.

- Has 3 Tuners - This allows viewer to record 2 HD (High Definition) channels whilst watching another HD channel OR to watch a pre-recorded programme while recording 2 others.
- 300GB of hard drive space - To record up to 180hrs of SD (Standard Definition) and 50hrs of HD TV.
- Up to 1080P HD playout through HDMI 1.
- TV Guide with picture-in-picture functionality
- MPEG2, MPEG4, Windows Media, Flash Video and H264 compliant
- Dolby AC3, MP2, MP3 and AAC audio compliant – The best options to cover all the best audio formats
- Supports future internet video delivery

The TelstraClear Set-top-Box is shown in figure 9.

Figure 9: Telstraclear Set-top-Box [19]

Chapter 8

8. Control Technologies and solutions

8.1 Encryption of video and audio data

Encryption provides secure connections and protects data from unexpected modification by other outsiders. Encryption is the first step taking the raw video and audio and encoding it in a systematic way so as to become unreadable to anyone without the necessary key [20]. Decryption is the reverse process which is taking the key and the encrypted file and decoding it to produce an exact copy of the original signal. The decoder needs to have exactly the same key for decryption that the encoder used for encryption.

Many different encryption systems have been designed that embody these core traits. Some of the more common ones are listed below.

Smart Cards:

This is one of the common forms of key distribution for STBs. These cards are called "smart" because they incorporate a processor and memory that can be used by a variety of applications [5].

Each television channel has a unique decryption key that is created when the content is prepared for broadcast. When an authorized viewer wants to watch scrambled content, the viewer's device sends a request to a central server. This server checks to see if the viewer is authorized to view the content. If so, the server locates the correct descrambling key for the desired content and encrypts it using the appropriate public key that corresponds to the user's smart card. Then the server sends the encrypted descrambling key to the viewers' device over the communication path. When it arrives, the encrypted key is fed into the smart card, and the smart card performs the decryption process. Then viewers' STB can use the decrypted descrambling key to process the incoming signal and play the content for the viewer [5].

Watermarking:

Watermarking is the process of inserting data into video or audio streams to track usage or rove ownership of the streams. Digital watermarking capabilities that detect piracy to the guilty individual's set-top box [21].

Watermarking helps in rights enforcement when a unique watermark is created for each individual user. Individual watermarks can serve as a deterrent to unauthorized use of the content, since any misappropriate can be traced back to the specific source of the leak.

8.2 Digital Rights Management System

A Digital Rights Management (DRM) System is designed to protect the property rights of a content owner. This involves some form of encryption or scrambling that renders the content unwatchable without the appropriate key. The key is usually a numeric value that controls the operation of a descrambler or decryption device.

The DRM system also needs to be able to securely deliver the appropriate keys to authorized viewers' STBs. With these keys, the STBs will be able to make sense of the incoming stream and display it properly. Key distribution needs to be secure to prevent unauthorized viewers from obtaining the keys either by deliberate action or unintentionally [5].

Chapter 9

9. Home Networking

9.1 The importance of the home network connection

Today, people's homes are becoming a place where members of the family use an increasingly large variety of different media devices. So the home-networking has been used for communication between digital divices deployed in home, usually iPods, mobile phones, DVD recorders, personal computers, gaming consoles, storage devices and many others [22]. Home-network system allows users to share content regardless of where it originated or stored, control the delivery and access, allocate the bandwidth and intergrate the new devices automatically.

The important function of Home-networking is that it uses IP to share the files and streams through the cable tv or Digital Subscriber Line (DSL) provider. But generally uses may like to replace their old caoxial cables with more modern Wireless Local Area Networks (WLAN), Power-Line Communications (PLC) or even Giga-bit Ethernet cabling.

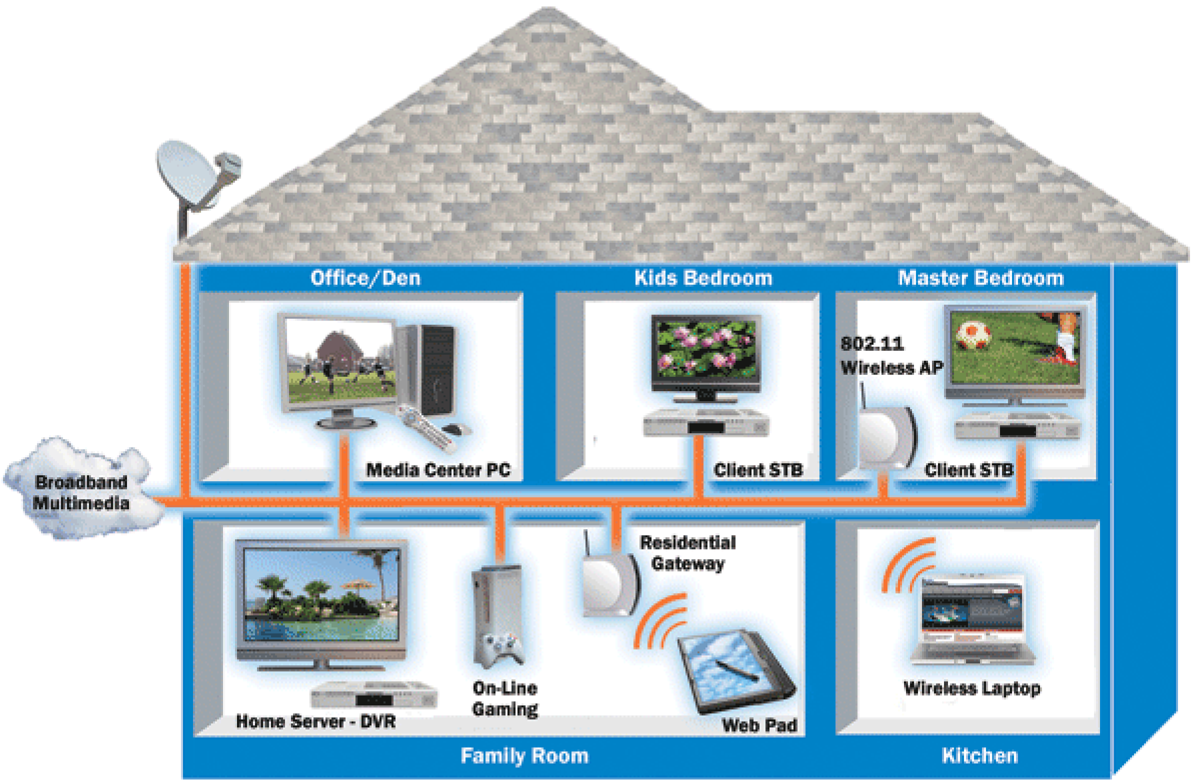

Figure 9: Typical Home-Networking scenario [23]

The figure 9 depicts a typical home-networking scenario with several content sources and devices located in different rooms.

Home Networking is anticipated to grow significantly, with the number of enabled households increasing worldwide from around 172 million in 2008 to nearly 280 million in 2013 [5].

