# ANALYSIS OF VIDEO STREAMING OVER MOBILE WIRELESS NETWORK

**A Thesis Submitted to the Department of Computer Science and Engineering**
**Of**
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**By**

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**Of**

**Bachelor of Science in Computer Science and Engineering**
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## Declaration

In accordance with the requirements of the degree of Bachelor of Science (B.Sc.) in Computer Science & Engineering program at BRAC University, I present the following thesis entitled "Analysis of Video Streaming over Mobile Wireless Network". This work was performed under the supervision of Sadia Hamid kazi.

I hereby declare that the work submitted in this thesis is my and based on the results found by myself. Materials of work found by other researcher are mentioned by reference. This thesis, neither in whole nor in part, has been previously submitted for any degree.

| | |
|---|---|
| Signature of Supervisor | Signature of Author |
| ----------------------------- - | -------------------------- |
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# Abstract

Streaming media presents the professional communicator with a whole new way to deliver information, messages, and entertainment. By leveraging the Internet, distribution costs can be much lower than the traditional media. As third-generation wireless networks are rolled out, it becomes feasible to view video from mobile appliances. This paper analyzes the quality of the streaming MPEG-4 video over a mobile wireless network using an integrated tool environment, which comprises a network simulator[13], a video quality streaming tools which is EvalVid[3]. Through this work I establish guidelines for the transmission of video based on the mobile and wireless networks and leads to a conclusion of that is the link bandwidth must be greater than the video Streaming rate to viewing a good quality streamed video by the end user.

# Appendix

## List of Acronyms with abbreviations

| | |
|---|---|
| BW | Bandwidth |
| GoP | Group of Pictures |
| MAC | Medium Access Protocol |
| MPEG | Motion Picture Expert Group |
| MPEG-4 | Motion Picture Expert Group Layer 4 |
| NS-2 | Network Simulator 2 |
| PSNR | Peak Signal to Noise Ratio |
| QoS | Quality of Service |
| WLAN | Wireless Local Area Network |

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## 1. Introduction

Mobile cellular telecommunication networks have been growing continuously. Users of modern telecommunication systems will expect the support of sophisticated services over wireless transmission. And one of these services is video. Recently more and more telecommunication systems are supporting different kinds of real-time transmission, video transmission being one of the most important applications. So streaming media is becoming prominent over current generation of mobile wireless network. Since bandwidth availability to the end user still has severe limitations even with the current high-end technology, such streaming are still limited to low-quality video. And to deliver a fair quality of video over this modern telecommunication system different types of video compression format have been invented. And most of these video compression formats are a lossy compression due to the limitation of the bandwidth of the end users. So the delivering a good quality streamed video to the end user does not only depend upon medium of the transmission and is also depends upon the compression formats.

This paper intends to give an understanding of the transmission of the video over mobile wireless networks. I investigated the types of error that can be observed using objective video quality metrics such PSNR (Peak Signal to Noise Ratio) while transmitting of MPEG-4 encoded video streams over mobile wireless network environments. This paper does not provide the subjective video quality estimations based on the evaluation of decoded video streams by informed viewers because of limitation of time.

The paper is organized as follows. Section 2 provides an overview of video compression format. Section 3 provides an overview of the characteristics of most common mobile and wireless network. Section 4 is on background information on objective quality evaluations method used in the paper. Section 5 describes the video characteristics, the setup, and the scenarios used to evaluate the transmission of streaming video in a wireless network. Section 6 present the results if the objective evaluations. And the paper ends with a last section on conclusion.

## 2. Video Compression

Since the size and streaming rate of raw format of video file which is YUV format is huge enough and is not feasible to transmit this format over any wired and wireless network, so the raw format needs to be compressed. Compression reduces the number of bits used to represent each pixel in the image. Compression systems exploit the mechanism of human perception to remove redundant information, but still produce a compelling viewing experience. As a result redundant data can be eliminated if the raw video file is compressed. Redundant data may consists of like by reducing the total numbers of colors, amplitude of neighboring pixel are often correlated, consecutive frames often having same object perhaps undergoing some movements. So a lower compression ratio results in less data being discarded and higher compression ratio results in higher data being discarded. Hence if the compression is increased more artifacts become apparent. That is why it needs to trade-off the level of artifacts of the video and the bandwidth if transmission medium.

### 2.1 Compression Algorithm

Compression can be lossless or lossy. If all the original information is preserved, the codec is called lossless. But for streaming video over mobile wireless network, data should be more reduced. That is why lossy compression is generally being chosen for streaming video over wireless networks. Compression algorithms aim at lowering the total number of parameters required to represent the signal, while delivering a reasonable quality picture to the player. These parameters are then coded into data packets for streaming. There are four main redundancies present in the video signal.

- Spatial
- Temporal
- Perceptual

- Statistical

### 2.1.1 Spatial

Spatial redundancy occurs where neighboring pixels in a frame of a video signal are related; it could be an object of a single color.

### 2.1.2 Temporal

Video is a sequence of similar images, with step changes at scene boundaries. In many sequences there is virtually no change from one frame to the next. In scenes with subject motion, or where the camera is moving, there will be differences from one frame to the next, but there are many areas of the picture that do not change. This redundancy of information from one frame to the next can be exploited to lower the data rate. The basis of the compression is to transmit only the difference between frames **–** ***frame differencing***. The player stores the entire picture in a frame store, and then reconstructs the picture from the previous frame and the difference information. Since most of the difference between frames is from moving objects, there is further potential to reduce the data.

### 2.1.3 Perceptual

Perceptual redundancy takes advantage of the varying sensitivities of the human visual system. The human eye is much more discriminating regarding changes in luminance than chrominance, for example, so a system with this feature can discard some color-depth information, and viewers do not recognize the difference.

