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Multicasting of Video Streams over WiMAX Networks - A Review

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Abstract: ***Multicast and Broadcast service of mobile WiMAX is the fastest growing technology in the past few years, because it provides the multimedia content to large scale users in a cost efficient manner. The high speed wireless networks have made it possible to provide real time multimedia streaming. This paper presents an exhaustive survey of recent work addressing multicasting of video streams over WiMAX networks. The following sections provide the detail analysis of the work. Section 1.0 describes the brief introduction of WiMAX networks and video streaming, section 2.0 describes the background which further describes the WiMAX frames and different scalable coding techniques for video streaming, in its sub-sections, section 3.0 describes the literature survey and section 4.0 describes the conclusion.***

Keywords: Multicasting, WiMAX, scalable video coding, video streaming, scalability.

1. Introduction

From recent years, the demand of internet access bandwidth for multimedia streaming has been increasing steadily. The vast developments in high speed wireless networks have made it possible to provide real time multimedia streaming. Multimedia streams can be delivered to mobile devices by different wireless networks such as 3G, Wi-Fi and WiMAX.[1] Among these wireless networks, Worldwide Interoperability for Microwave Access (WiMAX) is conspicuous on the aspects of high data range and high coverage. The standard of WiMAX is IEEE 802.16. [2][3].Recently, new IEEE 802.16e WiMAX standard has attracted lot of attention. This standard defines a wireless broadband technology that can support mobile users. The physical layer used in IEEE 802.16e is scalable OFDMA. It has spectral efficiency and is resistant to multipath. Thus WiMAX system offers high bandwidth up to 70Mbps over several kilometers (km). [4]

WiMAX supports less delay applications such as video, voice and Internet access. The performance of WiMAX will empower transparency of quality of services between mobile WiMAX and broadband wired services such as cable and DSL. Mobile WiMAX accepts the fixed wireless application and empowers it like a cell phone applications. It powerfully replaces cell phones and mobile data contribution from cell phone operators. For example, mobile WiMAX empowers streaming video to be broadcast from a speeding police or other emergency vehicle at 70MPH. Mobile WiMAX will be very valuable for rising services such as mobile TV and gaming. WiMAX standard supports various network services. One of these services is multicast and broadcast service (MBS).

A WiMAX network would be divided into cells and further sub-divided into sectors. Within a sector, the MAC layer of WiMAX base station directs users on the uplink and on the downlink for a particular time slot and frequency channel. Since a central existence schedules users, implementing multicast is easier in WiMAX network: a base station then needs to inform all users belonging to multicast group to listen into the same time slot and frequency channel. Thus WiMAX has natural support for multicasting.

In WiMAX networks, video streaming is consisted of three parts: (i) WiMAX base station, (ii) content source and (iii) WiMAX receivers. Multimedia contents are collected from different sources and set to the WiMAX base station. The WiMAX base station constructs a schedule to transmit the incoming data to the subscribers. Each base station provides wireless coverage over area of 50 km or 30 miles. Content sources are national TV broadcasters, internet TV operations, local TV broadcasters and other video broadcast service providers. The WiMAX transmitter station can connect directly to internet using high bandwidth. [6]

2. Background

A background on the work can be obtained by understanding the following terminologies and concepts.

2.1 WiMAX / IEEE 802.16

WiMAX is a wireless data transmission technology for mobile and fixed users. This technology is having IEEE 802.16 standard. It is based on the air interface protocol. This standard describes the Physical (PHY) and Media Access Control (MAC) layers for the wireless link between the Base Station (BS) and the Mobile Station(MS). MAC layer can support multiple PHY specifications. With the use of Orthogonal Frequency Division Multiple Accesses (OFDMA) PHY in which the BS allocates transmission resources to multiple MSs and data transmission is done on the basis of frames. An OFDMA is stable sized connected region, which is divided into up-link and downlink sub-regions, in both frequency and time domains. Within an OFDMA frame, the BS scheduler distributes slots to MSs. This slot is the smallest transmission resource in a frame. [7]

