ABUAD Journal of Engineering Research and Development (AJERD)
ISSN (online): 2645-2685; ISSN (print): 2756-6811

Volume 7, Issue 1, 221-230

Assessing the Impact of Media Stream Packet Size Adaptation on Wireless Multimedia Applications

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Date Submitted: 17/03/2024
Date Accepted: 16/05/2024
Date Published: 05/06/2024

Abstract: *Multimedia applications constitute greater percentage of traffic in wireless networks. Thus, require investigation of factors influencing effective delivering of media contents in the future, which will include not only conventional multimedia broadcast, but also video streaming to users on demand while meeting the expected quality requirements. In this article, analysis of effect of media packet size adaptation on quality performance of multimedia application is presented. Experiments were performed using standard test media sequences. The encoded media streams at different packet sizes were transmitted over wireless channel at different channel conditions. The quality performance of received media streams were measured using Peak to Signal Noise Ratio (PSNR) software tool to assess the impact of media packet adaptation on quality performance of multimedia applications. A comparative quality performance under same poor channel condition, shows that small media packet size of 256 bytes recorded the highest received quality performance of 22.52dB, compared to the quality performance of 21.87dB for 384 bytes, 21.37dB for 512 bytes, 20.68dB bytes for 640 bytes and 19.47dB for 768 byes, respectively. The findings show media packet size and channel conditions have significant impact on the quality performance of wireless multimedia applications.*

Keywords: *Multimedia, Packet Size, Packet Loss Rate, Media Quality, Peak Signal-to-noise-ratio.*

1. INTRODUCTION

Wireless networks are currently dominated with multimedia applications. It constitutes greater percentage of traffic in wireless networks [1,2,3,4] in form of real time image sharing, online games and video distribution. Research to investigate factors influencing effective delivery of wireless applications including video streaming and uploading to users on demand [5,6] while meeting the expected quality requirements is necessary. There are fundamental factors influencing quality of wireless multimedia services such as power constraints, bandwidth, channel conditions and content characteristics. However, much research has not been carried out in terms of seeking relationship between media stream packet size and received quality performance. This research work examines the effect of packet size adaption on the quality of wireless multimedia applications. The objective of the research includes unveiling useful information on the relationship between media stream packet size and received quality performance. The findings will be harnessed to develop solutions to address the challenges facing multimedia applications quality performance under constrained networks such as wireless and satellite networks [7,8,9,10,11,12].

Different schemes for improving quality of multimedia applications have been discussed in the literature such as such as enhancement of mobile video services through optimal power allocation scheme [13]. Unequal power allocation for scalable video transmission, where base layers of scalable video are allocated more transmit power compared with the enhancement layer packets, is discussed. However, excessive increment in transit power to improve quality of communication link sometimes results in interference [14]. Shadowing effect can also affect the quality of wireless network [15,16]. An unequal error protection scheme for object-based video communications, where different quantization parameters are allocated for coding of each object is discussed in [17]. Much research on quality enhancement of multimedia applications has been focusing on power and bandwidth allocation schemes. Thus, the need to examine other factors influencing quality of multimedia application which can be harnessed to develop efficient system for effective multimedia communication. Media motion-based resource distribution system has been discussed in [18] where motion characteristic of video contents influences the quality performance of media content and allocation of network resources. The research work performed in [19] show that video distortions which consist of source distortion and channel distortions also influence quality of multimedia services. The author further discussed on the effects of bitrates allocation on quality performance of mobile video services. It has been demonstrated that as the bitrates increases, the quality performance of mobile video services improves. In [20] the researchers investigated the effect of content characteristic on received mobile video quality and proposed bitrates adaptation based on the content characteristics. However, it becomes difficult under constrained network resources where bandwidth is limited to support continuous higher bitrates allocation scheme for improved received video quality. Thus, the need to further investigate other factors capable of affecting quality performance of multimedia applications which can be deployed to improve communication systems. Experiments were carried out with the objective to carefully examine the effect of media packet sizes on quality performance over wireless networks. Section two presents methodology adopted in the study, section 3 presents the results and discussion. The article is concluded in section 5.