9.2 Home Network devices

A home network may consist of the following components [24]:

- ***A broadband modem:*** For connection to the internet. This can be either a DSL modem using the phone line, or cable modem using the cable internet connection.
- ***A Residential gateway (router):*** Connected between the broadband modem and the rest of the network. This enables multiple devices to connect to the internet simultaneously. Routers, hubs/switches, DSL modems, and wireless access points are often combined.
- A PC, or multiple PCs including laptops
- ***A wireless access point:*** Usually implemented as a feature rather than a separate box, for connecting wireless devices
- ***Entertainment peripherals:*** An increasing number of devices can be connected to the home network, including Digital video recorders, Digital audio players, game machines, stereo system and IP set-top box.
- Internet Phones (VoIP)
- ***A network bridge:*** Connects two networks together, often giving a wired device, e.g. Xbox, access to a wireless network.
- ***A network hub/switch:*** A central networking hub containing a number of Ethernet ports for connecting multiple networked devices
- ***A Network Attached Storage (NAS) device:*** Can be used for storage on the network.
- ***A print server:*** Can be used to share printers among computers on the network.

Chapter 10

10. Server/Head end hardware

According to [25], to provide a successful IPTV offering, the video head-end effectively addresses following ***key requirements***.

- Superior scalability and flexibility
- MPEG-4 AVC encoders with better video quality at lower bit rates
- Carrier-class reliability
- Superior manageability
- Proven head-end and middleware integration

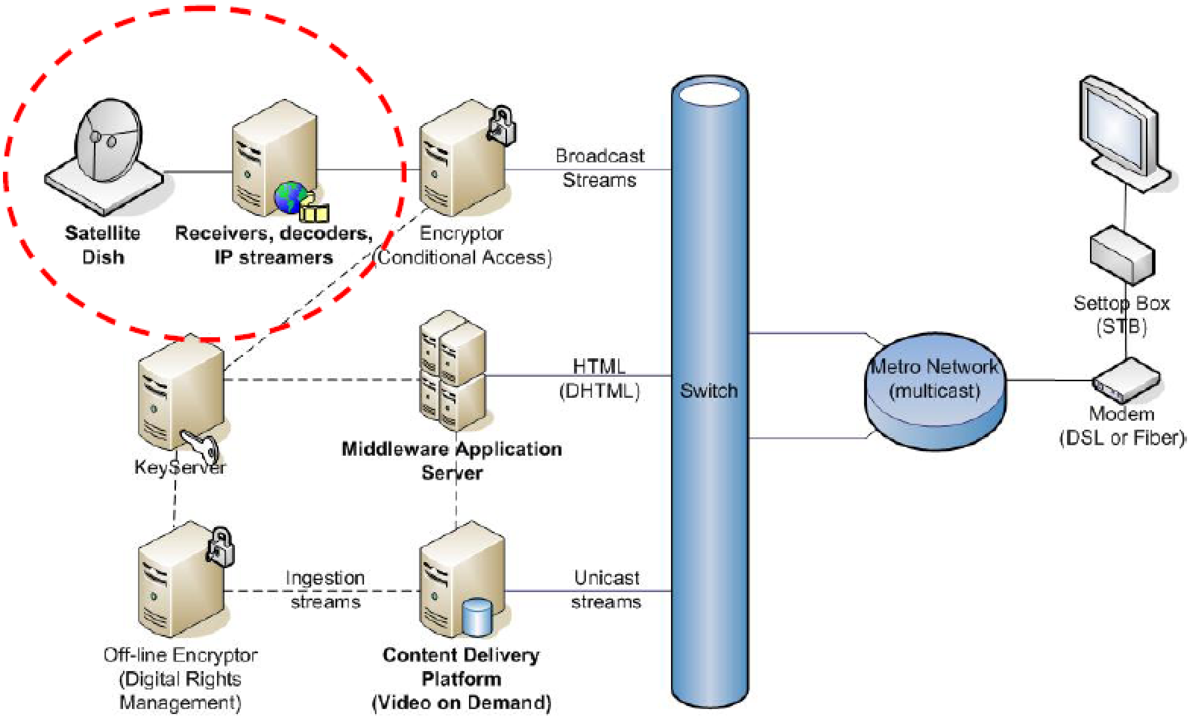

Figure 10: Head-end in an IPTV solution [3]

The IPTV head-end encompasses solutions to acquire, process, encode, and manage video content. However, each of these areas presents unique challenges that must be addressed to create the high-quality video output that subscribers demand.

Head-end solution includes **four major building blocks** which are shown in figure 8 below.

- Video Acquisition

- Video Processing
- Video Encoding
- Video Management

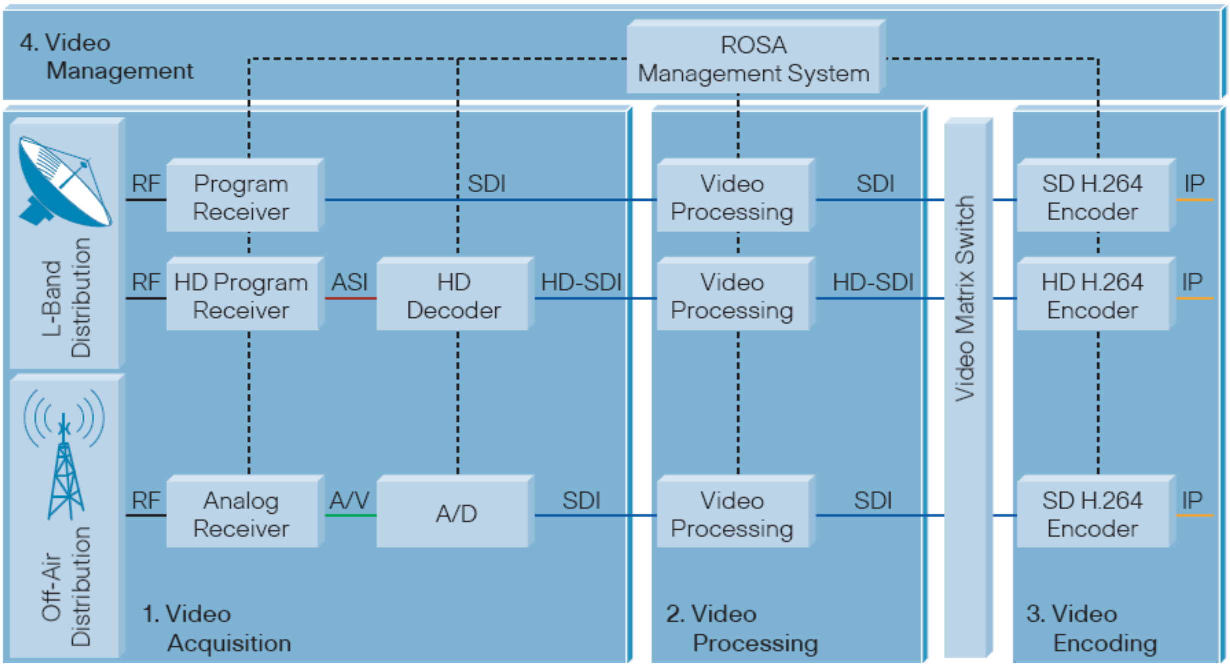

Figure 11: IPTV Head End Building blocks [25]

