Identification and Performance Analysis of Multimedia to Enhance Blended Learning Experience in Constrained Bandwidth Environment

Nazir Ahmad Suhail[*1], Jude Lubega[#2], Gilbert Maiga[#3]

[*1]School of Computer Science and Information Technology, Kampala University, Kampla, Uganda
[#2]School of Computing and Engineering, Uganda Technology and Management University
[#3]College of Computing and Information Sciences , Makerere University, Kampala, Uganda

[1]nazir_suhail@yahoo.co.uk; [2]jlubega@utamu.ac.ug; [3]gilmaiga@yahoo.com

Abstract

Multimedia is increasingly becoming popular in higher education worldwide as it significantly improves the perceived level of user satisfaction and motivation. This paper identifies visual media formats such as video, audio, and graphics compatible with constrained bandwidth environment using a Multi Level Systematic Approac**h.** Critical literature investigation indicates that MPEG-4, MP3, and JPEG or PNG are the only media formats suitable for implementation of blended learning process in developing countries. By using client driven metric 'latency' , the paper also examines the performance of various media types with focus on visual media through an experimental scientific research process. The research results affirm that performance of the above identified visual media is better than other formats in the same category, as well as multimedia performance has enhanced significantly when both network and application are optimized as compared to independent optimization. This paper is the extension of the authors previous publications.

Keywords

Blended Learning; Visual Media; Constrained Bandwidth Environment; Multi Level Systematic Approach; Experimental Study; Latency

Introduction

Multimedia technologies that present incredible effect on higher education are changing university environment, particularly in terms of teaching and research. Sufficient literatures have suggested that multimedia instructional methods based e-learning, a part of blended learning, is widely accepted as an effective teaching and learning approach having the potential to increase significantly the perceived level of user satisfaction and motivation of both aural and visual learners in blended learning environment (Astleitner and Wiesner, 2004).

According to Adegoke (2011), multimedia is increasingly integrated into the education system in developed countries and Least Developed Countries (LDCs) are also exploring ways as how to benefit from the new exciting innovation that provides richer learning environments in a wider variety of formats in an effective manner.

However, universities in emerging economies are facing some challenges such as Constrained Bandwidth Environment (CBE), impeding the process of integrating technology enhanced learning into their systems. CBE is characterized by insufficient bandwidth to meet the demand, coupled with other constraints such as high costs, misuse and mismanagent., viruses and spam causing network congestion (INASP, 2005).

Although a number of approaches (e.g., Azizan, 2010; De Vries, 2005; Khan, 2001; Bersin and Associates, 2003; Radient Systems, 2003; and Faridha, 2005) in several studies have been proposed, the issue of integrating blended learning process in CBE has not been adequately addressed. In relation to this study, the process includes optimizing the network efficiency and the content that is sensitive to the challenges of developing countries. To fill the knowledge gap, Suhail and Lubega addressed the issue in their recent work (Suhail and Lubega, 2011) emphasizing that performance of multimedia content can be improved significantly when network and multimedia applications both are optimized as compared to independednt optimization.

This paper first identifies the visual media (video, audio, and graphics) formats compatible with CBE, followed by measuring the performance of various media types with focus on visual media, delay sensitive media in particular, aiming to enhance blended learning experience in CBE. The study verifies the above mentioned theoretical concept by designing a real time experimental testbed. The paper extends some sections of the earlier publications from the same authors.

Constrained Bandwidth Multimedia Identification Process

This research used an extensive Multi Level Systematic Approach (MLSA) shown in FIG.1 to identify multimedia (video, audio, and graphics) formats compatible with CBE, discussed under the themes Video, Audio, and Graphics (Suhail, Lubega, and Maiga, 2012).

