An Observation and Analysis of IPTV and Multicasting Traffic

Shoyeb Al Mamun Shohag
MS in Computer Networks
KTH - The Royal Institute of Technology
Stockholm, Sweden

Mozammel-Bin-Motalab
Master in Information Technology
IIT, University of Dhaka
Dhaka, Bangladesh

ABSTRACT

IP TV is the short form of Internet protocol television. It's the technology that allows us to get television services via internet protocol over the computer networks instead of traditional cable TV medium. The multicasting technology is used in IPTV to send one packet that is being originated from one station to multiple stations at a time, is referred as broadcasting of internet version [16]. This paper describes the functionality of IPTV protocol and Multicasting with a short background of its. We also have studied on various compression techniques of audio and video file and format. Our main intention was to observed how various protocols works with IPTV services like Protocol independent module (PIM), Internet group messages protocol (IGMP), and Cisco group management protocol (CGMP) when packets are interchanged with in router, switch, video server and clients. To observe these, a lab work on IPTV has been conducted and the findings have been discussed.

General Terms

Computer Network, Information and Communication Technology

Keywords

IPTV, Multicasting, STB (Set-to Box), GOP (Group of Picture), ST (Transport Stream), PIM (Protocol Independent Module), IGMP (Internet Group Message protocol), CGMP (Cisco Group Management Protocol) JPEP (Joint Photographic Expert Group).

1. INTRODUCTION

Packets are traverse from one host to another host which is normally referred as unicast transmissions or from one host to all hosts that is referred to as broadcast. IP Multicast provides a third communication allowing a host to send packets to a group that is made up of a subset of the hosts on the network. IP Multicast is a bandwidth-conserving technology specifically designed to reduce traffic by simultaneously delivering a single stream of information to potentially thousands of corporate recipients or homes. By replacing copies for all recipients with the delivery of a single stream of information, IP Multicast is able to minimize the burden on both sending and receiving hosts and reduce overall network traffic.

2. BACGROUND STUDY

2.1 Literature Review

The authors in [1] mainly focused on triple play services (voice, data and video) and demonstrates the architecture of its. They also points out various services of IPTV and especially works on video on demand service (VoD). The authors has showed architecture of VoD services and describes working principles of its.

According to [2], the authors have developed an analytical model for the key points of IPTV networks (head-ends, network transport monitoring, last mile, set-top-box). Finally they summarized as their test result with this model has given an important result in terms of IPTV performance measurement. They also finds few factors (encoding and compression, jitter, packet loss, limited bandwidth) those effects IPTV networks.

In [3], the authors worked with error resilience methods and data partitioning for IPTV video stream over IEEE 802.16e Channel. They have proposed a FEC protection scheme for data partitioning of video stream by retransmission of additional data as and when it is required. They also have tested their proposed scheme and remarked as, it is not sufficient to apply just application FEC with poor channel condition that comes from slow and fast fading. The authors also remarked that a number of measurements required on their proposed schemes to deliver a good quality video in realistically.

The tendency of the authors in [4], was to develop a convergence service environment so that service requester can get access on various services (IPTV, ENUM and IMS) from various devices and multiple domains and even from different networks. Finally, they have proposed a compound modular architecture to define and provision the future internet service to a common platform, and tested their proposed architecture by the interconnection of different prototype deployed with this project work.

QoS management mechanism for IMS network component control and service delivery have been proposed by 3GPP but that mechanism only focused on the steps of service provisioning and didn't have any mechanism to monitor QoS dynamically. The authors in [5], has developed a QoS mechanism for the next generation IMS network and for IPTV service specific QoS policies, and this mechanism has been designed based on eTOM process. They have said and proof that their created platform will acts as proactive supervisor of the IMS network. It will correct and anticipate the QoS degradations before failures occur at customer premises.

The authors in [6] primarily discussed on the high throughput of IEEE 802.11N wireless LAN and its performance. This paper next discuss about the technical challenges of IPTV which

includes QoS, Traffic management, Multicasting admission control, admission control for Ethernet, WLANs, Security and Privacy etc. But it emphasise on QoS, because services are provided by the public internet so video quality depends on the network traffic condition.