10.1 Video Acquisition

IPTV service providers acquire television programming from many different sources. The goal is to collect and convert received video from a wide range of sources, including satellite, off-air, fibre, and other digital and analogue sources using a wide range of devices, including: C-band and Ku-band satellite receivers, as well as off-air receivers into a serial digital interface (SDI) [25]. Decrypting, converting, and multiplexing this content into a single national or regional video service are a complex challenge, requiring many different components to work together. Since every service provider offers its own menu of channels and services, with each requiring a unique mix of technologies, the video acquisition component of the head-end must be built from the ground up as a customized solution. Therefore Video Acquisition system requires intelligent design with many tradeoffs such as redundancy options, multiplexing capabilities, dish implementation to satisfy the service provider's uptime goals [25].

10.2 Video Processing

As video signals are acquired, the head-end must process each signal for distribution. In the past, this process was relatively straightforward, as all subscribers viewed content on a single type of television with a single video format and aspect ratio. For the most part, video processing primarily involved helping ensure that local programming was effectively join together with national video feeds [25]. Today, the situation is much more complex. Carriers must process video to account for:

- Multiple viewing devices: To effectively serve all subscribers across all devices, translating tools must be used to deliver the same video in multiple resolutions
- Local and regional ad insertion: IPTV services are switched to each subscriber's home allowing carriers to know what each viewer is watching and giving carriers the opportunity to deliver much more targeted, personalized, and profitable advertising.
- Trick-play functionality: To provide a more compelling, convenient video experience, many carriers are deploying VoD services that allow subscribers to pause, fast forward, and rewind television programs.
- Audio/Video adjustments: To provide equalized audio and video levels across all channels, some channels may need certain level adjustments to provide a consistent experience when users tune between channels.

10.3 Video Encoding

The core of the video head-end is the video encoding solution that shapes the video experience for display on the subscriber's screen. Even when carriers deploy excellent video acquisition, processing, and management solutions, the choices they make in video encoders ultimately determine the quality of the IPTV offering. While carriers are challenged to deliver the best possible picture quality, they must also do so using minimal bandwidth, and many IPTV providers are ready to deploy the latest Advance Video Codecs (AVC). MPEG-4/AVC video encoding meets these high-quality requirements using lower bandwidth [25].

MPEG-4/AVC allows carriers to cut the amount of bandwidth per stream on average in half when compared with MPEG-2 encoding. MPEG-4/AVC encoding is an extremely complex process, encompassing many more variables and a much larger set of techniques than MPEG-2 encoding.

Figure 12: Advanced Compression Encoder, Model D9054 HDTV [25]

The encoder shows in figure 10 accepts a High-Definition (HD) SDI signal and encodes it in real time to the MPEG-4 part 10 in 4:2:0 Main or High-Profile Level 4 standard.

10.4 Video Management

With all of the various technologies and applications operating within the video head-end, carriers need solutions to manage the entire head-end as a single entity, from a single interface.

The head-end Network Management System monitors, accesses, configures and controls network devices that are incorporated in the head-end and the Element Manager monitors, controls, configures, automatically backs up failed equipment, alerts the operator of the failure, performs automated tasks, and translates proprietary protocols to SNMP for the overall network manager [25].

Chapter 11

11. Implementation of IPTV services and issues

10.1 Implementation of IPTV

Figure 13 shows a block diagram of the IPTV system. In order for a system operator to deliver IPTV, it would require to encode, broadcast, and do the appropriate management before the end user can connect their set-top-box.

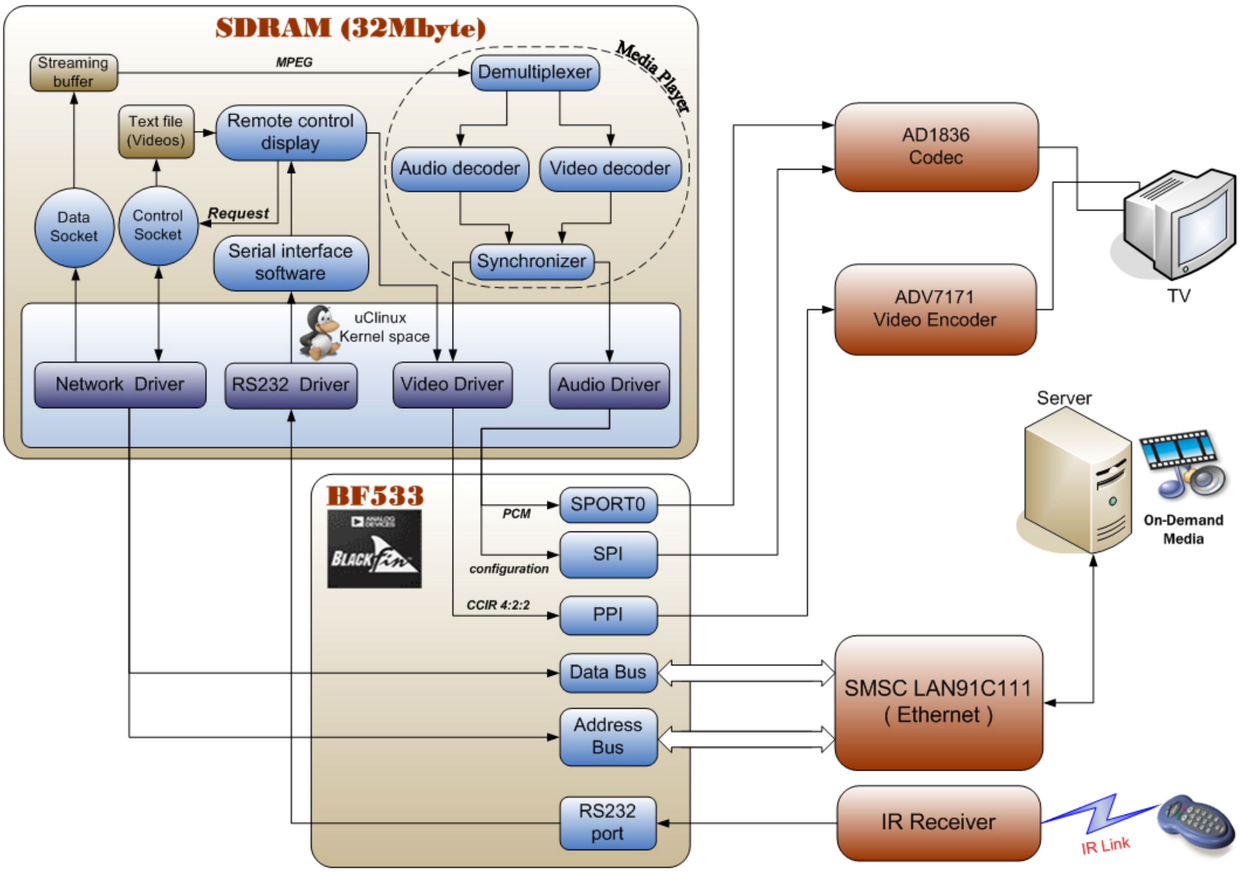

Figure 13: System block diagram [26]

10.1.1 Hardware Blocks

BF533 Processor:

Blackfin ADSP-BF533 is a high-performance member of the Blackfin family, were designed specifically to meet the computational demands and power constraints of embedded audio and video applications, delivering breakthrough signal-processing performance and power efficiency with a RISC programming model. There's also an advantage of Blackfin's memory architecture, particularly the direct memory architecture (DMA) and cache memory.