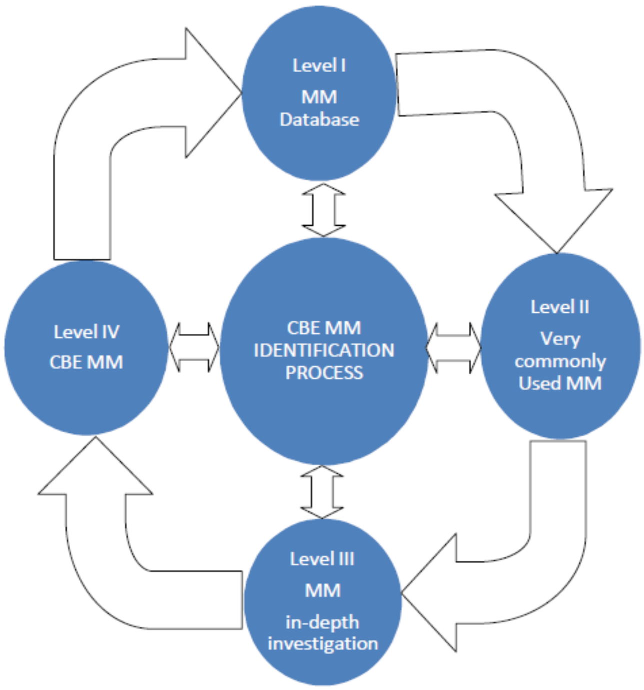

FIG. 1 CONSTRAINED BANDWIDTH ENVIRONMENT MULTI MEDIA IDENTIFICATION PROCESS

Video: Video is a time sensitive application. At level I, the research identified a huge database (Fileinfo.com) for existing video formats clustered into four groups: Very Commonly Used, Commonly Used, Average, and Rare. At level II, we selected 9 Very Commonly Used Video Formats (9VCUVF); Audio Video Interleave (.avi), Advanced System Format (.asf), Apple QuickTime Movie (.mov), Moving Pictures Expert Group-4 (MPEG-4) (.mp4), Moving Pictures Expert Group 1,2 (.mpg), Real Video (.rv), Real Media (.rm), Shock Wave Format (.swf), and Window Media Video (.wmv). At level III, an in-depth critical investigation of the selected video formats was carried out.

The Level III investigation was based upon the following characteristics: Developer (Publisher), Platform Operatability (platforms; Windows, Linux, and Macintosh require to open), Non-proprietary (Non Licensed or Open Source), International standards/ISO (Recognition by International Standard Organization), No packet data dependency and Mix media ability.

At level IV, it was concluded that MPEG-4 (.mp4) has the characteristics: No packet data dependency and Mix media ability, in addition to Cross platform operatability, High popularity, Non-proprietary, and International standards/ISO approved.

Audio: Audio is also a delay sensitive multimedia application and requires much space as compared to graphics and text. In a similar manner like video, for identifying audio format compatible with CBE, at level I, we found database (Fileinfo.com) for audio files with characteristics: Very Commonly Used, Commonly Used, Average, and Rare.

At level II, we selected Very Commonly Used Audio Formats (VCUAF); Window Media Audio (.wma), Wave Audio (.wav), Real Audio (.ra), and Moving Pictures Experts Group Layer 3 (MP3) (.mp3). At level III, an in-depth critical analysis of VCUAF was conducted.

Level III investigation of selected audio formats was based on following characteristics: Developer, Platform, Non-Proprietary and International Standards.

At level IV, the study found that MP3 (.mp3) is a very commonly used audio format that has other characteristics such as non proprietary, cross platform, and has attained the international standards. In addition to above, MP3 is a best sound format due to its high sound quality, efficiently uploading and downloading music files from Internet, preserving quality while creating 12 times smaller files, and quick downloading characteristics (Begg and Thede, 2001). More importantly, MP3 files can be easily exchanged in CBE.

Graphics: Following the methodology used for video and audio, at level I this research identified a database for various graphic formats. At level II, we considrerd Very Commonly Used Graphic Formats (VCUGF); Bitmap Image File (.bmp), Graphic Interleave Format

(.gif), Joint Pictures Expert Group (JPEG) (.jpg), Portable Network Graphic (PNG) (.png), and Tagged Image File (.tiff). The level III investigation of the selected graphics was based upon four characteristics; Developer, Platform, Non-Proprietary and International standards.

At Level IV, it was concluded that JPEG and PNG files which are cross platform, non-proprietary, have attained International standards and widely use graphic formats to store images on the web. However, JPEG compression standard does not make any significant noticeable change in the original image required in the context of CBE to increase the perceived level of user satisfaction. The high popularity of this format is due to its distinct and unique characteristic of providing the "trade off between quality and size" of the graphic file.