In [7], the authors discussed that traditional unicast is not adequate for IPTV. XDSL can support limited number of TV channels. Author analyse that using multicast in core network avoids multiple copies in core, but still we have multiple copies at the access network. To provide IPTV with high QoS, multicast mechanism is essential. This paper has also analysis on the communication scenarios for IGMPv1 and IGMP v2.

The authors in [8] evaluated the fact, benefit and challenge to implement IPTV over WiMAX. Authors proposed two-level superposition coded multicasting (SCM) scheme with video coding in the H.264/MPEG4 technique for IPTV.

2.2 Compression

It's a technique, is used to compress the audio and video data to transmit over internet. It is important to handle audio and video compression for the efficient usage of bandwidth in IPTV services.

Audio compression is used in speech or music. Two types of technique are used for audio compression those are predictive encoding and perceptual encoding. There are few standards which does predictive encoding like GSM (13 kbps), G.729 (7 kbps). Perceptual encoding is used to create CD-quality audio (MP3 format audio).

Video compression can be done by compressing the image because video is a form of multiple frames where each frame represents one image. There are two standard, JPEG (Joint photographic expert group) which is used to compress image and MPEG (Moving picture expert group) that is used to compress video.

2.3 MPEG-2

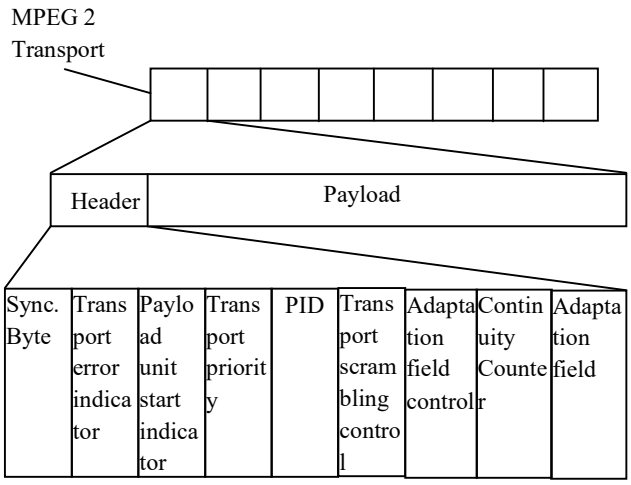

Figure 1: MPEG packet format

It's a standard that define the generic coding of moving picture and associated audio information. It describes a lossy video compression and lossy audio data compression method that permit storage and transmission of video data using currently available storage media and transmission bandwidth. Lossy compression is a method where data is compressed and then decompressed; the received data is different one from the original but it is close enough to be useful in some way [9].
MPEG-2 allows two forms of multiplexing one is MPEG program stream and the other is MPEG transport stream.

2.4 MPEG Transport Stream

It consists of a sequence of fixed sized transport packet of 88 bytes, where each packet takes 184 bytes of payload and a 4 byte header. A 13 bit packet identifier (PID) include in the 4 byte header that play a key role in the operation of the transport layer. According to [10], the packet format looks like as fig-1.

The header field start with a byte called synchronisations that has a bit pattern like 0x47(01000111). Three flag fields also there in the packet format in fig-1. The first flag is used to indicate transport error (1 bit), second flag is used to denote the start of payload and third flag is for transport priority (1 bit). A 13 bit packet identifier (PID) is used to uniquely identify the stream to which the packet belongs to. Two scrambling bit are also used to encrypt the payload of some TS packets. Adaptation field (2 bit) is used with the combinations like 01 for payload only, 10 indicate no payload, 01 followed by payload and 00 reserved for future use. Lastly, there is a 4 bit continuity counter.

2.5 Video Stream

The MPEG-2 video coding standard is primarily aimed at coding of CCIRR-601 or higher resolution video with fairly to support a challenging bitrates of 4 to 9 Mbps. The video stream data hierarchy look like as fig-2 [11].

