Wireless IPTV over WiMAX

Alexey Borodinsky
Director of Astrakhan branch of PJSC «Southern Telecommunication Company»

Abstract

Based on IP protocol, IPTV features advantages like bandwidth efficiency and ease of management. IPTV supports both broadcast and unicast services like LiveTV and VideoOnDemand. WiMAX wireless system, capable of ensuring high bandwidths and low latencies, is suitable for delivering multimedia services. In addition, it also provides wide area coverage, mobility support, and non-line-of-sight operation. Therefore, WiMAX is a promising solution for delivering IPTV services anytime anywhere, especially to rural areas or remote locations. This paper identifies the challenges in delivering IPTV over WiMAX wireless system and proposes a framework to provide some solutions to those challenges, at MAC and Physical layers. Taking advantage of the WiMAX features, IPTV services can be delivered at low costs and with high audio/video service quality.

Index Terms: IPTV, QoS, WiMAX, VideoOnDemand, LiveTV.

I. Introduction

The increase of satellite services and digital cable, and the appearance of HDTV have had a big impact on the television market. Besides the standard TV services, nowadays people want to be able to watch their favorite TV programs and shows anytime anywhere using their mobile devices, all these without a loss in video or audio signal quality. They also want to be able to use the same device for other services such as voice and data. The telecommunications companies are trying to explore the existing technologies to provide all these by the means of the TripplePlay services. A new TV delivery method, the Internet Protocol Television (IPTV), has appeared as a solution to ubiquitous TV access. IPTV is a system capable of receiving, decoding and displaying video streams transmitted as Internet Protocol (IP) packets. The video content is first compressed and encoded into video streams, which are then transmitted over the network as IP datagrams. Sending digital video using compression over an IP network has many advantages such as bandwidth efficiency.

Besides TV contents, the networks can also carry digital audio, telephony and data, allowing cable and phone companies to deliver triple play services over the same existing infrastructure. However, while there are many advantages to using IP, there are also considerable challenges. For example, transmitting TV services over IP faces significant Quality of Service (QoS) challenges for the service provider. Video over IP is unreliable and something as simple as channel surfing can easily become a problem on an IP network. The premises that made possible the appearance of IPTV services include the development of Gigabit Ethernet, the appearance of high speed switches and routers, and the availability of QoS provisioning for IP networks. IPTV has a typical bandwidth requirement of 2Mbps/channel to 8Mbps/channel (HDTV) and it requires a broadband connection with QoS support. The only certain way, until now, to meet the consumer’s needs is to use fiber all the way to the home. This allows bandwidth up to 1Gbps, and can provide 30-75 Mbps per user. With a typical 20Mbps for a HDTV channel we have to keep in mind that when changing the channels, even for a short time, there are two streams simultaneously transmitted. This means about 40Mbps for only one TV. If we count multiple TV sets in a household and add the data traffic and voice, all these can reach to about 100Mbps per connection. Fortunately, PON networks can provide this kind of fast speed. Until now, there are many companies delivering IPTV over optical fiber networks. The quality of the signals delivered using optical fiber is superior to that of cable TV systems. Fiber systems make it possible to supply signal to several TV sets, including reasonable cable loss. Given that many fiber systems have adequate bandwidth to deliver an MPEG-2 signal (even HDTV) using IP, this is a very feasible solution.

IPTV is very popular as it delivers the content to users whenever they want. The next step is to deliver this content wherever the users are. This is where a wireless technology that supports mobility is needed. Worldwide Interoperability for Microwave Access (WiMAX) technology is based on IEEE 802.16−2004 and 802.16e−2005 standards for fixed and mobile wireless access in metropolitan area networks (MAN) [3]. It supports data rates of 70Mbps over ranges of 30km with mobility support. Nowadays, WiMAX is the only wireless networks.