2.2 WiMAX FRAME

In WiMAX PHY(physical) layer, Time Division Duplex (TDD) frames are used for transmitting data over multiple

carriers. As shown in Figure 1, every frame comprises of header information and also upload/download maps guided by bursts of user data. Since video scattering is expected to be a dominant traffic pattern, the WiMAX standard defines a service called Multicast and Broadcast Service (MBS). To make easy multicast and broadcast in the MAC layer using MBS, a certain area in every TDD frame can be set on one side for broadcast only and multicast only data. The complete frame can also be chosen as a download-only broadcast frame. The problem is selecting most favorable sub-streams of scalable video streams under bandwidth conditions. The solution for this problem is important because it empowers the network operator to transmit more number of videos or high quality videos streams at the same capacity. [8]

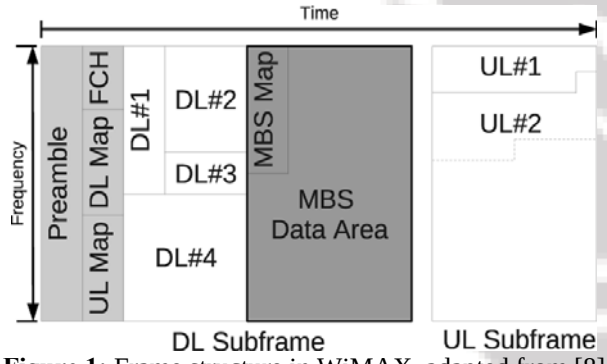

Figure 1: Frame structure in WiMAX, adapted from [8]

2.3 Support for Real-time services:

The WiMAX MAC allows user to select amongst five service classes: rtPs (Real Time Polling Service), nrtPS (non-Real Time Polling Service), ertPS (Extended Real Time Polling Service), UGS(Unsolicited Grant Service) and BE(Best Effort). Among all these rtPS is designed to support real time video.

2.4 Multiple Descriptions Coding (MDC):

It is a coding technique that shatters a single media streams into n sub-streams ($n \geq 2$). The goal of MDC is to create different independent descriptions or representations which can add to one or more characteristics of video: signal-to-noise ratio, spatial or temporal resolution and frequency content. Representations are directly proportional to the video quality i.e. the more representations received, higher the quality of video decoded. Descriptions can have balanced MDC schemes or unbalanced MDC schemes. The quality of streams can be expected to be roughly proportional to data rate confirmed by the receiver. MDC allows for rate adjustable streaming. Content providers send all representation of a stream without checking the download limitation of user. It has been shown by experiments that the quality delivered by Multiple Description or Representation is acceptable even at high loss rate and it is very robust. [9]

2.5 Layered Coding

Single Description (SD) video coding has been used by majority of codecs. As MDC is a technique of data partitioning but this technique does not partition any data. It generates two layers-base layer and n-enhancement layers. The base layer is essential for decoding media stream. The enhancement layers are used to improve the video quality. The first enhancement layer depends on the base layer and every enhancement layer n+1 depends on its lower layer n. So it can only be applied if n was already applied. So, if the base layer is missing, then the data of respective enhancement layers are interpreted as useless.

2.6 H.264/Scalable Video Coding(SVC)

H.264/SVC standardization enables the capability of high quality video bit stream which contains one or more sub-set bit streams ,i.e. base layer plus one or more enhancement layer, that can themselves be decoded independently to achieve the desired level of quality of video decoded. H.264/MPEG-4 AVC plans with same quantity of data as in the sub-set bit stream. The sub-set bit stream is obtained by dropping packets from larger bit stream. SVC supports three main type of scalabilities-Temporal, spatial, SNR/Quality/Fidelity scalability. [9][10]

2.6.1 Temporal scalability

Temporal scalability means various frame rates are available. The progression compensation dependencies are organized in such a way that entire pictures (including their associate packets) can be dropped from bit stream.

2.6.2 Spatial resolution

Spatial resolution means bit stream can provide different spatial resolutions. In order, to reduce bit rate to code the higher qualities, the decoded samples and data of lower qualities can be used to fore hold samples and data of higher qualities.