2. METHODOLOGY AND SYSTEM DESIGN

Methodology adopted in this study includes system design, simulation and collection of data for analysis to assess impact of different media packet size on quality of wireless multimedia applications. The system architecture include wireless communication network [21, 22, 23] which is predominantly characterised with high bit error rate. The server stores test media sequence and H.264/AVC software performed source encoding and packetization of media streams into different packet sizes and transmitted over wireless network to the mobile users' devices. The received media streams are decoded and quality performance measured using Peak Signal-to-Noise Ratio. Figure 1, presents the system architecture adapted in the study.

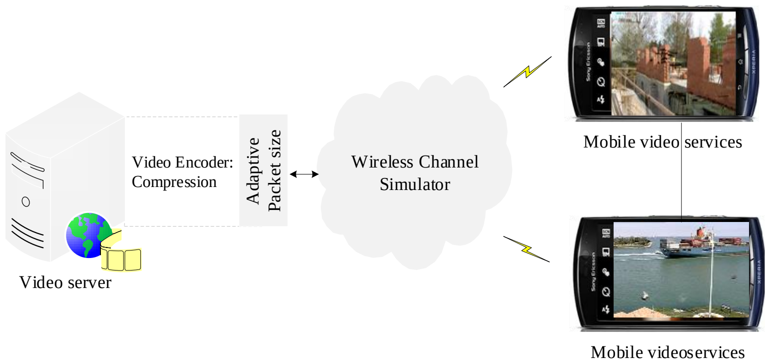

Figure 1: System design architecture

In all, four test scenarios were carried out for critical assessment of the impact of different media packet sizes on wireless multimedia applications. The experiments were performed using standard test media sequences, Football, Soccer, Foreman, Crew, Hall, Container and Akiyo. The test media samples were encoded and segmented into different media packet sizes using advanced video coding reference software (H.264/AVC). The segmented media streams were transmitted via simulated wireless channel model to study the effect of packet sizes on received video quality performance. The received media streams were decoded using H.264/AVC decoder reference software [24,25] The measurement of quality performance was possible by assigning sequence number to each media packet and counting the missing packets. When a media packet is lost or corrupted due to poor channel conditions, the sequence number enables the decoder to identify the lost packet such that the location of the lost packets in a frame is identified and concealed. The quality performance of received media streams transmitted at different test scenarios are measured using objective video quality metric, Peak Signal-to-Noise Ratio (PSNR).

2.1 Multimedia Applications Quality Performance Assessment Metric

Multimedia applications in this context include video conference, video streaming over internet, video on demand (VOD), digital television broadcasting, wireless mobile video networking. This research work used Peak Signal-to-Noise Ratio (PSNR) software to assess the impact of packet size adaptation on wireless multimedia applications. PSNR measured the media quality performance in decibels (dB), by correlating the maximum possible value of the luminate and the mean squared error (MNSE). The algorithm for calculation of PSNR, include:

$$PSNR_{(dB)} = 10\ Log_{10}\left(\frac{Max^2}{MSE}\right) \quad (1)$$

$$PSNR_{(dB)} = 20\ Log_{10}\left(\frac{\text{Max}}{\sqrt{MSE}}\right) \quad (2)$$

$$PSNR_{(dB)} = 20\text{Log}_{10}(Max) - 10\text{Log}_{10}(MSE) \quad (3)$$

Where *Max* is the maximum possible pixel value of the media signal and *MSE* is the mean squared error. The overall quality performance is obtained by averaging PSNR values across the media signal. The high value of PSNR indicates better quality. More details on PSNR objective media quality assessment are available in the literature [26].

3. RESULTS AND DISCUSSION

The first test scenario was performed using standard test media sequences. H.264/AVC, was used for source coding and adaptation of media streams into 128 bytes and 512 bytes packet sizes. The parameteric configuarations of the experiment include test sequence in YUV format (4:2:0), encoded at 30 frames per seconds, with a total number of 300 frames at 384kbs in common intermediate format (CIF) for mobile application. The media streams were transmitted over wireless networks using Quadrature Amplitude Modulation scheme with convolutional encoder of ½ coding rate [27]. The system parameters used for first test scenarios is presented in Table 1.