WiMAX medium access control (MAC) layer supports real time polling services (rtPS) ensuring required bandwidth and minimum latencies for video services through quality of service (QoS). It uses orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) physical layer (PHY). It also uses adaptive modulation and coding schemes and forward error correction (FEC) to increase service quality [3]. Moreover, it is an all IP access network and offers transparency for packet based core networks. All these make WiMAX an ideal choice for IPTV applications with ubiquitous access. In the future, WiMAX could deliver IPTV to rural regions, off-shore rigs and other remote locations, with high degree of video and audio quality at affordable prices. It may also be well suited for medium quality video services delivered to mobile devices such as notebooks and WiMAX capable phones. In this paper author aims to identify the challenges related to delivery of IPTV services over WiMAX networks Then we propose a framework that we would like to use next in implementing a system capable of delivering IPTV services over an IP based WiMAX network. We try to give some solutions especially from the Physical and MAC layers.

II. Main part

While all the streams are multicast from the national head end to local offices at the same time but here, the local last mile line can not support all the channels at once. The question is how to send hundreds of channels to an IPTV subscriber with a WiMAX line? The answer is only sending a few at a time. A Windows Media stream takes up 1.0 to 1.5Mbps for SDTV; ten channels could be sent at once with bandwidth left over for voice and data. HDTV uses about 20-25Mbps and for H.264 the rates are 7 to 8 Mbps. This means the number of video streams sent from the local office to the subscriber is about four due to the limited bandwidth. When a user changes the channel on their STB, it does not "tune" a channel like a cable system, but it switches channels by using the IP Group Membership Protocol (IGMP) to join a new multicast group. This way, only signals that are currently being watched are actually sent from the local office to the user and so, the WiMAX available bandwidth may be enough for delivering IPTV services.

One great advantage of the WiMAX is its multicast capability. The multicast technology allows a base station (BS) to send video packets to a subset number of stations. For example, during a Super Bowl game, a large number of viewers may want to watch a single channel. Using the multicast feature of WiMAX, all of these users can be served by consuming a relatively very small bandwidth. The idea can be extended to any TV channel as it is expected to be more than a single viewer for any TV show. On an IP-based network though, channel surfing can become an issue because only one stream of video is transmitted to the TV at any one time. When the TV viewer wants to change the channel, he punches a remote that sends the signal to the television set which, in turn, sends another signal on to a router on the network. The router then has to stop sending the original stream and then send a new stream based on the requested channel. This creates a delay between the time the router stops sending over the old channel and when it starts sending over the new requested channel. The situation is worsened when the router is subjected to multiple change requests all at the same time. IPTV is expected to provide ubiquitous access with mobility support. Providing services to mobile users is always a challenge, especially the multimedia services. Another advantage of WiMAX is the support for data communications at vehicular speeds, feature which was impossible until now in regular cable TV systems. Another problem that arises when IP networks handle video is due to the way the network handles data. In an IP network, data is broken up into small packets and then sent off separately. At its final destination, all the data packets are reassembled again. When video is put on an IP network, that video is also broken up into small packets and sent from the source, the broadcaster, through the network, to eventually be reassembled into video that TV viewer gets to watch. While this system is a good way of sending ordinary data files, when applied to video, it creates problems. Video files are extremely large and to send a complete file over might take several hours. The solution is to have the video play as the packets are downloaded. However, due to factors such as routing changes, network congestion or timing drift, the packets do not all arrive at the same rate or even in the correct order. This problem is known as jitter. The solution to this problem is a jitter buffer. The jitter buffer stores the packets as they come in. These packets are assembled in the buffer ahead of their use so that late packets can be added. In a packet based system, each layer is adding significant amount of overhead to the initial packet, therefore reducing the effective payload capacity and the altering the quality of the IPTV signal. WiMAX is decapsulating the frames up to the MAC layer, therefore it can use payload header suppression and compression techniques in order to reduce the amount of overhead at Physical and MAC layers.