This section has identified the visual media (video, audio, and graphics) compatible with challenges of constrained bandwidth environment, while the next section will present the details of an experimental testbed that measures the performance of some selected visual media files.

Experimental Testbed

An experimental testbed has been designed to examine and evaluate the multimedia (visual media) performance, aimed to apply optimization technique on both network and multimedia in CBE (Suhail, Lubega, and Maiga, 2011).

Hardware and Software used: The testbed is composed of 2 Computers running Microsoft Window XP, conneccted to a Cisco router using a Cisco switch. A Broad Band 128 kb Internet connection was purchased from an Internet Service provider. Other hardware and software include: An indoor Wimax Internet Antena to receive and send back the signals to Internet; File conversion tools; Latency measuring tool VE Catchlite; Straight through UTP cables; Video files (.mov, .mkv, .mpg, .mpg2, and .mp4; Audio files (.wav and .mp3); and Graphic files: (.bmp and JPEG).

Multimedia Performance Evaluation Procedure

Prior to measuring the multimedia performance, this study applied the optimization technique on various media types (video, audio, graphics) for efficient usage of limited bandwidth available in the context of developing countries (Abdelfattah and Mohiuddin, 2010). Thereafter, unoptimized and optimized multimedia files of all types mentioned above were uploaded on Internet aiming to download them in CBE and evaluate their performance by activating "VE Catchlite" tool installed on the client computer. Google server was utilized to upload the multimedia files.

For video files, we acquired .mkv file from the Internet and by using a video conversion tool converted the same file to other formats such as .mov, .mpg and .mpg2 for the sake of consistency. Afterwards, all these files were optimized to .mp4. The same procedure was adopted for audio and graphic files.

Visual media Performance for Unoptimized Network

The following section will list the screen shots taken by Net Catchlite tool that measures the latency, when each of the unoptimized and optimized visual media files from various categories were transmitted over the unoptimized network. This experiment was repeated several time and consistent results were shown by the tool. The vertical line on right side of the graphs measures the latency (file download time from a remote server) calculated in milliseconds with minimum/average/maximum values shown at the bottom, and the left side measures the 'packet loss' as latency and packet loss are closely interrelated. However, the focus of this study is only on latency which is end user oriented multimedia performance metric.

Latency measurement for unoptimized and optimized video files: With unoptimized network state, FIG. 2-FIG. 5 present the latency 522, 553, 555, and 505 ms for .mov, .mkv, .mpg, and .mpg2, respectively, while FIG. 6 presents the latency 422 ms when they were optimized (compressed) to .mp4.