Table 1: System parameters for first test scenario

System	**Parameters**
Media encoder	H.264/AVC encoder
Packet sizes	128 bytes and 512 bytes
Media format	4:2:0, YUV
Group of pictures	8.0
Frame rate	30Hz
Total frame number	300 frames
Bitrates	384Kbps
Channel type	Wireless channel
Media decoder	H.264/AVC decoder
Test media sequence	Football, soccer, crew, foreman, hall and container
Quality measurement	PSNR

PSNR software was used to evaluate the received quality performance of the received media streams. The results obtained during the first set of experiment are presented in Table 2.

Table 2: Quality performance of different test sequence and media packet sizes

Test Media Stream	**Media Packet Size (512bytes)**			**Media Packet Size (128 bytes)**		
	Bitrates (Mb/s)	**PSNR (dB)**	**Error free (dB)**	**Bitrates (Mb/s)**	**PSNR (dB)**	**Error free (dB)**
Football	0.384	24.72	29.54	0.384	27.26	28.94
Soccer	0.384	25.28	33.44	0.384	28.56	32.91
Crew	0.384	28.61	33.91	0.384	31.03	33.28
Foreman	0.384	29.04	35.52	0.384	32.83	35.07
Hall	0.384	32.42	38.73	0.384	33.83	38.51
Container	0.384	34.25	38.25	0.384	36.73	37.93
Akiyo	0.384	40.84	48.70	0.384	42.97	48.29

It is observed that error free channel condition outperforms quality performance under poor channel conditions. This is because during poor channal condition many media packets are corrupted or lost compared to error free channel condiiton where no or less media packets were lost. The lost of more media packets during poor channel condition results in the significant quality performance degradation. It is also noted that small packet size of 128 bytes outperforms the large packet size of 512 bytes under poor channel condition. Figure 2, present comparative quality performance of Football test media stream packet sizes of 128 bytes and 512 bytes under similar channel conditons.

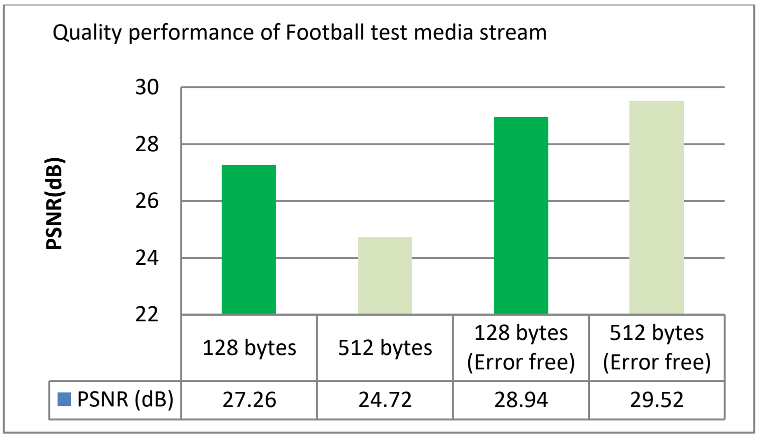

Figure 2: Quality performance of Football test media stream

Figure 2, presents quality performance for the Football test media stream at 128 bytes and 512 bytes. Under same channel conditions, the 128 bytes media packet size recorded 27.26dB compared to the quality performance of 24.72dB for the media packet size of 512 bytes. However, during error free channel condition, the 512 media packet size outperforms the smaller media packet size. Figure 3, present the quality performance of Soccer test media stream