WiMAX systems are using very performing radio transceivers. The parameters of such a transceiver are high stability, low noise, high linearity and wide dynamic range. Beside these, in order to support IPTV and video applications, a high bandwidth is also required. The power consumption is another important issue in designing a WiMAX system able to support IPTV services. A TV program can last a few hours; therefore the system delivering will use a high amount of power. A good way to reduce the power consumption is to implement different modes of operation that can be changed dynamically according to the needs (e.g. idle mode, sleep mode). Another way to save energy is by using a high sensitivity receiver. The proposed system has to be able to support multiple users.

A good way to increase the capacity of the system is to use high gain sectorized antennas. By using such a method, the IPTV services can be delivered further away and to a bigger number of customers. IPTV as we said is currently being delivered over fixed networks. How about in mobile ones? Such a system may be depicted in Figure 1, where the IPTV is delivered from the service provider regardless of the type of network, through a fixed or wireless network.

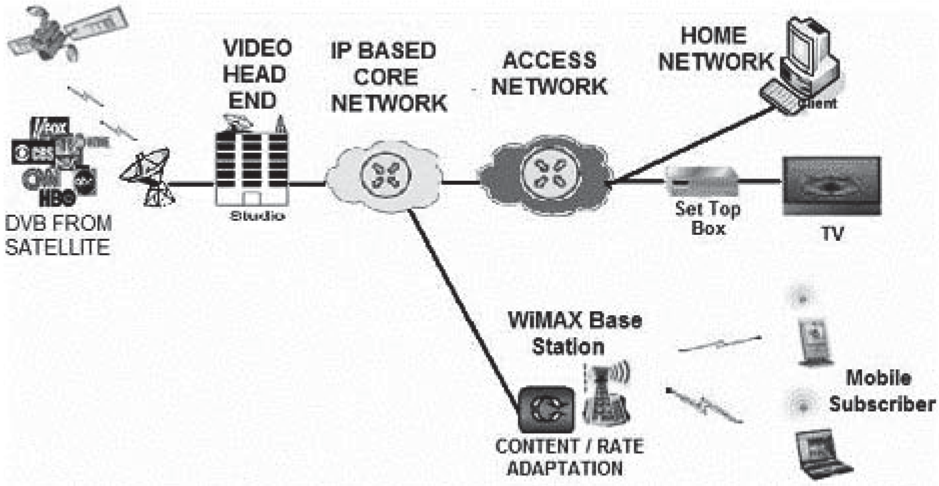

Fig. 1. Delivering IPTV Services to both Fixed and Mobile Subscribers

The content/rate adapter block is here responsible for adapting the IPTV service bandwidth to the available WiMAX bandwidth and is performing the IP decapsulation and reincapsulates the video streams.