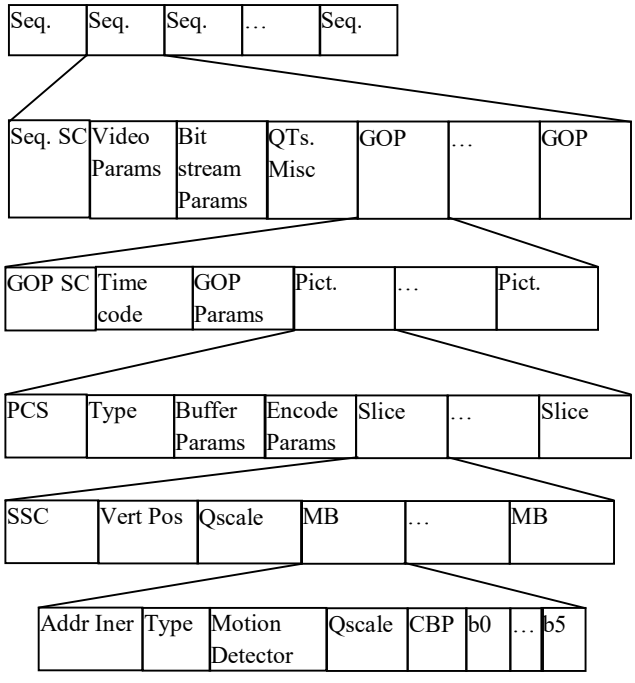

Figure 2: Video stream file format

According to [11], video stream data hierarchy consist of four layers those are GOP, Picture, Slice, macro block and block .Video sequence, begins with a sequence header, include one or more group of picture and ends with an ends of sequence code. Group of pictures (GOP), a header used to take a series of one of more pictures intended to allow random access into the sequence. Picture, it consists of three rectangular matrices representing luminance (Y) and two chrominance (Cb and Cr) values. Y matrix has an even number of rows and columns.

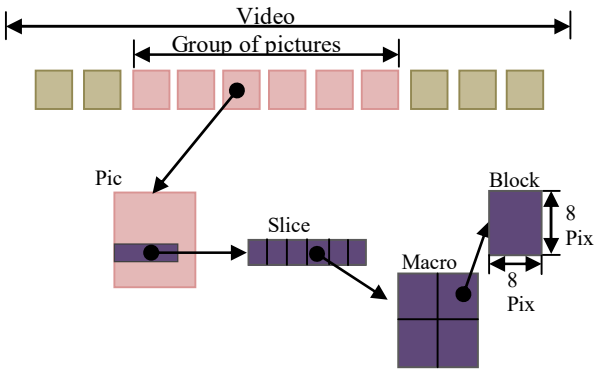

Figure 3: Group of pictures

Slice consists of one or more contiguous macro blocks. Within a slice the macro block is count from left-to-right and top-to-bottom. Slices are important in the handling of error. Block represents the smallest coding unit in macro block or slice. It can be of three types such as luminance (Y), red chrominance (Cr), blue chrominance (Cb).

3. IPTV

The short form of Internet protocol television is IPTV. The video signals are converted into a stream of data which pass over the network in the same way as other traffic.

3.1 Background of IPTV Multicasting

Today's most of the distribution of television is running over a wire line distribution medium network based on analogue technologies. This network usually builds separate network islands. Each network provides their services using their own terrestrial and satellite receivers and, a shared coaxial cable. TV channel management was wide-meshed and often inadequate in such networks. Mix of multiple channels was distributed to end user using a STB (Set-Tob-Box) that is either hardwired or configured by means of the periodic distribution to end user. The problem with this STB box was the inability to create a mechanism of restricting access to premium subscriber channels such as movie channels. Few factor that have created the need to reassess the situation, those factor includes revolution of internet, a rapid increase in the performance of fiber infrastructure and a corresponding fall in price, and the new generation IP telephony [12].

4. MULTICASTING

It is a bandwidth−conserving technology that reduces traffic because it simultaneously delivers a single stream of information to thousands of corporate recipients and homes. For example, an application that takes advantage of multicast include video conferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news. [13].