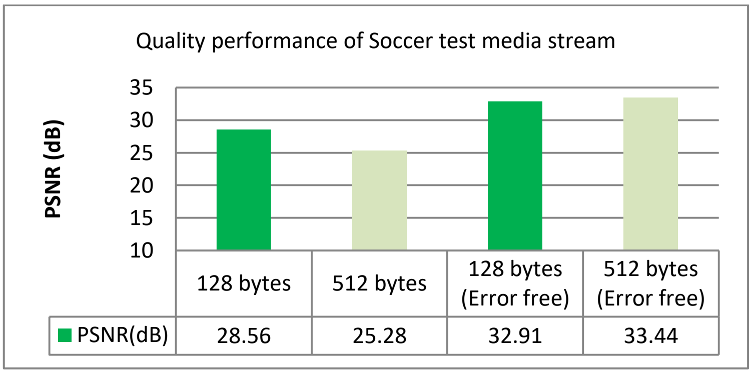

Figure 3: Quality performance for Soccer test media stream

Figure 3, shows quality performance for the Soccer media stream at 128 bytes and 512 bytes media packet sizes. The 128 bytes media packet size recorded 28.56dB compared to 25.28 dB quality performance recorded with the 512 bytes media packet size. Comparing the quality performance of 33.44 dB for 512 bytes media packet size and 32.91dB for 128 bytes media packet size, at error free channel condition. Observably, the 512bytes video packet size outperform 128 bytes media packet at error free channel conditions. Figure 4 - 8, present the quality performance for Crew, Foreman, Hall, Container and Akiyo test media stream.