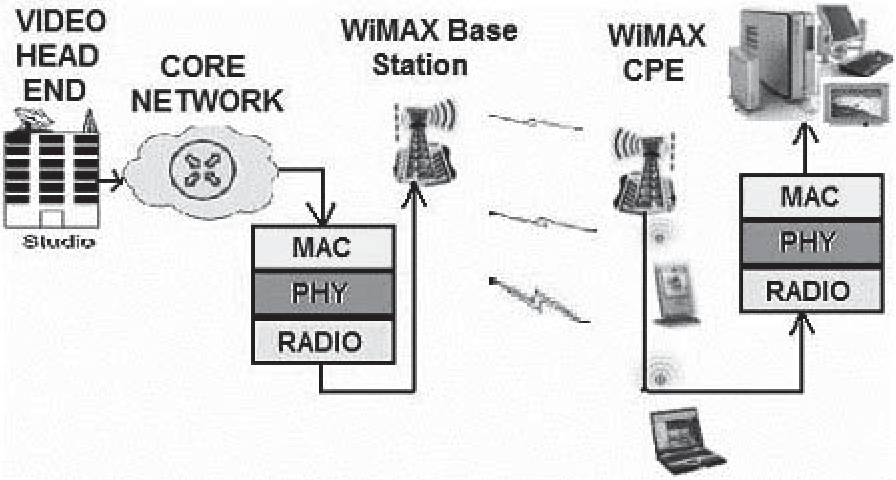

Fig. 2. System Model for IPTV Applications

The adaptation, depending on the type of network is addressed to, has to be done in two steps: rate adaptation and content adaptation. A functional block diagram of an IPTV application is illustrated in Fig. 2, while Fig. 3 shows IPTV protocol stack. A system model was proposed in [2] but in our implementation we intent to use a traffic classifier at the MAC layer, adaptive modulation and coding at the Physical layer, as well as power management algorithms at the radio transceiver, in order to provide an improved multimedia experience to the IPTV users.

At the video head end, the video streams are encoded and compressed (e.g., MPEG2) from live and stored programs. The MPEG channels are encapsulated as real time transport protocol (RTP) and transported as a UDP or TCP streams to the IP layer. The IP packets are encapsulated into Ethernet frames and then sent over the network through the physical layer. The WiMAX BS receives this data and decapsulates them up the IP layer and re-encapsulates them into specific MAC and PHY PDUs. The physical layer performs FEC, symbol mapping and modulation while the radio transceiver transmits the resulted signals to the mobile nodes. Here, the video streams are sent to the STB or PC decoder and regenerated into video content. The MAC and Physical Layer together with the radio transceivers are the components where we will focus our attention at, with the remark that the MAC implementation is a key component because here is where the queuing and scheduling of service is done. The MAC layer implementation is also the one that will facilitate the QoS provisioning necessary for our system.

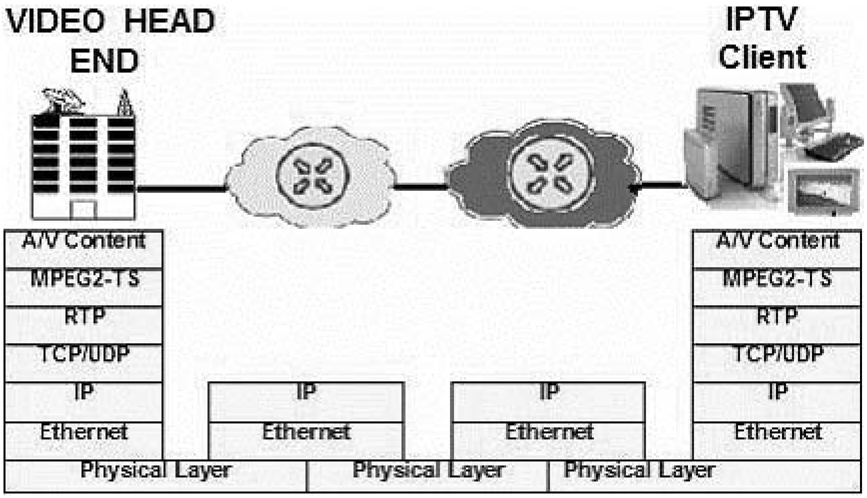

Fig. 3. The IP Protocol Stack for IPTV transmission

1) Medium Access Control (MAC) Layer

WiMAX is a point-to-multipoint system, connection-oriented. The WiMAX MAC layer protocol is a Dynamic service “editing” protocol [4], with Add/Change/Delete functions, which allows a management of the message payload format. One of the biggest advantages is that it offers flexible QoS provisions and this major advantage is exploited in our proposal. Fig. 4 shows the proposed implementation of the MAC layer classifier. The BS receives the downlink IP traffic which may contain data for different kind of services (internet data, voice, video, etc.). According to the type of service it is addressed to, this traffic is QoS classified as UGS, rtPS, nrtPS or BS. The video streaming uses rtPS.