Video Encoder ADV7171:

The ADV7171 is integrated digital video encoders that convert digital CCIR-601 4:2:2, 8- or 16-bit component video data into a standard analogue baseband television signal compatible with worldwide standards.

Audio Codec AD1836:

The AD1836 is a high-performance, single-chip codec providing three stereo DACs and two stereo ADCs. An SPI port is included, allowing a microcontroller to adjust volume and many other parameters.

Ethernet Interface SMSC LAN91C111 Chip:

The SMSC LAN91C111 is designed to facilitate the implementation of a third generation of Fast Ethernet connectivity solutions for embedded applications. The LAN91C111 is a mixed signal Analogue/Digital device that implements the MAC and PHY portion of the CSMA/CD protocol at 10 and 100 Mbps. The design will also minimize data throughput constraints utilizing a 32-bit, 16-bit or 8-bit bus Host interface in embedded applications.

10.1.2 Software Blocks:

uClinux OS:

The uClinux operating system will be loaded into the memory and divided it to kernel space and user space, the kernel space will contain the system functions and the user space will contain the application program, Accessing the hardware in uClinux is limited to the system only i.e. it must be accessed through a system function, these functions is called the device driver so uClinux must has a driver for each device to be able to use it, So our system has some drivers , Video driver to use the video encoder chip ADV7171, Audio driver to use the codec AD1836, RS232 driver to use the UART, and Network driver to use the Ethernet device SMSC's LAN91C111.

Video Driver:

The user application gives a frame of YUV422 format and put it on a user Frame buffer. After that, the user application tell the driver that the next frame start address by doing driver write call with an argument that is a start address of the frame. Then at each timer interrupt the Timer Interrupt handler transfer the YUV422 user buffer to the Driver buffer, and while transferring interlacing is done (Interlacing is separate Odd lines and even line to make DMA send odd line first then send vertical blanking then send Even line then send vertical blanking)

Note: Also at start of each line a horizontal blanking must be sent. After finishing one frame return from interrupt handler to complete the work that the processor was working on. (it work on 15 frame/sec).

Audio Driver:

The SPORT and SPI are initialized as follows:

SPI is configured to operate with baud rate 2MHz, 16-bit data, MSB first, SPI Master.

The SPORT is configured to operate with I2S mode to transmit/receive data to/from the AD1836, External clocks which is 2 MHz, External Frame sync. MSB first, 16-bit data, Secondary side enable. DMA2 is mapped to Sport0 TX and work in the stop mode.

About the driver operation, the DMA2 is disabled for first as its start address will be assigned to the decoder address buffer and this cannot be done unless DMA2 is disabled otherwise the modification of the address will not take place. Afterwards, the DMA is enabled again then the sport too. It uses the DMA2 bit done that will indicate that the DMA has finished transferring the data to the audio chip. So any new write operation to the device will not be done unless this bit is set to one by the DMA, then it avoid overlapping.

Media Player:

It has been usde FFmpeg which is a complete solution to record, convert and stream audio and video. It includes libavcodec, the leading audio/video codec library. FFmpeg is developed under Linux, but it can be compiled under most operating systems, including Windows.

Streaming:

When the Set-Top Box start it create socket for control and connect it to the server, after the server accept the connection set-top box ask the server for the available media, it create another socket for streaming and make thread for it, now the set-top box program has two threads streaming thread and control thread, on the control thread it wait for a request from the user, if the request is to close connection it will terminate the two threads and end the program, else it will block the streaming thread then send the user request to the server and release the server thread again, on the other hand the streaming thread will request the selected media from the server then it start to receive the data and store it into streaming buffer, it ask the server to update the streaming buffer, after that it check if the media is ended or not, if it ended it will return to wait for another request from the user else it will continue the streaming process with the server.

User Interface:

In order to control the IPTV set-top box, there was a need to make it interactive with user, so there was an interface between user and the IPTV set-top box.

Hardware interface implemented by a remote control which will be connected to the IPTV set-top box through the serial port and finally talks to a display software which is responsible of displaying user interactions effects on TV screen.

Remote control menus will be displayed in the centre of TV screen -on top of the last displayed video frame- and won't take the whole TV screen area.

10.2 Factors Affecting Service

- Encoding and Compression

  The quality of the video being distributed across the network can be affected right at the source. The encoding and compression usually deal between the quality of the video and the desired compression level.

- Jitter

  This is the variation in the packet arrival time caused by the network congestion. If the Ethernet frames arrive at the STB at a rate that is slower or faster, as determined by the network conditions, buffering is required to help smooth out the variations. Based on the size of the buffer, there are delivery conditions that can make the buffer overflow or underflow, which results in a degradation of the perceived video.

- Limited Bandwidth

  As core IP infrastructure is usually based on optical networks with a low level of congestion, bandwidth limitations and the total amount of video-stream data that can be sent are limited mostly by the access network or the customer's home network supported rate. When traffic levels hit the maximum bandwidth available, packets are discarded, leading to video quality degradation.

- Packet loss

  Loss of IP packets may occur for multiple reasons—bandwidth limitations, network congestion, failed links and transmission errors. Packet loss usually presents a bursty behaviour, commonly related to periods of network congestion.

Chapter 11

11. Business Model

The IPTV service provides rich multimedia services over IP networks and is widely believed to be the next killer application over the Internet. It is generating a lot of interest, especially in potential service providers who are eager to develop successful business models that will ensure their survival in this emerging market. The success of an IPTV business will depend to a large extent on the ability of the service providers to provide the right IPTV contents and services to the right subscribers, at the right time and in a way that is most convenient and appealing to the subscribers.

For the services of IPTV, the sub working groups has started on identification of IPTV services, players/roles and the identification of business models. The contribution made by the companies and organizations mentioned are IPTV services scenarios using NACF over NGN, technical issues on IPTV standardization, commercial billing model of IPTV and others. Some of the proposed services for the IPTV focus group activities are pay per view (PPV), Interactive TV (iTV), Games, Presence service, Communications Messaging and many more as defined in [27].