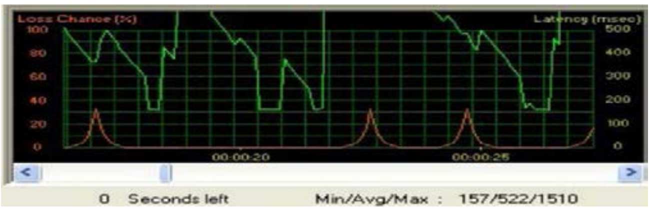

FIG. 2 LATENCY FOR .mov

FIG. 3 LATENCY FOR .mkv

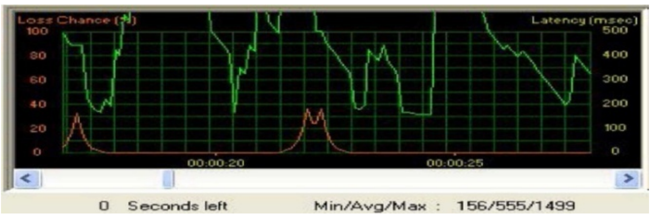

FIG. 4 LATENCY FOR .mpg

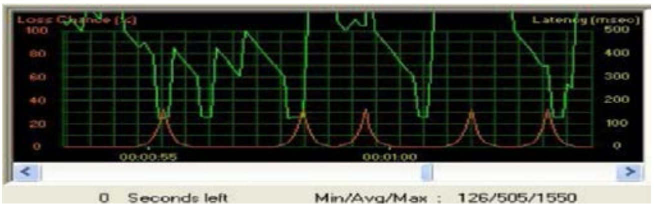

FIG. 5 LATENCY FOR .mpg2

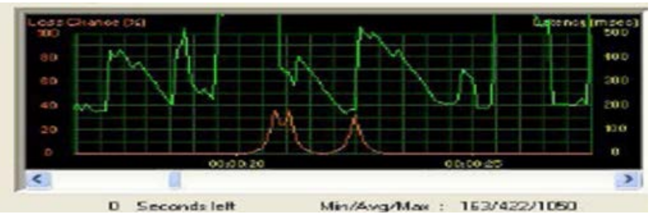

FIG. 6 LATENCY FOR .mp4

Latency measurement for unoptimized and optimized audio files: When network codition still remains the same, FIG. 7 and FIG. 8 present the screen shots for unoptimized and optimized (compressed to .mp3) form of .wav audio file. The average latency for .wav and .mp3 as shown in the graphs is 270 and 217ms, respectively.

FIG. 7 LATENCY FOR .wav

FIG. 8 LATENCY FOR .mp3

Latency measurement for unoptimized and optimized graphic files: With continued unoptimized network state, FIG. 9 and FIG. 10 present the screen shots for unoptimized and optimized (compressed to JPEG) for .bmp audio file. The average latency for .bmp and JPEG as shown in the graphs is 408 and 286 ms, respectively.

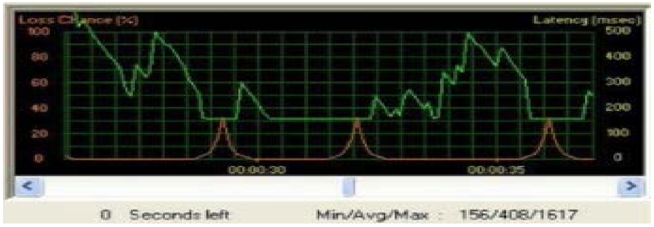

FIG. 9 LATENCY FOR FOR .bmp

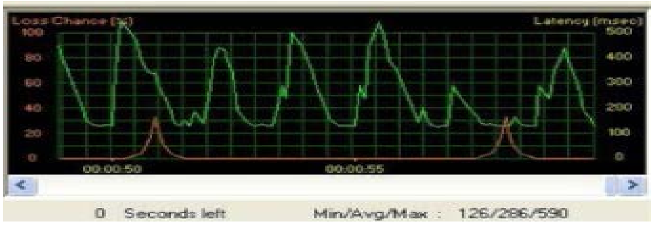

FIG. 10 LATENCY FOR jpeg

Network Optimization

Identifying Traffic Patterns and applying QoS: Prior to Quality of Service (QoS) configuration, Cisco Network-Based Application Recognition (NBAR) was applied to intelligently recognize a wide variety of applications, including Web-based applications and client/server applications dynamically and assigned TCP or User Datagram Protocol (UDP) port numbers. NBAR was also enabled on the router Interface Gigabit Ethernet 0/0 (GE0/0). TABLE 1 presents the details of various type of traffic identified during the process.

TABLE 1 IDENTIFYING TRAFFIC PATTERNS

Protocol	Traffic Type
Skype- Bittorrent	Real time traffic: video, audio, interactive video, VoIP
POP3 & SMTP	e-mail and file transfer
http	Other Web traffic
Secure http	secure traffic e.g., bank accounts
Scavenger traffic	traffic that has no contribution to the experiment

Providing efficient multimedia services is challenging in CBE where network is congested. Therefor, it is important to apply QoS in the wireless LAN environment to increase the perceived level of users satisfaction (Abbasi, Iqbal, and Malik, 2010). In computer networks, QoS refers to assigning various priority levels to different types of network traffic and prioritizing some specific application, by allocating specific amounts of bandwidth to each, aimed to optimize the network efficiency (Suhail, Lubega, and Maiga, 2011). Therefore, this research applied QoS by configuring policy map on the router interface by allocating specific amounts of bandwidth to various classes and prioritizing a specific type (e.g., video and audio) over other network applications as shown in TABLE 2. According to the table, the bandwidth priority allocation for real time traffic (video and audio) was 60% , the highest among other types of traffic.