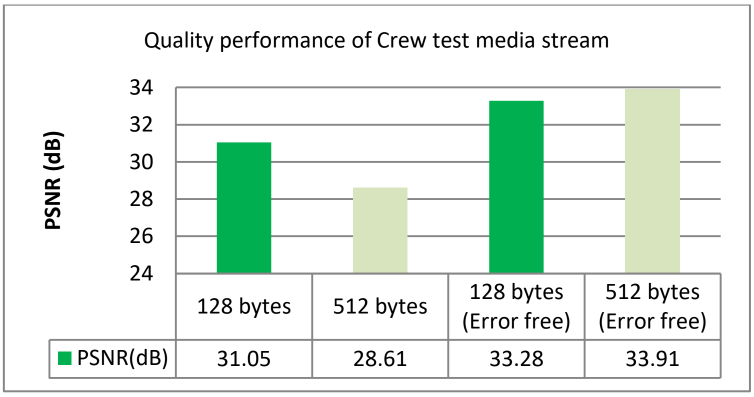

Figure 4: Quality performance of crew test media stream

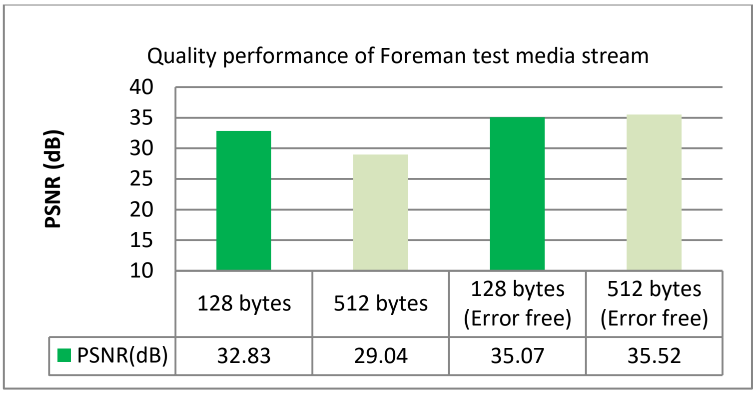

Figure 5: Quality performance of foreman test media stream

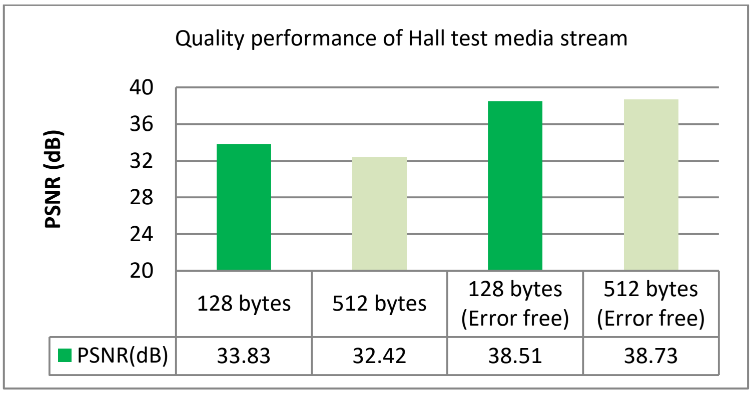

Figure 6: Quality performance of hall test media stream

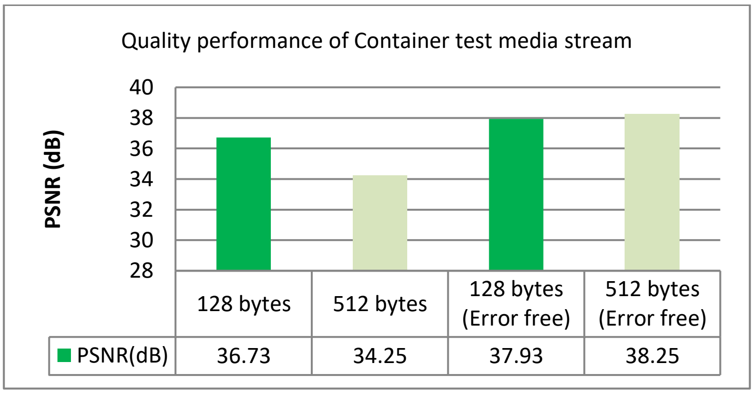

Figure 7: Quality performance of container test media stream

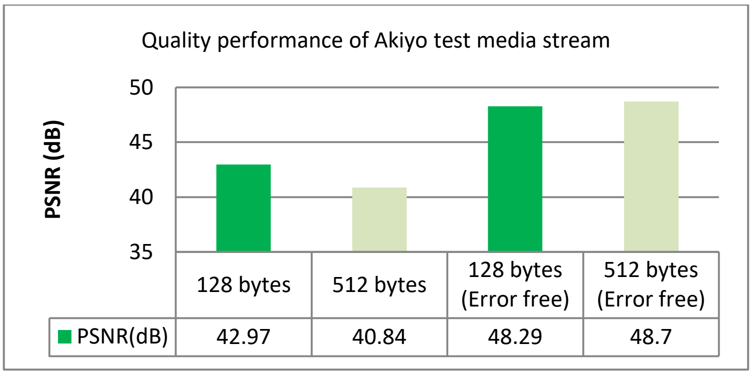

Figure 8: Quality performance of Akiyo test media stream

Figure 4-8, show quality performance for Crew, Foreman, Hall, Container and Akiyo test media streams at 128 bytes and 512 bytes packet sizes. Consistently, 128 bytes packet size recorded significant quality enhancement compared to the 512 bytes packet size. However, negligible quality performance was recorded for 512 bytes packet size compared to 128 bytes packet at error free channel conditions.

In the second test scenario, source coding and segmentation of Foreman and Container test media streams into packet sizes of 512 bytes and 256 bytes were performed. The test sequences in YUV format (4:2:0), encoded at 30 frames per seconds, with a total of 300 video frames for typical wireless application. The encoded media streams were transmitted over wireless channel with time varying channel characteristics using 16QAM, ½, with Signal-to-Noise (SNR) of 11.05dB. The system parameters used in the second test scenarios is presented in Table 3.

Table 3: System parameters for second test scenario

System	Parameters
Media encoder	H.264/AVC encoder
Packet sizes	256 bytes and 512 bytes
Media format	4:2:0, YUV
Group of pictures	8.0
Frame rate	30Hz
Total frame number	300 frames
Bitrates	384Kbps
Channel coding/modulation	Convolutional Turbo Coding, 16QAM, ½,
SNR	11.05dB
Media decoder	H.264/AVC decoder
Test media sequence	Foreman and container
Quality measurement	PSNR

The received quality performance of foreman and container test media streams were examined using PSNR tools to assess the effects of packet adaptation. Table 4, presents summary of quality performance of Foreman and Container test media streams at 512 bytes and 256 bytes packet adaptation under similar channel conditions.