2.6.3Quality/SNR/Fidelity

Quality/SNR/Fidelity scalability means the visual quality is scalable. Video is coded at single resolution but at different qualities. The decoded samples and data of lower quality can be used to fore hold samples and data of higher qualities. All these three scalabilities are highly appropriate both for video conferencing application and streaming application. [11]

3. Literature Survey

- In the paper [5] Chandra.R* et al focused on multicasting of video streams over WiMAX networks. Their goal was to achieve the quality of service in WiMAX networks. In the paper, the objectives carried out for this are (i) methods involved to carry out its sub-stream formation of video stream, (ii) the scheduling algorithm and (iii) performance evaluation comparison. The main idea was proposed for improving performance metrics such as throughput, loss rate and average delay in order to achieve the quality of service of WiMAX networks. For the calculation of delay jitter, throughput and loss rate the scheduling algorithm used in the paper was Deficit Round Robin (DRR), Weighted Round Robin (WRR), Virtual Clock (VC). For their results they measured throughput, delay jitter and loss rate for 1 sec. For varying frame sizes. Their results shows that DRR and VC gives better throughput i.e. 2,58,016 and 2,73,368 respectively and VC

gives lesser loss rate i.e. 37,853 and lower delay jitter , in comparison to other algorithms. So, their technique is useful for selecting optimal sub-streams of scalable video streams under bandwidth constraints and to maximize the quality of mobile receivers.

- In paper [6] Somsubhra Sharangi et al focus on optimally utilizing the WiMAX Multicast/Broadcast Service (MBS) to stream multiple scalable videos to mobile receivers. They showed that the substream selection problem in presence of bandwidth limitation is NP-Complete. They proposed a Substream Selection algorithm for this problem. In their algorithm they first derived bounds on solution value which reduced the size of search space and then they constructed a dynamic programming table for all quality values within the bounds and found the solution sub-stream using backtracking. For WiMAX network parameters, they used 16-QAM modulation scheme with ¾ convolution turbo coding and 10-MHZ channel. They compare their algorithm with the optimum algorithm in terms of video quality by taking receiver buffer size fixed= 512kb, the scheduling window size=1s and number of streams=10 to 50. In other experiment they kept number of streams fixed=20 and scheduling window size=1 to 10s. the results produced by their algorithm were close to optimal solutions, which meant that their algorithm can support large scale WiMAX streaming services. They proved that their algorithm has a small approximation factor of $(1+\in)$, and it has a time complexity of $O(nS/\in)$, where $n= O(\Sigma L)$ is the total number of layers and L is the maximum number of layers in scalable stream. Their simulation results show that the approximation factor of the proposed algorithm is very close to one for practical scenarios. They also verified that their algorithm can run in real time.
- In the paper [7] Swarna Parvathi.S et al focus on the multicasting of video streaming over WiMAX networks. They used multicast routing protocol, PUMA i.e. Protocol for Unified Multicasting through Announcements, to achieve scalability in the network. PUMA achieves desired packet delivery ratio with variable number of nodes. Puma uses multicast announcements for all its functions. In this paper, performance analysis was done and quality metrics like PSNR was analyzed. Their analysis shows that PSNR value in the WiMAX network is higher than that of WLAN. The overall PSNR for WLAN is 26.19 while for WiMAX it is 31.44. So, it was noticed that H.264 SVC performs better in WiMAX networks than WLAN.
- In the paper [8] Supratim Deb et al presented a technique for supporting real time multicast services in WiMAX networks. The paper focused on developing novel MAC algorithm that combine adaptive modulation and coding with layered video to optimize user perceived video quality and evaluating the system performance and the effect of different systems parameters through different simulations. They proposed a Greedy algorithm for video streaming. They proved that their proposed Greedy algorithm performs within 87-95% of the optimal for most realistic simulations. They also demonstrated that their algorithm offers a 25% improvement over a naive algorithm. They also studied the effect of varying number of layers and frequency of channel feedback on the system performance. Their results shows that, while increasing the numbers of enhancement layers from 0 to 5 increases the utility metric by 25% and an increase from 5 to 10 layers gives an incremental benefit of just 1%. So while, using small number of layers, good performance can be achieved.

4. Conclusion

In this paper, the different coding techniques used for scalable video streaming and various algorithms used for multicasting of video streams over WiMAX networks has been used. It can be easily concluded that multicasting of video streams over WiMAX networks can be carried out by many ways. All the algorithms and coding techniques used for multicasting and for its quality of service works in real time applications. Multicasting of video streams over WiMAX network can be very useful in future applications.

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