TABLE 2 POLICY MAP

Traffic Class	Priority Percentage (%)
Real Time Traffic (Video and Audio)	60
Bulky Data	20
Web Traffic	10
SCAVANGER Traffic	5
Class-Default	Fair-queue

Measuring Visual media Performance for Optimized Network

This section presents the screen shots taken by Net Catchlite tool that measures the latency, when unoptimized and optimized visual media files from various categories were transmitted over the optimized Wireless Network.

Latency measurement for unoptimized and optimized video files*:* With optimized network condition, FIG. 11–FIG. 14 present the screen shots for unoptimized video files: .mov, .mkv, .mpg, and .mpg2 while FIG. 15 presents the screen shot of their optimized form .mp4 when they were downloaded from the source where they were uploaded on the Internet. The latency for .mov, .mkv, .mpg, .mpg2 and .mp4 are 291, 254, 253, 217, and 212 ms respectively, as shown in the figures.

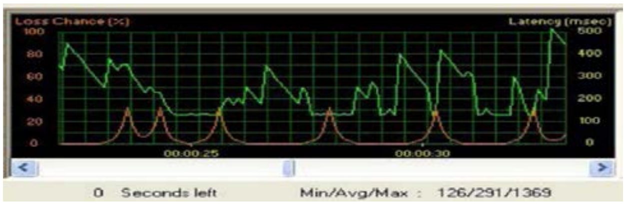

FIG. 11 LATENCY FOR .mov

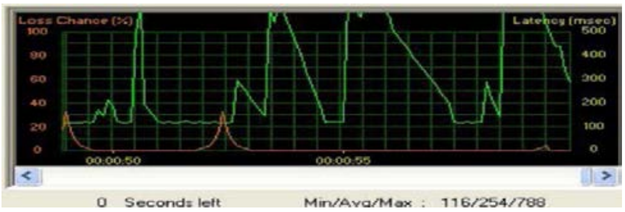

FIG. 12 LATENCY FOR .mkv

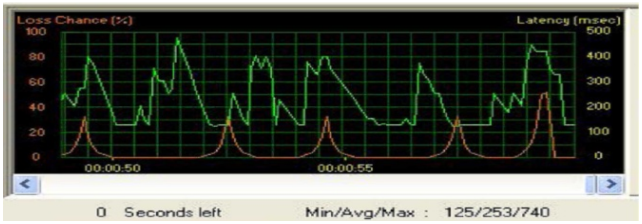

FIG. 13 LATENCY FOR .mpg

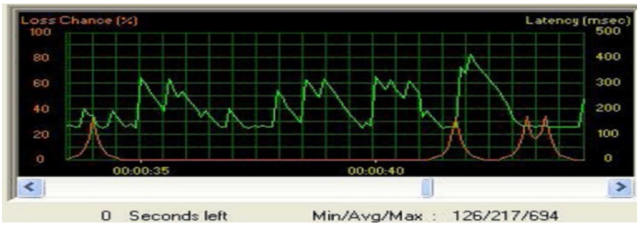

FIG. 14 LATENCY FOR .mpg2

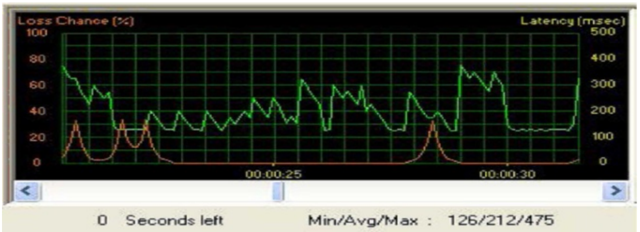

FIG. 15 LATENCY FOR .mp4

Latency measurement for unoptimized and optimized audio files: With the continued optimized network state, FIG. 16 and FIG. 17 present the screen shots for unoptimized and optimized (compressed to .mp3) form of .wav audio file. The average latency for .wav and .mp3 as shown in the graphs is 186 and 160 ms, respectively.