Table 4: Quality performance of Foreman and Container test media streams at 512 bytes and 256 bytes packet size adaptation

Test video sequence	512 bytes	256 bytes
Foreman	 PSNR; 29.11dB	 PSNR; 32.20dB
Container	 PSNR; 36.56dB	 PSNR; 37.80dB

It has been observed that under same channel conditions, Foreman test media streams at 256 bytes packet size performs better, 32.20dB compare to 512bytes of 29.11dB quality performance. Similar quality performance was observed with container test media stream that recorded 37.80dB at 256bytes and 36.56dB at 512bytes packet size.

In the third experimental scenario, source coding adaption of Foreman test media stream into different packet sizes of 256 bytes, 384 bytes, 512 bytes, 640 bytes and 768 bytes were performed to acquire higher accuracy of findings. The media stream were transmitted over two channel conditions, poor channel condition with high Bit Error Rate of 1.40×10^{-4} and better channel condition of low BER of 1.40×10^{-6}. The system parameters used in the third test scenarios is presented in Table 5.

Table 5: System parameters used in the third test scenarios

System	Parameters
Media encoder	H.264/AVC encoder
Packet sizes	256 bytes, 384 bytes, 512 bytes, 640 bytes and 786bytes
Media format	4:2:0, YUV
Group of pictures	8.0
Frame rate	30Hz
Total frame number	300 frames
Bitrates	384Kbps
Channel condition (BER)	$1.40\text{x}10^{-4}$ and $1.4\text{x}10^{-6}$
Media decoder	H.264/AVC decoder
Test media sequence	Foreman
Quality measurement	PSNR

PSNR software was used in the quality performance assessment. The summary of the results recorded during the third test scenario are tabulated in Table 6.

Table 6: Quality performance for foreman test video sequence at different packet sizes and channel conditions

Channel conditions (BER)	Quality Performance for Foreman test media stream at different packet sizes				
Quality Performance	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)
Media Packet Size	256 bytes	384 bytes	512 bytes	640 bytes	768 bytes
Poor Channel (BER; 1.40×10^{-4})	22.52	21.87	21.37	20.68	19.47
Improved Channel (BER; 1.40×10^{-6})	41.32	41.33	41.35	41.35	41.37

Based on the obtained results, the quality performance of 256 bytes packet size improves significantly at poor channel condition 22.52dB, compared to 19.47dB for larger, 768 bytes media packet sizes as presented in Table 3. However, under error free channel condition, the larger video packet size of 768 bytes recorded 41.37dB quality performance compared to the quality performance of 41.32dB for 256 bytes and 41.35db for 512 bytes. This quality enhancement under error free channel condition is as a result of lower or no media packet loss compared to under poor channel condition.

In the fourth test scenario to examine the impact of media size on wireless multimedia applications, the test media streams were streamed over internet protocol [28] at various packet loss rate. Packet Loss Rate (PLR) is a significant performance index for assessment of wireless multimedia applications performance. For reliable communication network, the number of packet loss or dropped must be low to guaranteed acceptable received quality performance. PLR, is defined as the corrupted or lost packets divided by the total number of packets transmitted. Mathematically, PLR is expressed [29]:

$$PLR = \frac{X^{TN} - X^{RN}}{X^{TN}} \tag{4}$$

Where X^{TN} and X^{RN} are the total number of transmitted and received media packets, respectively. The measurement is done by assigning a sequence number to each packet and counting the missing numbers. When a media packet is lost, the sequence number enables the decoder to identify the lost packet such that the location of the lost packets in a frame is identified and concealed. The test scenario configurations include adaptation of media streams into 256 bytes, 384 bytes, 512 byes and 640 bytes and streamed over internet. The received quality performance of the media streams at different channel conditions in terms of PLR of 2%, 4%, 6%, 8% and 10% parametric configurations were decoded using H.264/AVC software. The system parameters used in the fourth test scenarios is presented in Table 7

Table 7: System parameters for the fourth test scenarios

System	Parameters
Media encoder	H.264/AVC encoder
Packet sizes	256 bytes, 384 bytes, 512 bytes and 640 bytes
Media format	4:2:0, YUV
Group of pictures	8.0
Frame rate	30Hz
Total frame number	300 frames
Bitrates	384Kbps
Channel type	Internet protocol
PLR	2%, 4%, 6%, 8% and 10%
Media decoder	H.264/AVC decoder
Test media sequence	Football
Quality measurement	PSNR

PSNR tool was deployed in quality performance assessment. The comparative quality performance results of Football test media stream at different packet sizes and PLR is presented in Figure 9.