The following sections describe some of the business models that can be used for IPTV system.

11.1 Free To Air (FTA)

One way for service providers to create revenue from this type is to charge users a fee to host their video content, to simplify sharing between friends and family members.

Another way to fund "free" video web portal is to sell advertising space on the portal itself or to push advertisements to viewers before the content is played.

The other common method is to offer preview of video content that needs to be purchased. For example, numbers of web sites have been created that provide free previews of these clips, along with the links to sites where they can purchase and downloaded [5].

In New Zealand Telstraclear service provider uses this FTA model to reach the subscribers.

11.2 Pay Per View (PPV)

PPV is often used for high-value content such as movies. In this model, the viewer purchases the right to view a specific piece of content over a specific time period. The viewer is allowed to pause, fast forward and rewind the content, but loses all rights after the viewing window expires. Part of the reason for these tight viewing window restrictions is simple profit maximization and the security [5]. For example, TiVO uses this model technique in New Zealand [14].

11.3 Subscription

Subscription services are one of the most common methods used for funding IPTV systems. In this system, viewers sign up for a package of video channels and pay a flat monthly fee. Subscribers are then allowed to watch as much of any of the channels that are included in their subscription package.

There are two business models used under subscription.

- Live Video Access, where viewers pay a monthly fee in exchange for the rights to view live streaming video.
- Video Library Access, where viewers pay a monthly fee to have access to a collection of content that can be played.

Mysky HDi is one of the examples that use this model.

11.4 A La Carte

This is similar in concept to subscription, except that each viewer is allowed to select exactly the channels they want to view, so he or she does not pay for the undesired channels.

For IPTV providers, there are two advantages to this approach. These are:

- It is technically less difficult to deliver only a specific group of channels to each subscriber.
- IPTV providers may capitalize on subscribers' desires to pay only for those channels they wish to view

Chapter 12

12. IPTV Performance Measure

Quality of Service (QoS)

QoS is one or more measure of desired performance and priorities through the IPTV communication system.

Key Measures include:

- Service availability
- Maximum bit error rate, minimum committed bit rate
- Packet loss and latency performance
- Transmission quality

Quality of Experience (QoE)

QoE is one or more measure of the total communication and entertainment experience from the perspective of end users.

Key Measures include:

- End user quality
- Ability to use the system easily
- Application driven
- Content impairments
- Blockiness, Jerkiness

12.1 Delivering IPTV service with QoE

The Quality of Experience (QoE) is the overall performance of a system from the point of view of the users. QoE is a measure of end-to-end performance at the services level from the user perspective and an indication of how well the system meets the user's needs [28]. This is highly subjective and takes into accounts many different factors beyond the quality of the service, such as service pricing, viewing environment, stress level and so on. The figure below shows us the IPTV QoE in the end-to-end model.

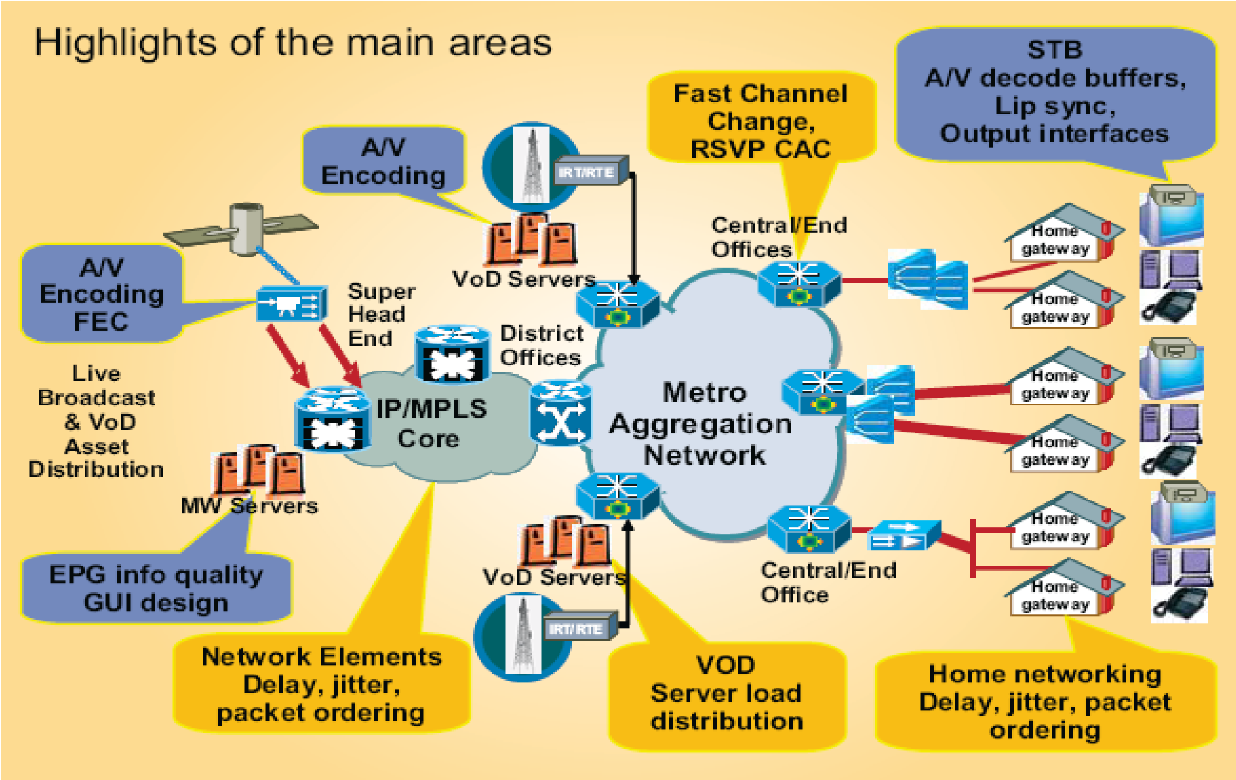

Figure 14: IPTV QoE in the end-to-end model [9]

12.1.1 Planning and monitoring

QoE-based Engineering

The process of engineering a network for services includes [28]:

- End user requirements analysis
- Definition of application layer QoE requirements
- Translation from subjective QoE requirements to objective service performance requirements end-to-end at the network and application layers
- Allocation of performance impairments to protocol layers, network segments or nodes

Video QoE Measurement

The video picture quality contributions to QoE can be measured in three ways [28]:

- Subjectively - using a controlled viewing experiment and participants who grade the quality using rating scales such as Mean Opinion Score (MOS)
- Objectively at the service layer – using electronic test equipment to measure various aspects of the overall quality of the video signal (e.g. PSNR)
- Indirectly – using measurements of network impairments (loss, delay, jitter, duration of the defect) to estimate the impact on video quality, where there is an established relationship between QoE and QoS.