### 2.1.4 Statistical

Statistical redundancy uses a more compact representation for elements that frequently recur in a video, thus reducing the overall size of the compressed signal.

## 2.2 International Standards of Video Codec

The video codec we use today come from two backgrounds: the first is the telecommunications industry and the second is multimedia. These are some of the most used codec.

- H.261
- AVC(Advanced Video Codec H.264)
- WMV
- RealVideo
- MPEG-1,MPEG-2,MPEG-4
- And many more

### 2.2.1 MPEG-4 Codec

MPEG compression divides a video sequence into groups of pictures. The temporal compression is arranged in short sequence of frames called a group of pictures (GOP). MPEG defines three types of frame within the group.

- I-frame (Intra-frame)
- P-frame (Predicted frame)
- B-Frame (Bidirectional frame)

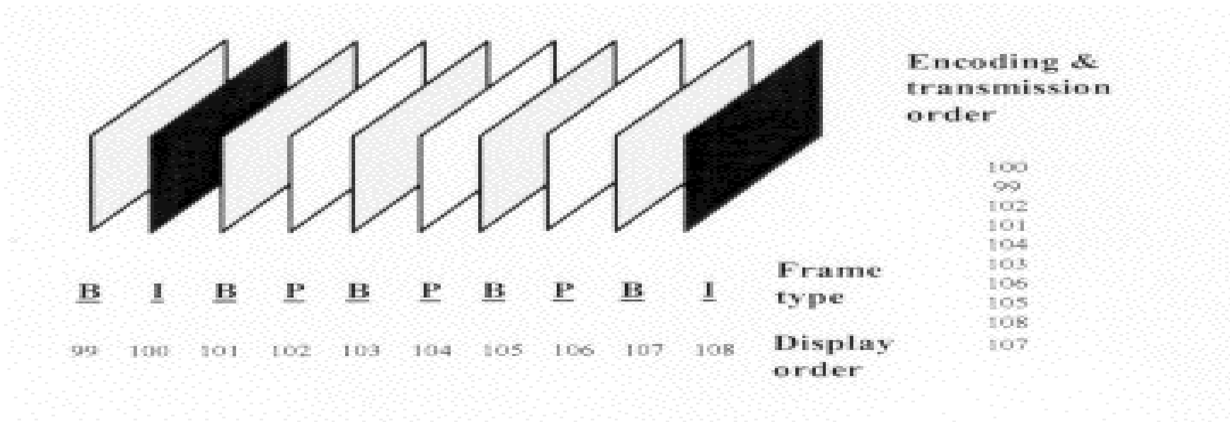


***Fig 1: Different types of frames generated by MPEG-4 Codec.***

#### 2.2.1.1 I-frame (Intra-frame)

These are coded spatially; solely from information contained within the frame. I-frames provide reference points for random access to a stream. The number of pictures between I-frames is set by the encoder, and can be varied to suit subject material.

#### 2.2.1.2 P-frame (Predictive frame)

These are coded from previous I- or P-frame pictures. The decoder uses motion vectors to predict the content from the previous frames. The data in a typical P-frame are one-third of that in an I-frame.

#### 2.2.1.3 B-frame (Bidirectional frame)

These pictures use past and future I and P pictures as a reference, effectively interpolating an intermediate picture. The B frames however, are coded based on a forward prediction from a previous I or P- frames, as well as a backward prediction from a succeeding I or P frame. B-frames are half that of a P-frame.

## 3. Characteristics of Mobile and Wireless Networks

### 3.1 IEEE 802.11

Wireless local area networks (WLANs) based on the IEEE 802.11 standard are a significant and viable alternative to wireless connectivity. The standard has currently three variations widely deployed. The 802.11b operates on the 2.4GHz band and has a maximum theoretical data rate of 11Mbps, but operates also on 1, 2 and 5Mbps. The 802.11a and g operate on the 5GHz and 2.4GHz bands respectively and both have a maximum theoretical data rate of 54Mbps. Using different modulation schemes they can also operate on the lower scales of 6, 10,12, 18, 36, and 48 Mbps.

Based on CSMA/CA, a common resource sharing MAC protocol, 802.11 also adheres to the characteristic that the data rate allocated to each user is inversely proportional to the number of users in the local network. Therefore, the practical data rates are usually lower than those mentioned above.

## 4. Video Quality Assessment Schemes

### 4.1 Objective QoS Measures

In an optimal case, the quality of video is monitored during transmission. According to measurements, adjustment of parameters and possible retransmission of the data is carried out. Objective quality assessment methods of digital video can be classified into three categories. In the first category, the quality is evaluated by comparing the decoded video sequence to the original. The objectivity of this method is owed to the fact that there is no human interaction; the original video sequence and the impaired one are fed to a computer algorithm that calculates the distortion between the two. The second category contains methods that compare features calculated from the original and the decoded video sequences. The methods of the third category make observations only on decoded video and estimate the quality using only that information. The Video Quality Experts Group (VQEG) calls these groups the full, the reduced and the no reference methods. Traditional signal distortion measures use an error signal to determine the quality of a system. The error signal is the absolute difference between the original and processed signal. The traditional quality metrics are the Root Mean Square Error (RMSE), the Signal-to-Noise Ratio(SNR), and the Peak Signal-to-Noise Ratio (PSNR) in dB. In this work I employ a Full reference method and use the PSNR as the objective quality metric.

So in this work PSNR is calculated by the comparison of the sender side (original) raw YUV format video file with receiver side (processed) raw YUV format of video file. The receiver end (processed) raw YUV video file is being decomposed by the receiver end MPEG-4 codec files which are already missing of some redundant information due to compression of MPEG-4 encoder.