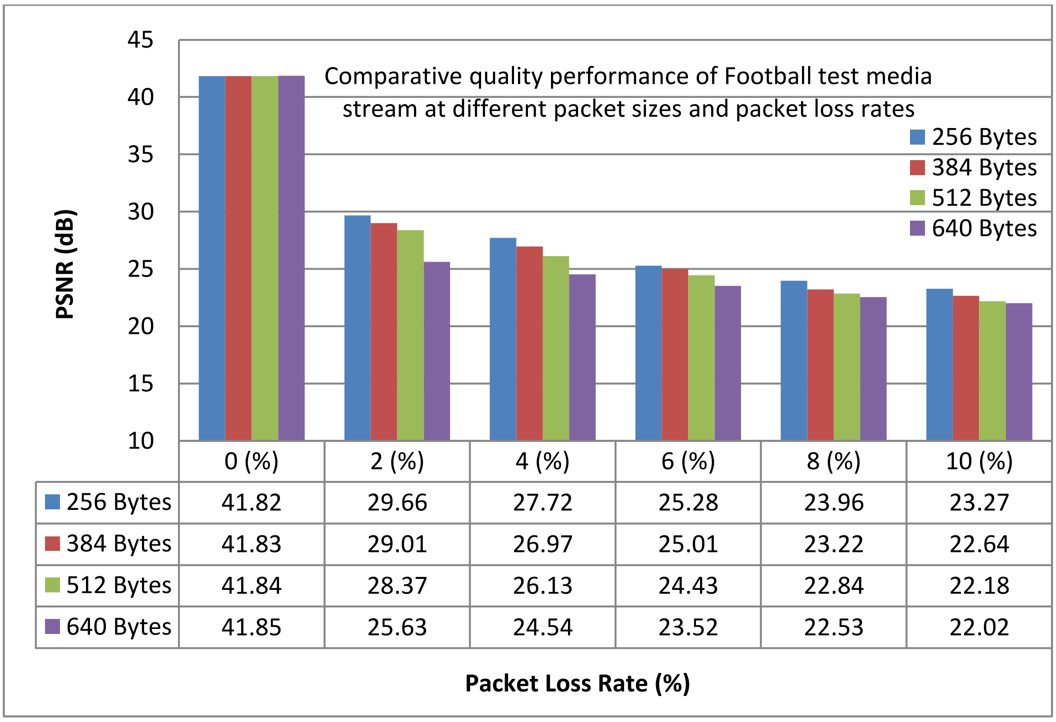

Figure 9: Comparative quality performance of football test media stream at different packet sizes and packet loss rates.

Figure 9 presented comparative quality performance of football test media stream at 256 bytes, 384 bytes, 512 bytes and 640 bytes packet sizes at 0%, 2%, 4%, 6%, 8% and 10%, PLR respectively. It has been observed that the highest value of quality performance was recorded at 0% with 640 bytes and the poorest received quality recorded at 10% with 640 bytes. The improved performance at 0% with 640 bytes compared to poor performance at 10% with 640 bytes, is a result of low packet overheads in large media packet compared to high number of packet overheads in smaller packet adaptation.

4. CONCLUSION

In this research, impact of media stream packet size adaptation on quality of wireless multimedia applications has been investigated. The results obtained show that quality performance of smaller packet size of 256 bytes media performs better at poor channel condition compared to large media packet sizes of 512 bytes and 768 bytes. Similarly, at high PLR of 10%, the small media packet size, 256 bytes outperforms the larger packet size of 640 bytes. The enhanced quality performance for small (256 bytes) media packet size compared to large (768 bytes) at poor channel condition is a result of low complexity in reconstruction of corrupted small media packet size compared to the high complexity in the reconstruction of large (768 bytes) corrupted media packet size. The findings, variation in quality performance of different media packet sizes can be harnessed by the telecommunication industries in the development of advanced algorithm to improve quality of wireless multimedia applications.

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