4.1 Multicast Addressing Scheme

The Internet Engineering Task Force (IETF) has developed the IPv4 address scheme with four categories (classes), those are A, B, and C and D. First three addresses are used for unicasting traffic and Class D addresses are reserved for multicast traffic, and are allocated dynamically. The address scheme looks like as Figure 4

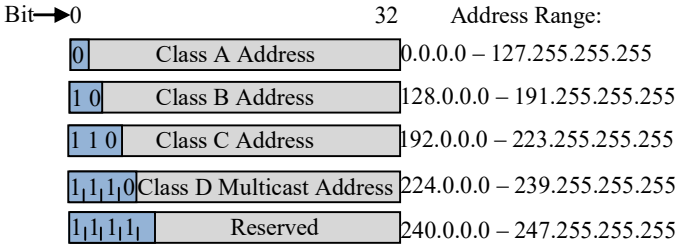

Figure 4: Multicasting address scheme

4.2 Multicast Routing Protocol

To do multicasting, we need to run special protocol on router and switches, those protocols are IGMP (Internet group Management protocol) and PIM (Protocol Independent module) [14].

4.3 IGMP

It control and limit the flow of multicast traffic throughout of a network with the use of special multicast queries and hosts. Query message send by network device such as router to discover which network devices are members of a given multicast group. A host is a receiver that sends report message in response to query messages. A set of quires and hosts that receive multicast data from same source is called a multicast group. Multicast address in the range 224.0.0.0 to 224.0.0.255 are reserved for use of routing protocol and other network control traffic and the host group address can be in range 224.0.0.0 to 239.255.255.255. IGMP general queries are destined to the address 224.0.0.1 (all system in a subnet).

The original IGMP version host membership model was defined in RFC1112 [18]. At present there are three version of IGM. Version-1 provide the basic query-response mechanism, According to RFC-2236 [17], version-2 has the IGMP leave process, group specific queries and an explicit maximum query response time. Version provides source filtering.

4.4 PIM

Protocol independent module keep the track of the current ip multicast service mode of receiver–initiated membership which is defined in RFC-2362. It operates in two mode that is PIM dense mode and PIM spare Mode. Router can handle those two modes at the same time. In dense mode, if a router receives a

multicast packet and has no directly connected member or PIM neighbor present, a prune messages is sent back to the source so that subsequent multicast packets are not flooded to this router on this prune branch. In spare mode, a router assumes that other router don't want to forward multicast packets for a group, unless there is an explicit request for the traffic. The RP (rendezvous' point) is used in spare mode. It keeps track of multicast groups. Host that send multicast packets are registered with the RP by the first hop router of that host. [14].

5. SETTING UP LAB OF IPTV

The network topology that we have used in test lab of IPTV has given bellows in the Figure 5. The equipments used with this lab were two Cisco Router (1800 series) and one Cisco Switch (2900 series), two hub, two client computer and one video stream server. We have only used hub in between router to router and router to switch to catch the multicasting traffic. A computer has been configured as a streaming server with VLC Player; two computers are connected to the switch as clients to receive the streaming data. Routers and switch are configured and enabled IGMP, PIM and CGMP protocols to support Multicasting. Wireshark network protocol analyzer has been used to capture and analyze multicasting traffic. We have considered four cases to capture the multicasting traffic.

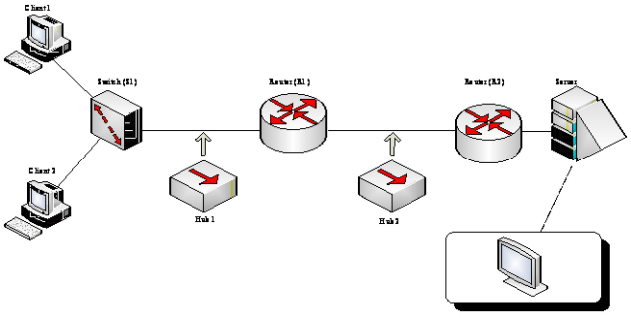

Figure 5: IPTV lab

6. RESULT OF IPTV LAB

Case 1: (Server & Router R2)