## 5. Evaluation Setup and Scenarios

### 5.1 Topology

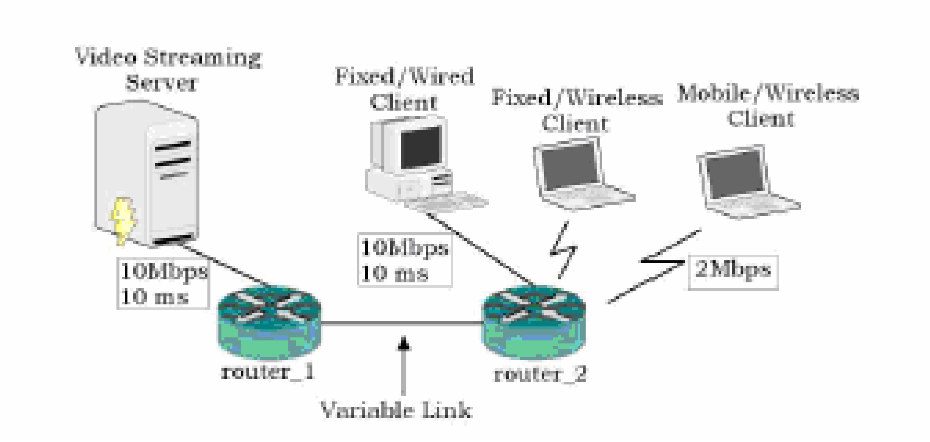


***Fig 2: Video Stream Evaluation Setup.***

The evaluation topology consists of one Video Streaming Server, two backbone routers and video clients of variable types and connectivity methods (fixed, mo bile, wired, wireless) as shown in Fig. 2. The video streaming server is attached to the first backbone router with a link which has 10Mbps bandwidth and 10ms propagation delay. These values remain constant during all scenarios. This router is connected to a second router using a link with unspecified and variable bandwidth, propagation delay, and packet loss. The different parameter values used to characterize this variable link are shown in Table 1. Using this topology, I conducted several experiments for two different sample sequences and with fixed-wired clients, fixed-wireless clients and mobile-wireless clients.

## 5.2 Variable Test Parameters

The choice of the parameters used in the video quality evaluations (Table 1) was based on the typical characteristics of mobile and wireless networks, as these are described in Section 3. For example, the Link Bandwidth can be considered as either the last hop access link BW or the available BW to the user.

**Table 1**

**Variable Parameters**

| Video Stream Bit Rate | Link Bandwidth | Propagation Delay |
|---|---|---|
| 64Kbps | 64Kbps | 10ms |
| 128kbps | 128kbps | 50ms |
| 256kbps | 256kbps | 100ms |
| 512kbps | 512kbps | 200ms |
| 768kbps | 1Mbps | 400ms |

## 5.3 Test sequences

The test sequences used in this work were the sample sequences Foreman. The sequences were chosen because of their different characteristics. The first is a stream with a fair amount of movement and change of background, whereas the second is a more static sequence. The characteristics of these sequences are shown in Table 2. The sample sequences were encoded in MPEG4 format with a free software tool called FFMPEG encoder [4]. The two sequences have temporal resolution 30 frames per second, and GoP (Group of Pictures) pattern IBBPBBPBBPBB. Each sequence was encoded at the rates shown in Table 1. The video stream bit rate1 varies from 64Kbps to 768Kbps. This rate is the average produced by the encoder. Since the encoding of the sample video sequences is based on MPEG4, individual frames have variable sizes.

**Table 2**

**Video Characteristics**

| Trace | Resolution | Total Frames # | I - Frames # | P-Frames # | B-Frames # |
|---|---|---|---|---|---|
| Foreman.yuv | 176*144 | 400 | 34 | 100 | 266 |

## 5.4 Data Collection

All the aforementioned experiments were conducted with an open source network simulator tool NS2[13]. Based on the open source framework called EvalVid[3], I was able to collect all the necessary information needed for the objective video quality evaluation like PSNR values, frames lost, packet end to end delay and packet jitter. Some new functionality was implemented in NS2[13] from in order to support EvalVid[3]. The whole data collection procedure and PSNR evaluation is illustrated in Fig. 3.