Voice QoE Measurement

There are ***four key factors*** affecting QoE for VoIP:

- Delay (including delay variation or jitter)
- The speech codec
- Cell/packet loss
- Echo

Each of the QoE contributing factors discussed above (and other, conventional voice impairments, such as noise and harmonic distortion) can be measured individually. However, it is useful to have an overall indicator of voice quality. Various metrics have been devised to quantify the overall perceived voice quality of a component or a system.

Three common metrics are discussed below [28]:

- The subjective measure called Mean Opinion Score (MOS),
- An objective MOS estimator called PESQ (Perceptual Evaluation of Speech Quality)
- A computed metric called Transmission Rating (***R***), which is calculated from objective measurements of fifteen contributing parameters using an ITU G.107 standard tool called the E Model.

The quality of a voice call is determined by the access types, the transport technology, the number of nodes the call passes through, the distance, packet transport links speeds, and many other factors that differ from one connection to another. To compare networks, specific connections (reference connections) representing equivalent calling conditions are defined that can be measured and compared.

12.1.3 Tools

Quality assurance processes need to be supported by a set of tools. By introducing a higher automation degree, tools help to increase the processes agility, accuracy, and efficiency. They include monitoring, test and measurement tools as part of a set of integrated systems focused on quality management [29].

Essentially, such category of tools is composed of a central management system and probes. Several probes distributed all over the service infrastructure, from the head-end to the set-top-box and through the network are responsible for measuring service quality by extracting the relevant parameters at each level.

12.2 IPTV Test Equipments

Some of the IPTV Test equipments and their functions are summarised below.

Video Analyser

- Receive and evaluate video signals
- Capable of evaluating multiple types of media formats such as MPEG2, MPEG4, VC-1, VC-6
- Analyse the stream rates, bit rates, display motion vectors, quantizer values, frame rates, frame counts
- Measure various types of errors such as bit rate, frame loss rate

MPEG Generator

- Create signals to simulate the source (head-end) of a Broadcast TV
- Create SPTS or MPTS
- Insert or adjust the error rate to simulate common network impairments

Network Impairment monitor

- Create or simulate operational or communication impairments for the device under test
- Produce jitter, latency, burst loss, packet loss, out of order packets, route flapping and link failures to simulate fault conditions

Protocol Analyser

- Analyse protocol data in promiscuous and listening mode
- Used for problem determinations
- Analyse packets independent of destination address

Network monitoring tools

- Analyse network alarms and performance data
- Can detect trouble in interoffice, loop and switching systems

Test clients

- May be installed on the STB to monitor performance conditions
- Can determine packet losses, monitor packet jitter, and analyze their impact on the display of the video

Chapter 13

13. Case Studies

13.1 New Zealand

In New Zealand, there are three main Tele-companies service New Zealand IPTV market: Telecom, Sky TV, and TelstraClear.

The TiVo IPTV STB is from Telecom of New Zealand. The STB of TiVo needs a wireless or Ethernet broadband environment to work, and also need a PC or Mac and a TV. The TiVo enable to transfer music and photos from a PC or Mac to a TiVo; transfer video from a PC to a TiVo recording device; convert media data files for Cell phone, PlayStation Portable; transfer TiVo recordings to a PC; watch a wide range of video and music formats; and enable multi-room viewing. Viewer can download music, photos, and videos through the TiVo's share button, but music must be in MP3 format, and ACC or iTunes-purchased music content are protected that will not allow to stream to your TiVo. All completed data can be found in your My TiVo Recordings folder. To transfer a recording program from TiVo to a PC, the easy way is tick the program and then click the Pick Recordings to Transfer button. It is same way to transfer a program from a PC to a portable device that is connecting a mobile device to a PC and then click Convert for the device. There are more functions to help viewer to keep their program data and all designs focus on viewer's convenient.

The recording programs what download through TiVo can be shared on home-network. Viewer use Media Access Key (MAK) enable share the recording programs to other family members by use TiVo media device and router. Other household allow transferring recording programs to their TV or PC screen. That means, in one house that family member can watch different programs in different room in same time, and they still can record two shows at once when watching other program [11]. The figure 5.1 is shows TiVo's specialties.

Figure 5.1: TiVo specialties [12]

Telecom is the largest telecommunications service provider in New Zealand (by revenue). Telecom's broadband has wholesale and unbundled bit-stream service (UBS), the broadband for the majority of residential consumers in New Zealand. In 2007, Telecom's broadband service in New Zealand was growing fast. The broadband connections increased 170,000 in 2007. The total broadband customer base was about 605,000 at end of June 2007. The total dial-up internet connections about 238,000 at 30 June 2007. The revenue not grown as fast as the customer base, because of downloads price, particularly in the business sector. In 2008, Telecom has completed installing ADSL2+ technology to 400,000 end-users. In the end of June 2008, Telecom had 437,000 residential customers using Telecom broadband and 163,000 residential customers using dial-up. The total broadband connections at 30 June 2008 were 759,000 in New Zealand. In 2009, Telecom fixed 835,000 broadband connections in New Zealand. Multiple high-speed broadband networks are available through mobile, WiMax and fixed networks. Telecom improved the download speed by ADSL2+ technology. It is about 37% customers have available download speeds up to 10Mbps and Telecom will upgrade download speed over 80% lines at least 10Mbps by Dec. 2011. From 2008 to 2009, Telecom Broadband's consumer market share has declined from 64% to 57%. TiVo maybe can help hold the line [13] [14] [15] [16] [17] [18].

The figure 5.2 shows Telecom broadband and internet revenue overview from 2005 to 2009.

Business review

Results overview

YEAR ENDED 30 JUNE (DOLLARS IN MILLIONS, EXCEPT PER SHARE AND PER ADS AMOUNTS)	2009 NZ$M	2008 NZ$M	2007 NZ$M	2006 NZ$M	2005 NZ$M
Income statement data					
Operating revenues and other gains					
Local service	1,049	1,061	1,084	1,081	1,101
Calling	1,239	1,291	1,336	1,385	1,435
Interconnection	177	178	187	201	203
Mobile	783	833	895	869	835
Data	652	638	561	602	602
Broadband and internet	582	547	485	448	376
IT services	486	439	380	346	308
Resale	333	370	399	363	337
Other operating revenue	286	309	235	200	213
Other gains	12	7	20	60	154
Total operating revenues and other gains	**5,599**	**5,673**	**5,582**	**5,555**	**5,564**

Figure 5.2: Telecom business review from 2005 to 2009 [19]

SKY Television launched My Sky HDi in July 2008. The Sky HDi is a new High Definition decoder and Personal Video Recorder (PRV) with Dolby Digital surround sound. The Sky HDi functions as similar as Telecom's TiVo. It can do video on demand, pause Live TV, replays Live TV, record any two programs at once, and high definition viewing. Sky HDi Users can record the digital signal directly to the hard drive and the record as the same quality as a live show, and users do not need the expense of hardware based video encoders. The different between Sky HDi and TiVo is that My Sky HDi only support Vodafone Internet, Telecom's TiVo only can be used on Telecom broadband. SKY Television is New Zealand's pay television operator. SKY TV offering more than 100 channels and My Sky HDi PVR. In the end of 1998, SKY TV used digital satellite service make that more than 47% of subscribers to SKY via digital satellite and UHF networks in New Zealand. In July 2008, SKY launched My Sky HDi IPTV Set-top Box

(STB). By the end of 2009, Sky TV had 144,148 MySky HDI customers in New Zealand and Sky TV's revenue was up 6.6%. There is much room for growth of Sky HDi market in New Zealand [20] [21] [22].