A traffic classifier has the role to sort the incoming traffic according to the priority and QoS demands. First it extracts the header information from the IP packets and sends it to the connection management unit. Based on the header info, the connection management assigns a unique FlowID to each packet. The FlowID will contain information about the type of service and type of connection for each packet and will be assigned according to the QoS policy protocol stored in the QoS Database. For IPTV services, this protocol has to be designed by taking into account specific parameters as:

Minimum/Maximum Delay, Minimum/Maximum Data Rate, Retransmission and Requests Policy, etc.

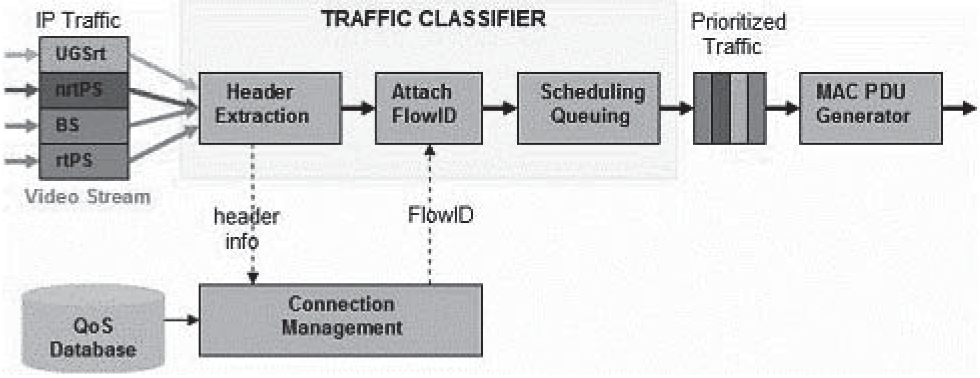

Fig. 4. MAC Layer QoS Support

The traffic classifier attaches the generated FlowID to the IP packets and the Scheduling/Queuing block will sort the IP traffic accordingly. In this case, the video IPTV stream has to have the maximum priority. In the end, the specific WiMAX MAC PDU will be generated and sent to the Physical layer. The same process has to be implemented in the reverse way.

2) Physical Layer (PHY)

Fig. 5 shows the block diagram of our Physical Layer implementation. According to the WiMAX standard [4], at the Physical layer, the packets arriving from the MAC layer are first subject to Channel Coding and Modulation. The Channel Coding consists of randomization, forward error correction, coding (such as Reed Solomon and convolutional line coding) and interleaving.