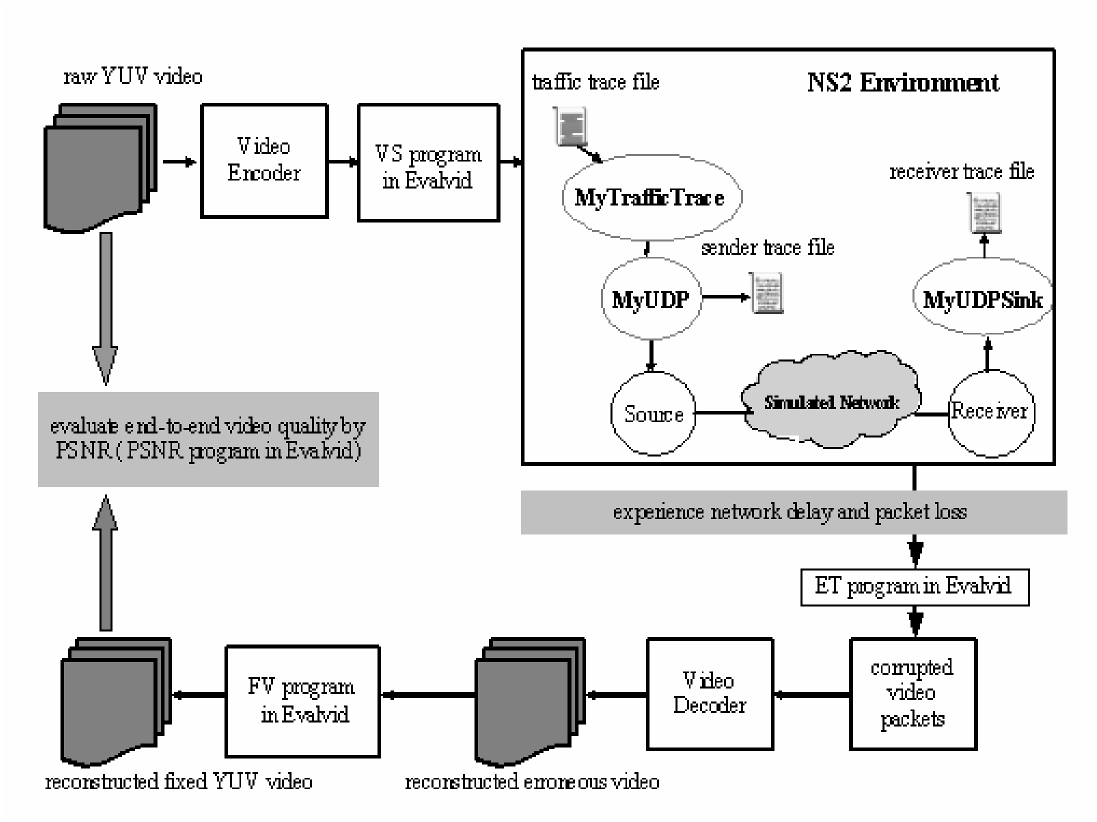


***Fig 3: PSRN calculation through Evalvid[3].***

## 6. Results

In this section I analyze results obtained from the above scenario evaluations. Given the very large number of produced streams, I chose to present and analyze only one scenario. The results presented are for the following case: single user, single video stream, No background traffic, Foreman test sequence, mobile and wireless terminal. All other parameters are variable as shown in Table 1. To identify if and how the different parameters affect the objective value of PSNR I compare them in pairs.