From the Packets captured between server and router (R2), it is found that UDP is used as transport protocol with the source port 1821 and destination port 1234. The other important thing is IGMP is used as multicast protocol and PIM is used as a multicast support protocol which looks like as Fig 6.

```
Protocol Independent Multicast
Version: 2
Type: Hello (0)
Checksum: 0x473a [correct]
PIM Parameters
Holdtime (1): 105s
Generation ID (20): 1976377667
DR priority (19): 1
Unknown Option (21), length: 4, value: 0x1000000
```

Fig 6: PIM messages

Case 2: Router R1 & Router R2 (by using Hub 2)

In this scenario, UDP is used as the transport protocol. PIM is also used as a multicast support protocol. CDP (Cisco Discovery Protocol) is used between two routers that looks like as Fig 7.

```
Internet Group Management Protocol
IGMP version:  2
Type: Leave Group (0x17)
Max Response Time: 0.0 sec (0x00)
Header Checksum: 0x08f4 [correct]
Multicast Address: 224.10.0.1 (224.10.0.1)

Cisco Discovery Protocol
Version: 2
TTL: 180 seconds
Type: Hello (0)
Checksum: 0x11d5 [correct]
Device ID: ROUTER1
Software Version
Platform: Cisco 1841
Port ID: FastEthernet 0/0
```

Figure 7: Packets between R1 & R2

We also find two kinds of packet from the captured traffic those are membership query and membership report messages of IGMP as shown in the Fig 8.

```
Internet Group Management Protocol
IGMP version:  2
Type: Membership Report (0x16)
Max Response Time: 0.0 sec (0x00)
Header Checksum: 0xfa04 [correct]
Multicast Address: 239.255.255.250 (239.255.255.250)

Internet Group Management Protocol
IGMP version:  2
Type: Membership Query (0x11)
Max Response Time: 10.0 sec (0x64)
Header Checksum: 0xee9b [correct]
Multicast Address: 0.0.0.0 (0.0.0.0)
```

Figure 8: Member ship query and report message

Case 3: Router (R1) and Switch (S1) using Hub 1

Again UDP is used as the transport protocol and PIM is used as a multicast support protocol. The other packets include IGMP packets of query & report messages as mentioned above.
In addition to this, there was another packet named CGMP (Cisco Group Management Protocol) which indicates we have used CGMP technique instead of IGMP Snooping. Captured packets contents have given in Figure 9.

```
Cisco Group Management Protocol
0001....  = Version: 1
....  0000 = Type: join (0)
Count: 1
Group Destination Address: IPV4mcast_7f:ff:fa
(01:00:5e:7f:ff:fa)
Unicast Source Address: 3com_de:af:24 (00:50:da:af:24)
```

Figure 9: CGMP messages

We also found information which is related to STP (Spanning Tree Protocol) as shown in Fig 10.

```
Spanning Tree Protocol
Protocol Identifier:  Spanning Tree Protocol (0x0000)
Protocol Version Identifier: Spanning Tree (0)
BPDU Type: Configuration (0x00)
BPDY flag: 0x00
Root Identifier: 32769 / 00:0a:41:8c:7d:80
Root Path Cost: 0
Bridge Identifier: 32769 / 00:0a:41:8c:7d:80
Port Identifier: 0x8003
Max Age: 20
Hello Time: 2
Forward Delay: 15
```

Figure 10: STP protocol

Case 4: (Client C1, C2 and Switch)

Again, UDP is used as the transport protocol. But here there is no PIM packet is captured. Along with this, there is no IGMP packet with Membership query message because it is usually sent by multicast routers.