TelstraClear let customer access YouTube on their televisions via its Inhome cable networks in Wellington and Christchurch. Like MySky HDi and Telecom TiVo, TelstraClear will start offering personal video recorders (PVRs). The PVR will let viewers pause and review "live" television and record programs. But MySky and TiVo have trumped consumer markets. TelstraClear provide traditional and wireless telephone, Internet, and pay television services in New Zealand. It is a subsidiary of Australia-based Telstra Company. TelstraClear serves residential, business, and government customers [23] [24] [25].

13.2 Europe

In France, there have 421,000 ADSL Television subscribers. Figure 5.3 shows that this number growth over two years and with a cumulative annual growth rate of more than 150 percent. France had about 25 million television households, with approximately 3 million Community Antenna Television (CATV) subscribers and 4 million satellite subscribers. In June 2006, France had 11.7 million broadband subscribers, so in France, there were a huge number of potential IPTV viewers. Because a competitive market, the IPTV service price were very low. There only 16 Euros per month for more than 40 channels. For the 30 Euros basic triple-play package included high speed ADSL2+ Internet access, free voice calls to fixed lines in more than 20 countries and IPTV. Many customers were happy purchasing the triple-play package. The channel of IPTV offered was quite extensive. IPTV offered programming from a large number of other countries in Europe and Middle East. The total offered more than 200 channels. Another important reason have acted to drive subscribers to IPTV is High Definition (HD) content with VOD services. In France, the HD broadcast market was much less developed than the U.S. market at the time. This new services will be attract new customers to use IPTV [26].

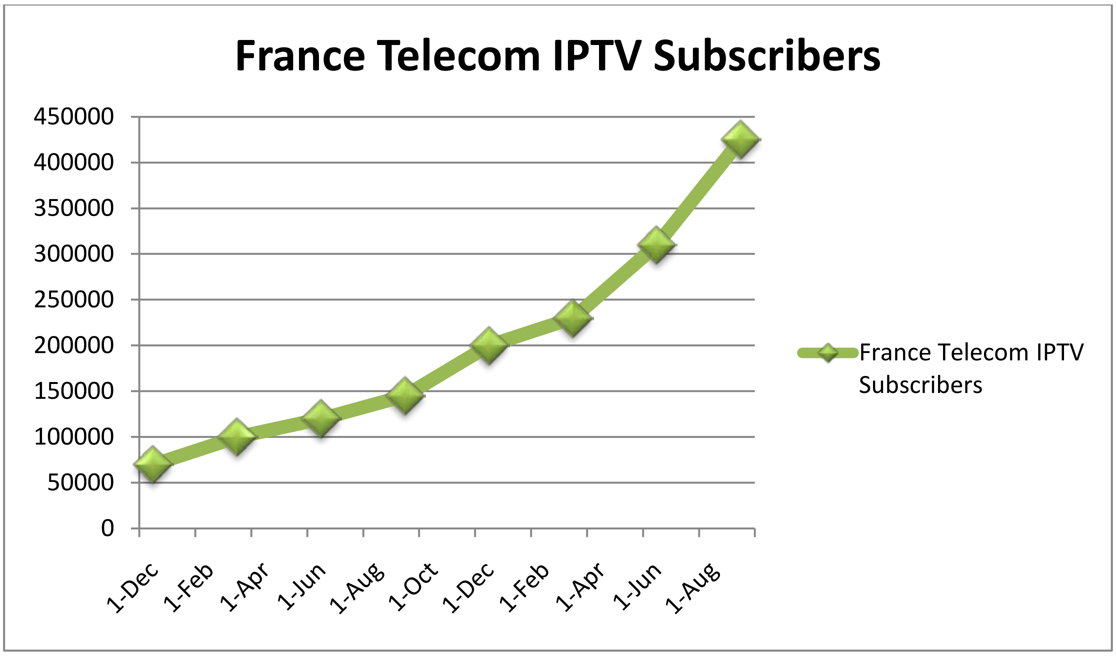

Figure 5.3: France Telecom's IPTV Subscriber Growth 2004-2006

13.3 USA

The US is the largest Internet video country. In 2006, the US revenue of Internet video is 537.6 million US$. Also, the US had very active Internet users. At present, with about 300,000 subscribers in the US in 2005, but now the figure went up to 7,000,000 by 2010. Although the US getting close to the end of the early adopter phase, the country is still at a point where the number of subscribers is very small compared to traditional video delivery [33][34][35].

13.4 Australia

The Australian IPTV market is less developed than other markets internationally. In 2007, a survey for Australia found that only 34% of Internet users had streamed a video at least once when they using the Internet. In the end of 2007, there are only 5 IPTV service providers and 15 Internet video providers. The investment of IPTV in Australia is much higher than in other countries, because Australia is too big lead to the lower density of people in the same area [36] [37].

13.5 China

In 2005, China has the first IPTV license in Shanghai. In the same year, Haerbin is the first city use IPTV technology in China. In the end of 2010, there have about 7,760,000 IPTV subscribers in China, about 3,000,000 IPTV users in Korea and bout 2,000,000 viewers in Japan. According to Pyramid Research report, China will be the biggest IPTV subscribers market in the world after 2014. From 2010 to 2014, the viewers will increase 7,000,000 each year, and until end of 2014 that the number of IPTV users will be about 30,150,000 in China [38] [39].

13.6 Europe

The first IPTV business commercial company starts in England in 1999. In France, there have 421,000 ADSL Television subscribers. Figure 11.3 shows that this number growth over two years and with a cumulative annual growth rate of more than 150 percent. France had about 25 million television households, with approximately 3 million Community Antenna Television (CATV) subscribers and 4 million satellite subscribers. In June 2006, France had 11.7 million broadband subscribers, so in France, there were a huge number of potential IPTV viewers. Because a competitive market, the IPTV service price were very low. There only 16 Euros per month for more than 40 channels. For the 30 Euros basic triple-play package included high speed ADSL2+ Internet access, free voice calls to fixed lines in more than 20 countries and IPTV. Many customers were happy purchasing the triple-play package. The channel of IPTV offered was quite extensive. IPTV offered programming from a large number of other countries in Europe and Middle East. The total offered more than 200 channels. Another important reason have acted to drive subscribers to IPTV is High Definition (HD) content with VOD services. In France, the HD broadcast market was much less developed than the U.S. market at the time. This new services will be attract new customers to use IPTV [40].