### 6.1 Link Bandwidth and Propagation Delay

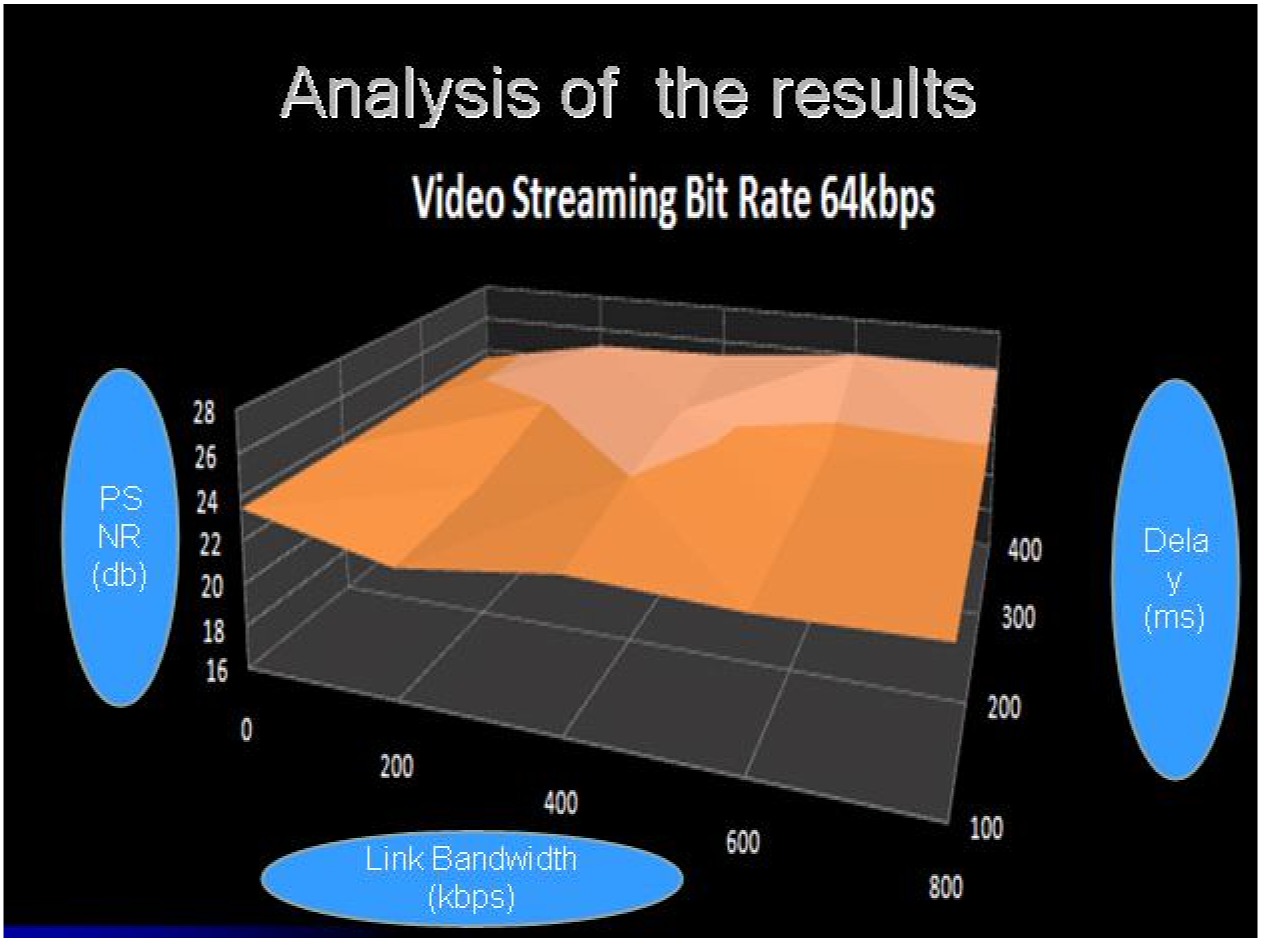


***Fig.4.a Mean PSNR values VS Link Bandwidth and Delay for 64K Video Streaming Rate***

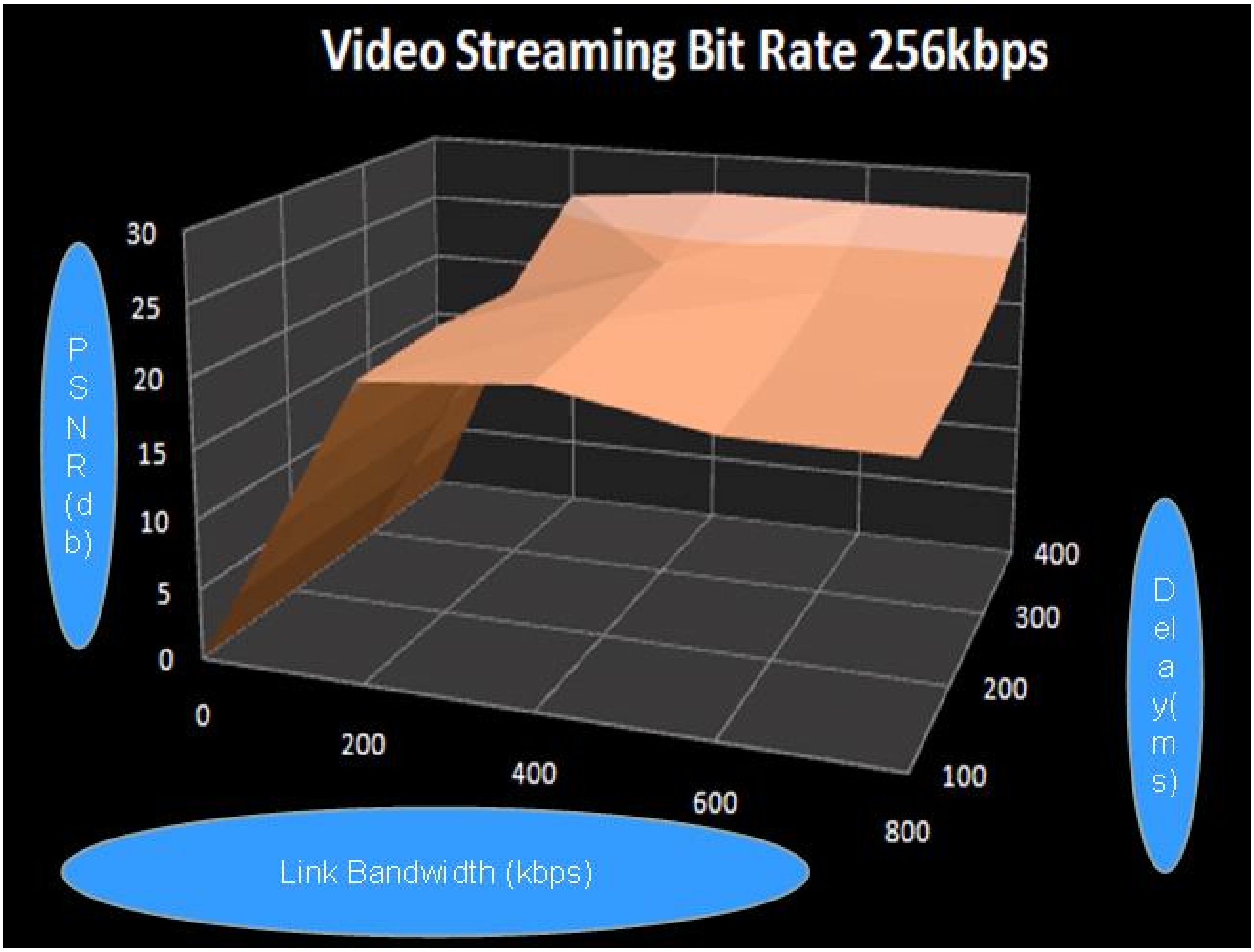


***Fig. 4.b Mean PSNR values VS Link Bandwidth and Delay for 256K Video Streaming Rate***

In the above two graph Fig 4.a and Fig 4.b the PSNR is determined by the effect of propagation delay and the link bandwidth where in the fig 3.a the streaming rate is 64Kbps and in fig 3.b the streaming rate is 256Kbps. And also shows that the PSNR is almost constant but PSNR value slightly increases by increasing of link bandwidth. And comparing the above two graph I can conclude that the PSNR value is better in 256kbps streaming to 64kbps.And in fig.4.b graph shows that PSNR is extremely low if the link bandwidth is less than video streaming rate.