We have only found IGMP packets with Membership report and leave group messages because they are sent by the hosts and it has shown below in Figure 11.

```
Internet Group Management Protocol
IGMP version:  2
Type: Leave Group (0x17)
Max Response Time: 0.0 sec (0x00)
Header Checksum: 0x08fa [correct]
Multicast Address: 224.10.0.1 (224.10.0.1)

Internet Group Management Protocol
IGMP version:  2
Type: Membership Report (0x16)
Max Response Time: 0.0 sec (0x64)
Header Checksum: 0x09f4 [correct]
Multicast Address: 224.10.0.1 (224.10.0.1)
```

Figure 11: Message transaction between host computer and switch

7. FINDINGS AND ANALYSIS

Few parameters those includes Hello, Hold timer, Generation ID, Length, Checksum, DR Priority have found from the captured packet between router 2 and video steam server (Fig 6). Hello messages will send a router as soon as PIM enabled and configured to detect other PIM enabled router. In this case router 2 sends this Hello message but didn't receive any Hello message from other end because other end of this link is a streaming server and it's not PIM enabled. Hold time indicates the time period by which a receiver must response to the originator. The Generation ID is a random number which is generated whenever PIM is enabled to any router interface; the checksum is a calculated value of 16 bit one's complement of the one's complement sum of the entire PIM message used in data communication to check the packet has been transmitted successfully or not [20]. DR indicates the designated router of a network that can be changed by assigning value within the range of 1 to 65535 and 0 is the default value.

From the captured packet of router 1 and router 2 interaction (Fig 7, Fig 8 and Fig 11), we have got few message of IGM those are header checksum, max response time, multicast address and type of message (leave group, query and response). Checksum is a 16 bit value which is calculated and insert with the message by sender. At the receiver end before processing this packet the checksum must be checked that ensure successful delivery of the messages. Maximum response time will only be noted during membership query message, for leave group and response message it will always set to zero by the sender and that's why we have got max response time for query message 10 sec where member ship response time and leave group time 0 sec (Fig 7 and Fig 8). We also have found multicast address 0.0.0.0 for general membership query message, 239.255.255.250 for membership report message and 224.10.0.1 for leave group message. This is because for query message the group address field is set to 0 , leave group message and report messages holds the multicast group address [21].

In Fig 9, we have seen another protocol named CGMP. It's only used in the IGMP enabled router interface. As soon as its enabled, router will send join messages to advertise themselves to switches with in this network. CGMP works with IGMP

messages to keep updated cisco switch port, to forward IP multicast traffic to only those port that are belongs to IP multicast host. When a CGMP router receives an IGMP control messages, its creates a CGMP packet that holds join or request message, multicast group address and actual MAC address of the host and only Cisco router sends this message instead of any host. When a switch receives a CGPM messages changes the forwarding behaviour and send it to only that port associated with IP multicast client[22][23]. Fig 9 holds the CGMP messages are Join, group destination address and unicast source address.

From Fig 7 and Fig 10, we have found two another protocols named CDP (cisco discovery protocol) and STP (Spanning Tree Protocol).CDP is used to get the information of neighbouring devices like platform, IP address and is a Cisco proprietary protocol. STP is used to make a loop free path for multicasting traffic.

CONCLUSION

Initially, a specific study on compression technique of audio video file format has been done that allows IPTV to consume less bandwidth. We also studied on various protocol of IPTV those includes IGMP, PIM, and CGMP that helps us to run the IPTV lab. Few factor have been remarks those includes revolution of internet, a rapid increase in the performance of fiber infrastructure and a corresponding fall in price, and the new generation IP telephony from the back ground study of IPTV and multicasting that aware us to think about the present situation of IPTV services. Mainly, what we have done with this paper work was to find out the protocols that are used with IPTV and Multicasting. It has been done capturing multicasting traffic considering four possible cases and discussed. Finally, it can be said this paper works gives us a clear understanding how various protocols of IPTV works and interact with each other.