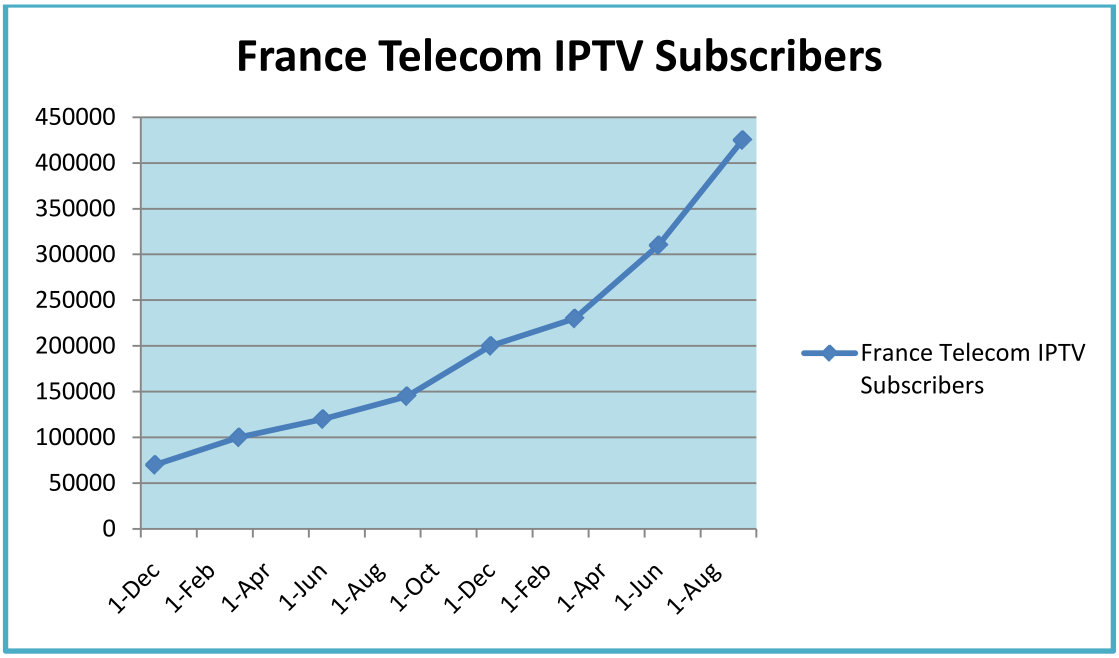

Figure 11.3: France Telecom's IPTV Subscriber Growth 2004-2006

13.7 Sri Lanka

13.8 Japan

13.9 Europe

13.10 US

13.11 China

13.12 Australia

13.13 Syria

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List of Abbreviations

ATSI	Association of TeleServices International
AVC	Advance Video Codecs
DLNA	Digital Living Network Alliance
DMA	Direct Memory Architecture
DRM	Digital Rights Management
DSL	Digital Subscriber line
DSLAM	Digital Subscriber Line Access Multiplexers
DVB	Digital Video Broadcast
EPG	Electronic Program Guide
ETSI	European Telecommunications Standardization Institute
FTA	Free to Air
FTTH	Fibre-To-The-Home
GSM	Global System for Mobile Communications
HDTV	High definition TV
HFC	Hybrid Fibre Coaxial
HGI	Home Gateway Initiative
IM	Instant Messaging
IPTV	Internet Protocol Television
ISMA	Internet Streaming Media Alliance
ITU	International Telecommunication Union
iTV	Interactive TV
MOS	Mean Opinion Score
MPEG	Moving Picture Experts Group
MPLS	Multiprotocol Label Switching
MPTS	Multi-Program Transport Stream
MSB	Most Significant Bit
NACF	Network Attachment Control Function
NAS	Network Attached Storage
NGN	Next Generation Network
PESQ	Perceptual Evaluation of Speech Quality
PLC	Power-Line Communications
PoP	Point of Presence
PPV	Pay Per View
PSNR	Peak Signal to Noise Ratio
PVR	Personal Video Recorder

QoE	Quality of Experience
QoS	Quality of Service
RTSP	Real Time Streaming Protocol
SCTE	Society of Telecommunications Engineers
SDI	Serial Digital Interface
SDTV	Standard Definition TV
SPI	Service Provider Interface
SPORT	
SPTS	Single Programme Transport Stream
SNMP	
STB	Set-top-box
TM-IPI	
VOD	Video on Demand
VOIP	Video Over IP
VoIP	Voice over IP
WLAN	Wireless Local Area Networks

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2. List of Abbreviations

ACC	Advanced Audio Coding
ADSL2+	Asymmetric Digital Subscriber Line 2+
API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ATM	Asynchronous Transfer Mode
CA	Certificate Authority
CATV	Community Antenna Television
CO	Central Office
CPU	Central Processing Unit
DTH	Direct to Home
DRAM	Dynamic Random Access Memory
DNS	Domain Name System
DSL	Digital Subscriber Loop/ Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexers
DVDs	Digital Video Discs
DVR	Digital Video Recorder

EOD Everything on Demand

EEPROM Electrically Erasable Programmable Read Only Memory

EPG Electronic Program Guide

FVOD Free Video on Demand

GB Gigabytes

HD High Definition

HDMI High Definition Multimedia Interface

HEN Home Entertainment Network

HMN Home Media Networking

HTML Hyper Text Markup Language

HTTP Hyper Text Transfer Protocol

IB In-band

IOS International Organization of Standardization

IP Internet Protocol

IPTV Internet Protocol Television

ISP Internet Service Providers

LEO Local End Office

MAK Media Access Key

MHEG Multimedia and Hypermedia Experts Group

MHP Multimedia Home Platform

MP3 Moving Picture Experts Group Audio Layer 3

MPEG-4	Moving Pictures Expert Group
MHz	Megahertz
NPVRs	Network Personal Video Recorders
NVOD	Near Video on Demand
OOB	Out Of Band
OS	Operating System
PC	Personal Computer
PCI	Peripheral Component Interconnect
PID	Packet Identification
PPV	Pay per View
PVRs	Personal Video Recorders
QoS	Quality of Service
RAM	Random Access Memory
ROM	Read Only Memory
RTOS	Real-time Operation System
RT	Remote Terminal
RTP	Real-time Transport Protocol
SD	Standard Definition
SET	Secure Electronic Transactions
SHE	Super Head End
SIMMs	Single Inline Memory Modules

SONET	Synchronous Optical Network
SRAM	Static Random Access Memory
SSL	Security Socket Layer
STB	Set-top Box
SVOD	Subscription Video on Demand
TCP	Transmission Control Protocol
UBS	Unbundled Bit-stream Service
UDP	User Datagram Protocol
USB	Universal Series Bus
VC1	Video Code 1
VoD	Video on Demand
VoIP	Voice over Internet Protocol
VOS	Video Service Office
VSO	Video Serving Office
WiMax	Worldwide Interoperability for Microwave Access
WWW	World Wide Web