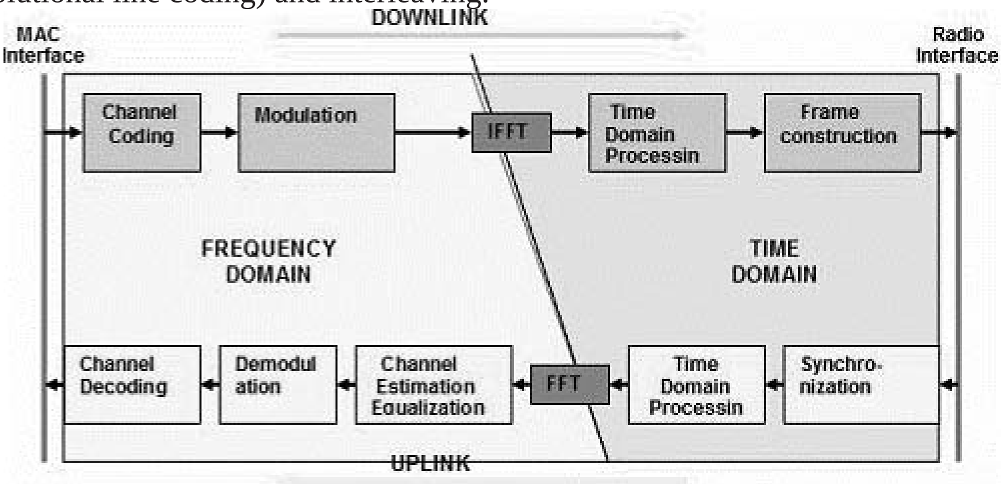

Fig. 5. PHY Layer Architecture

The Physical layer supports different modulation types (QAM, BPSK, and QPSK). In our design we propose an adapting modulation technique at optimal coding rates, in order to maximize the bandwidth efficiency with respect to quality. Following the modulation, the Inverse Fast Fourier Transform (IFFT) transforms the signal from the frequency domain to the time domain, followed by time-domain processing (such as spectral shaping, interpolation). Finally, there is a frame construction block which adds preamble and cyclic prefix, followed by the Radio Interface (IF and RF interfaces). The reverse path is similar. It includes time/frequency synchronization, channel estimation, equalization, demodulation and decoding and it moves the signals from time domain to frequency domain. The block diagram for the WiMAX BS transceiver is given in Fig. 6. It consists of digital and analog part. Here we intend to implement a power management algorithm that will tune the transceiver parameters (e.g., amplifier gain, power level, carrier frequency) in order to achieve the optimum quality of the signal.

From the Physical layer, the digital signal with the I and Q components is first Digital Up-Converted. This signal is then converted to the analog domain by the DAC while a two stage up converter (IF and RF) uploads the signal to the desired radio frequency. The resultant transmit signal is amplified by a Power Amplifier. The amplified signal is passed to the antenna through the switch or duplexing device, depending on the duplexing method (TDD or FDD).

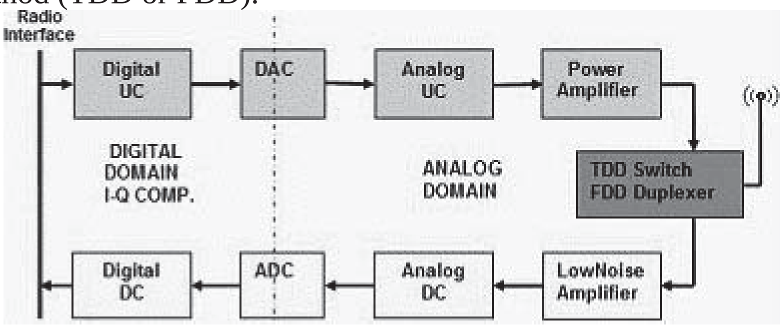

Fig. 6. Radio Transceiver Diagram

In the other way, the received signal is amplified using a low noise amplifier (LNA) down converted to the IF stage using the two-stage down converter (RF and IF). This signal is digitized and I/Q samples are downconverted and sent to the Radio interface.

III. Conclusion

IPTV enables users to have VoD services as well as to subscribe whichever broadcast channel of their choice anytime anywhere. With WiMAX offering high data rates to both mobile and fixed users with low cost and high quality, the implementation of IPTV over WiMAX become promising. In this paper, author has introduced IPTV, identified the challenges in implementing IPTV, and setup a framework for delivering IPTV over WiMAX. As a future work, we intend to design and develop specific adaptive modulation and coding scheme, power management mechanism, and resource allocation algorithm to facilitate IPTV over WiMAX.

References

[1] Maneesh Bakshi, "VoIP / Multimedia over WiMAX (802.16)", http://cse.wustl.edu/~jain/cse574-06/wimax_voip.htm
[2] Junqiang Hu, Dayou Qian, Haijun Yang, Ting Wang, Steve Weinstein, "Triple Play Services over a Converged Optical/Wireless Network", OFC/NFOEC Digest, 2006
[3] IEEE Standard 802.16 Working Group, "IEEE Standard for Local and Metropolitan Area Networks part 16: Air Interface for Fixed Broadband Wireless Access Systems" IEEE, 2004.
[4] "Application Usage Scenarios Using WiMAX Technology", December 2005, Prepared by Application Working Group WiMAX Forum
[5] Wan-Ki Park, Chang-Sic Choi, Youn-Kwae Jeong, Intark Han – "An Implementation of the Broadband Home Gateway supporting Multi-Channel IPTV Service ", Consumer Electronics, 2006. ISCE '06. 2006 IEEE Tenth International Symposium