## 6.2 Video Streaming Rate and Propagation Delay

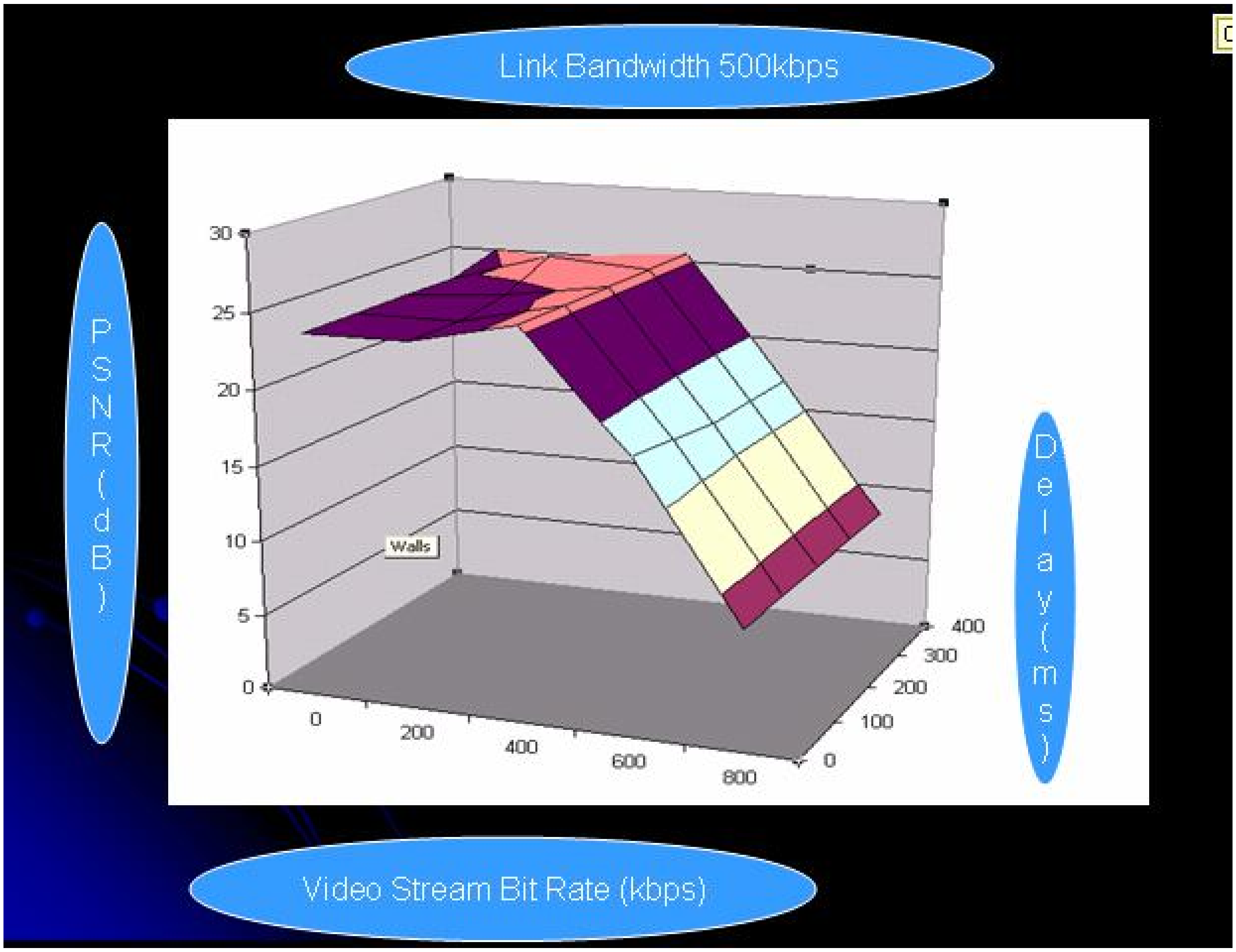


***Fig 5.a: Mean PSNR values VS Video Streaming Rate and Delay at 500Kbps link BW***

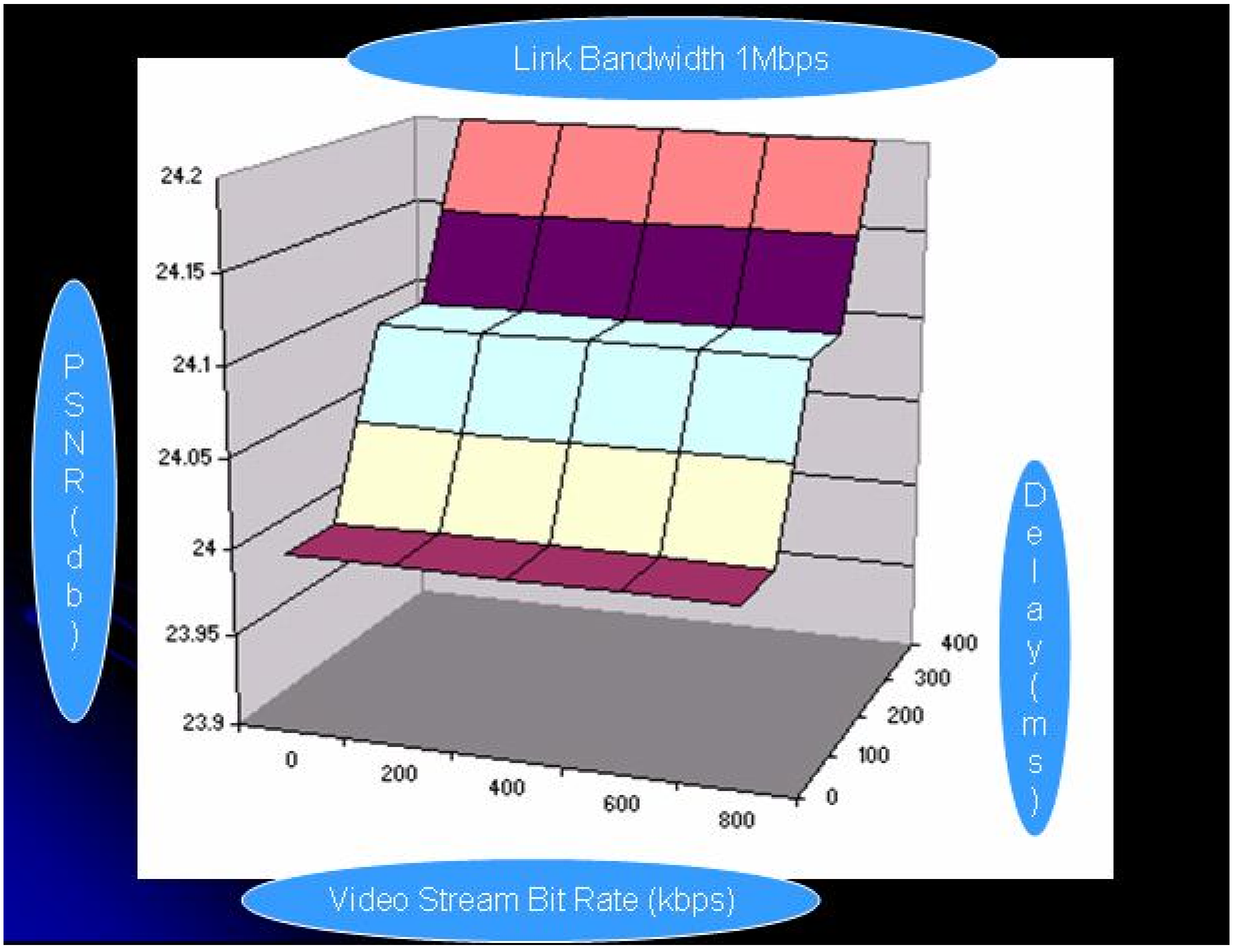


***Fig 5.b: Mean PSNR values VS Video Streaming Rate and Delay at 1Mbps link BW***

In the figure 5.a graph since the bandwidth of the link is 500kbps so for any value above 500kbps of video streaming rate the PSNR drops down extremely but below the 500kbps streaming rate the PSNR is quite fair hence the quality of the video streaming is pretty good. And in the fig 5.b the link bandwidth is 1mbps so the PSNR is pretty much constant which almost above 24 because the streaming rate is less than the link bandwidth. And the delay propagation does not affect much in these above figures.