REFERENCES

[1] D. Pajdušáková, B. Adamec, Triple play service and IPTV services offered within it, Department of , Advances in Electrical and Electronic Engineering Year: 2011 Vol: 7 Issue: 1 - 2Pages/record No.: 33-35

[2] Snezana Tilovska, Aristotel Tentov, Performance Model of Key Points at the IPTV Networks, International Journal of Computer Networks (IJCN), Volume (3) : Issue (2) : 2011

[3] Laith Al-Jobouri, Martin Fleury, Mohammed Ghanbari,Error Resilient IPTV for an IEEE 802.16e Channel, Wireless Engineering and Technology, Year: 2011 Vol: 02 Issue: 02Pages/record No.: 70-79

[4] Sergio Gonzalez-Miranda, Tomas Robles, Fernando Ortigosa, Juan Carlos Plaza, and Jose Luis Peña, Converging Multidomain Services in an IMS environment for IPTV and 3G Networks ,International Journal of Next-Generation Networks (IJNGN) Vol.3, No.2, June 2011

[5] D.Leghroudi, M.Eraisse, N.Moumkine, M.Bellafkih, M.Ramdani, ETOM process to Manitor and Corelat IPTV QoS in IMS, International Journal of Next-Generation Networks Year: 2011 Vol: 3 Issue: 2 Pages/record No.: 53-72

[6] Yang Xiao, University of Alabama, Xiaojiang Du, North Dakota State University, Jingyuan Zhang, University of Alabama, Fei Hu, Rochester Institute of Technology, Sghaier Guizani, University of Quebec, Internet Protocol ζiller Application for the Next- : 2007 Vol: 45 Issue: 11 Page: 126-134

[7] Arian IT Maraj, Adrian Shehue, Telecommunication Department, Faculty of Information Technology, Polytechnic University of Tirana, Tirana, Republic of Albania, The necessity of multicast for IPTV streaming, http://www.wseas.us/e-library/conferences/2011/Lanzarote/TELESI/TELESI-21.pdf

[8] James She, Fen Hou, Pin-Han Ho, and Liang-Liang Xie, University of Waterloo, IPTV over WiMAX: Key Success Factors, Challenges, and Solutions. Year: 2007 Vol: 45 Issue: 8

[9] http://en.wikipedia.org/wiki/Lossy_compression

[10] http://www.vbrick.com/docs/VB_WhitePaper_TransportStreamVSProgramStream_rd2.pdf

[11] A beginner's guide for MPEG-2, http://www.fh-friedberg.de/fachbereiche/e2/telekom-labor/zinke/mk/mpeg2beg/beginnzi.htm#MPEG-2%20Video

[12] PeterGustafsson, director of engineering packetfront, Inc. IPTV Distribution, http://www.iec.org/ Newsletter/feb07_1/analyst _corner.pdf

[13] http://ciscosystems.com/application/pdf/paws/356/48.pdf

[14] Cisco IOS IP configuration Guide http://www.cisco.com/en/US/docs/ios/12_2/ip/configuration/guide/1cfmulti.html#wp1065988

[15] Lab on IPTV and Multicasting

[16] What is Multicasting, http://www.savetz.com/mbone/ch3_1.html, last accessed on 8th July, 2011

[17] W. Fenner, Xerox PARC, Rfc 2236 http://www.ietf.org/rfc/rfc2236.txt

[18] S. Deering, Stanford University, Rfc 1112, http://www.ietf.org/rfc/rfc1112.txt

[19] D. Estrin, Usc, D. Farinacc, Cisco, A. Helmy, Usc, D. Thaler,UMICH, S. Deerin, XEROS ,Rfc 2362, http://www.ietf.org/rfc/rfc2362.txt

[20] A. Adams, J. Nicholas, Request for Comments: 3973, PIM-dense mode http://tools.ietf.org/html/rfc3973#section-4.3.1, January 2005

[21] W. Fenner, Xerox PARC, Request for Comments: 2236, Internet Group Management Protocol, , Network working group, http://www.ietf.org/rfc/rfc2236.txt, November 1997

[22] IP CGMP, IP multicasting Command, http://www.cisco.com/en/US/docs/ios/12_3/ipmulti/command/reference/ip3_i1g.pdf

[23] CGMP, Cisco Group Management Protocol, http://www.javvin.com/protocolCGMP.html