Video streaming application with post-decoding concealment technique

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Abstract. WiMAX employs high speed wireless technology and enables high bit rates real time video streaming in wireless environment. Many researchers have proposed various techniques and methods to evaluate and improve video transmission over WiMAX. However, dropped packets seem always exist. This paper implements java based video streaming application over WiMAX network and examines whole frame post-decoding concealment method to reduce dropped packet effect. The result is that packet drop impact in frame can be reduced with PSNR improvement about x dB. However, as concealment performed after decoding, there is additional delay in displaying the image which causes short flicker.

1. Introduction
Worldwide Inter-operability for Microwave Access (WiMAX) is radio technology based on 802.16-2004 standard [1], which was amended by 802.16e-2005 standard [2] to provide mobility support. The standard employs the orthogonal frequency division multiplexing (OFDM) technology which maximizes spectral efficiency and minimizes fading impact so that cell bit rate achieves more than 100 Mbps and coverage area is greater than 50 km [3]. Applications such high bitrates video streaming, live TV, video conferencing are applicable with high resolution video. WiMAX is able to serve rural area both line of sight (LOS) and NLOS [4]. The properties enable service quality differentiation (QoS) as well as point to point and multi point applications.

Video streaming applications can be used either for surveillance and business activities. Surveillance recognizes and monitors potential threats, criminal activities, social behaviors and law enforcement. Business application ranges from distant meetings, industrial monitoring as well as distance classes. Many researches have explored WiMAX for those applications. Scalabrino [3] tested voip through WiMAX test bed. Halepovic [5] experimented skype and real player application on WiMAX. Meanwhile Wang et al [6] improved video delivery by prioritizing video packets. Kumar et al [7] proposes wavelet packet transform (WPT)–based WiMAX for covert communication to enhance communication security. Securing link can also be performed by inserting key distribution messages into MAC header [8].

Regarding the concealment techniques, researches adjusted motion vector to apply spatial error concealment and temporal error concealment [9] to tackle packet loss impact to video frame. Jun-Hyung Kim [10] examined frame copy (FC) and motion vector (MV) using Kalman filter. Abraham et al [11] concealed the whole frame loss after decoding process. This method is codec independent.

This paper implements an experimental java based video streaming application, applies the whole frame concealment techniques to replace broken frame caused by packet loss and experiments the stream over real WiMAX device. Point to point system infrastructure is chosen with user datagram protocol (UDP) as the transport layer protocol.
2. Evaluation setup

The streaming experiment uses the Aperto PM-3000 base station and PacketMax-120 subscriber stations (Figure 1). One subscriber station SS1 was located 5m from the base station to provide additional background traffic. The Aperto’s PacketMax-3000 employs the WSS PM-BSR-58 radio that operates in 5.8 GHz (5.725-5.925GHz) spectrum by using the 8 levels of modulations (BPSK (½,¾), QPSK (½,¾), 16-QAM (½,¾) and 64-QAM (½,¾)). The system uses 3.5 MHz channel width with QPSK ½ modulation, and transmit power 5 dBm. Best effort (BE) scheduling and 1/16 cyclic prefix are set. HD video sequence of blue_sky.yuv is employed as evaluated traffic, taken from [12]. Details are in Table 1.

![Experiment Configuration](image1)

**Figure 1. Experiment Configuration**

| Parameter       | Value           |
|-----------------|-----------------|
| Sequence        | Blue sky        |
| Quality Factor  | 31              |
| Frame Rate/Type | 25/IPP          |
| Video Codec/Container | MPEG4/AVI   |
| Bit rate        | 2631 kbps       |
| Maximum Transfer Unit | 64000 bytes |
| Number of frames| 180             |
| Resolution      | 1920x1080       |

The streamer is designed by using Ffmpeg [13], Xuggle java wrapper [14] and Netbeans java editor. Xuggle bridges java programming language and Ffmpeg. Video client and server diagrams are shown in Figure 2.

![Video Grabber, Re-Packaging, Frame Analysis & EC overhead Generation, MAC monitoring, MAC monitoring, UDP Receiver, Frame Analysis & EC substitution, Buffering & Header Extension, Re-Packaging, Display](image2)

(a) **Figure 2. Server and client diagram blocks**

Frame concealment is performed to replaces loss or broken frame by using the most similar neighbouring frame. The most similar frame should be analyzed prior transmission. This is performed by comparing current frame to previous or next frames. The closest frame index is then stored as additional header in UDP packet. Frame similarity distance \( \delta \) is calculated and stored in its preceding frame \( n-1 \) header. If frame \( n \) is lost, previous frame information is used to restore or substitute the frame. The algorithm 1 shows how it works.
Algorithm 1: Whole Frame Copy

Sender
Prepare sending frame n-1
if $\delta(F_n, F_{n-1})$ less than $\delta(F_n, F_{n+1})$ then
    header frame n-1
    $x \leftarrow 0$
else
    header frame n-1
    $x \leftarrow 1$
end if
Send if

Receiver
if frame n ($F_n$) is missing, then
    Initialize previous frame index
    $m \leftarrow n-1$
    Obtain index in previous frame header
    $x \leftarrow F_m$ header
    if $x \leftarrow 0$
        Estimate frame using previous frame copy
        $E(F_n) \leftarrow FC_{n-1}$
    else
        Estimate frame using next frame copy
        $E(F_n) \leftarrow FC_{n+1}$
    end if

3. Evaluation results
During the experiment, 12 times video transmissions were performed with 540 frames transmitted. Three packets were broken during third, sixth, and eleventh trials: frame 21, 68 and 115. The packet loss causes these broken frames is 0.55% of all packets. The average transmission rate is 3.67 Mbps and receiving rate is 2.66 Mbps for blue sky video bit rate of 2.57 Mbps.

This experiment shows that the transmitted rate is higher than receiving rate and traffic rate. This means that WiMAX link is able to accommodate the traffic. Besides traffic content, WiMAX also sends some signaling data so that there is increment in number of data transmitted. By inserting the post coding concealment techniques, the three lost frames are replaced at the receiver end, so that the received video quality did not deteriorate. Figure 3 shows the comparison of received video quality compared to non erroneous video and the broken video.

![Figure 3. PSNR Performance of post-decoding concealment](image)

Compared to the broken image, the post-decoding whole frame copy successfully increases PSNR about 52.21%. Figure 4 shows images generated by frame copy post-decoding concealment over frame 115. It is not easy to identify the differences. Actually the frame copy is originated from previous images. The only weakness as post-decoding concealment is performed just before RGB image sent to display; the replacement causes short delay that seems like flicker.
4. Conclusions

This paper has presented post-decoding concealment technique using an experimental approach by streaming high bit rate video over WiMAX link. WiMAX is able to accommodate video transmission with transmitted rate is 3.67 Mbps and receiving rate is 2.66 Mbps for video bit rate of 2.57 Mbps. During transmission three images were broken due to packet losses. By applying the post-decoding concealment, PSNR improved about 52.21% compared to the broken images. The benefit of post-decoding concealment that it is applicable to any video coders as concealment performed in raw file. However, the concealment causes flicker as bytes sent to display is delayed for a moment for concealment process. This could be omitted by buffering more images on display memory.

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