## 6.3 Link Bandwidth and Video Streaming Rate

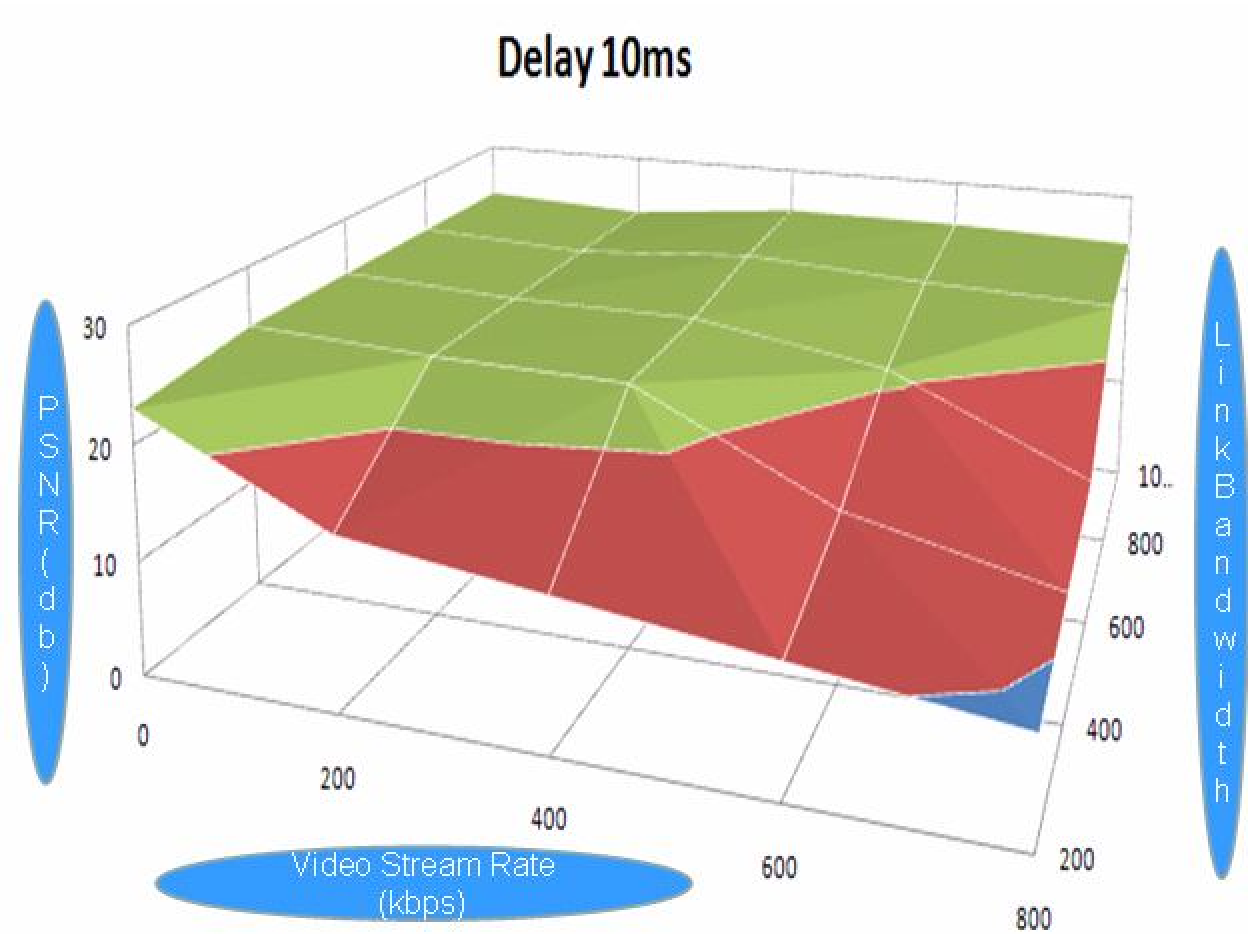


***Fig.6.a: Mean PSNR values VS Video Streaming Rate and Link Bandwidth for Delay 10ms***

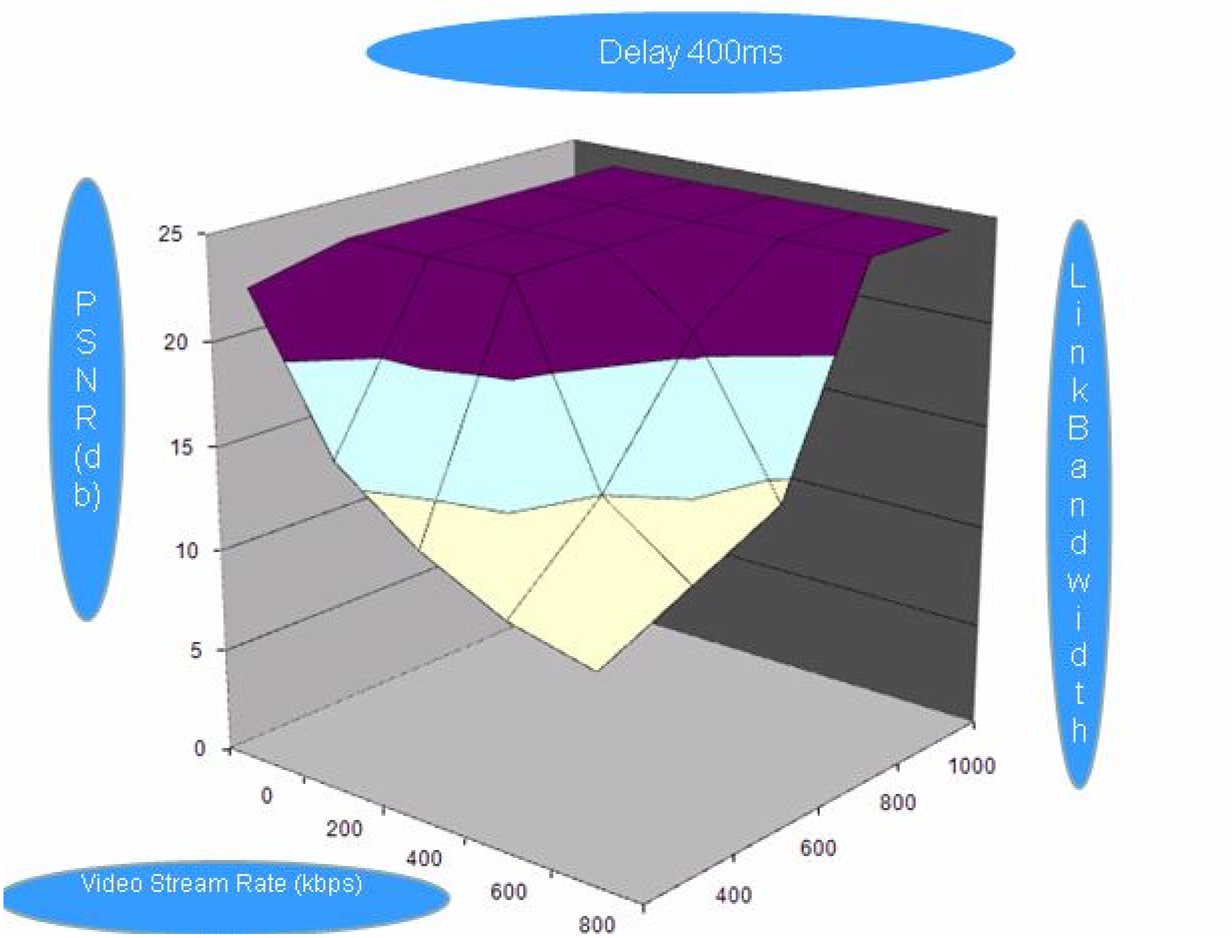


***Fig.6.b: Mean PSNR values VS Video Streaming Rate and Link Bandwidth for Delay 400ms***

In the above figures 6.a and 6.b gives a clear idea of streaming quality which is PSNR dramatically drops down when the video streaming rate is greater than the link bandwidth. The propagation delay does not play a vital role in video streaming quality.

### 6.4 Evaluation of Perceived Quality of Service

***Table 3***

***Evaluation of PSNR value***

| PSNR | QoS |
|---|---|
| >27.2 | Excellent |
| 26.9-27.2 | Good |
| 26.1-26.9 | Fair |
| 16.2-26.9 | Poor |

## 7. Conclusions

In this paper I analyzed the video streaming transmission over mobile wireless networks. The tests and simulation analyzed in this paper were designed to measure such video quality metric. Standard objective metrics such as PSNR were taken into consideration in order to evaluate objective quality. Many factors like bit rate, link BW, propagation delay had to be considered to specify effective objective tests. From the results of the examined scenarios, it can be said that to get a good quality video stream, the video streaming rate must be less than the link bandwidth.

Factors like buffer management, jitter control are not taken into consideration.

But one way can help to deliver a good quality of video streaming to the end user is implementing of adapting network congestion. Since today storage are pretty much cheaper so media server can store a particular video file in different encoding rates. For example for a particular video file media file the media server can store this file at different encoding rate like at 68k, 256k, 500k, and so on. So to deliver the best quality video streaming media server can start with delivering the highest encoding rate. If there is any problem like network slows down then media server could switch to smaller encoding rate. As I mentioned earlier in section 4.1 if the encoding rate is increased that will tend to increase the PSNR.

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