FIG. 16 LATENCY FOR .wav

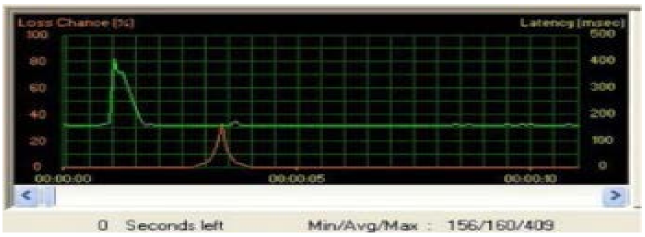

FIG. 17 LATENCY FOR .mp3

Latency measurement for unoptimized and optimized graphic files: With the same optimized network state, FIG. 18 and FIG. 19 present the screen shots for unoptimized and optimized (compressed to JPEG) form of .bmp graphic file. The average latency as shown in the graphs for .bmp and JPEG is 264 and

195 ms, respectively.

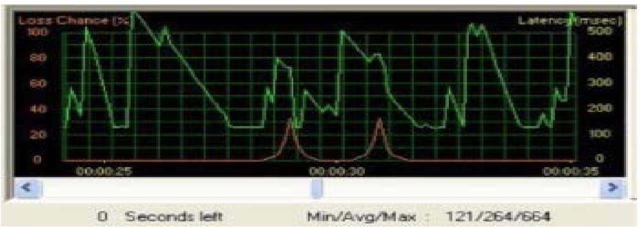

FIG.18 LATENCY FOR .bmp

FIG. 19 LATENCY FOR JPEG

Analysis of Multmedia Latency Results

The testbed focused much on video formats as video is the most important and dominant traffic among all multimedia applications. The performance of various multimedia formats was observed and evaluated in the following four Phases:

Phase I: Unoptimized Network & Unoptimized Multimedia (UNUM)

Phase II: Unoptimized Network & Optimized Multimedia (UNOM)

Phase III: Optimized Network & Unoptimized Multimedia (ONUM)

Phase IV: Optimized Network & Optimized Multimedia (ONOM)

Optimization technique has been used on both network and multimedia contents as described in the testbed, and results calculated in terms of the user–driven parameter 'latency' have been plotted. Tables 3-8 below present an analysis of the latency results for various visual media files.

Video Files: The analysis of latency results for identified video formats is presented in TABLEs 3- 6.

TABLE 3 LATENCY RESULTS FOR .mov

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	522	N/A
II (UNOM)	X	√	422	19.15%
III (ONUM)	√	X	291	44.25 %
IV (ONOM)	√	√	212	59.38 %

TABLE 4 LATENCY RESULTS FOR .mkv

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	553	N/A
II (UNOM)	X	√	422	23.68 %
III (ONUM)	√	X	254	54.06 %
IV (ONOM)	√	√	212	61.66 %

TABLE 5 LATENCY RESULTS FOR .mpg

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	555	N/A
II (UNOM)	X	√	422	23.96 %
III (ONUM)	√	X	253	54.41 %
IV (ONOM)	√	√	212	61.80 %

TABLE 6 LATENCY RESULTS FOR .mpg2

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	505	N/A
II (UNOM)	X	√	422	23.96 %
III (ONUM)	√	X	217	57.02 %
IV (ONOM)	√	√	212	58.01 %

Audio files: TABLE 7 present the analysis of the latency results for identified audio files.

TABLE 7 LATENCY RESULTS FOR .wav

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	270	N/A
II (UNOM)	X	√	217	19.62 %
III (ONUM)	√	X	186	31.11 %
IV (ONOM)	√	√	160	40.74 %

Graphics: TABLE 8 present the analysis of the latency results for identified graphic files.

TABLE 8 LATENCY RESULTS FOR .bmp

Phases	Optimized Network	Optimized Multimedia	Average Latency (milliseconds)	Percentage of Latency Reduction
I (UNUM)	X	X	408	N/A
II (UNOM)	X	√	286	29.90 %
III (ONUM)	√	X	264	35.29 %
IV (ONOM)	√	√	195	52.20 %

The analysis on latency results for all categories of visual media formats shown in above tables suggested that in phase II latency reduced, in phase III it further reduced, and it reduced significantly in phase IV in comparison with phase I. From the above discussion, it can be concluded that latency factor reduced significantly when both network and multimedia contents were optimized as compared to separate optimization, verifying the assertion that multimedia performance can be improved significantly when network and application are both optimized (Suhail, Lubega, and Maiga, 2011).

Conclusion

The paper has identified visual media formats compatible with constrained bandwidth environment, followed by the performance analysis of various media types. More importantly, the theoretical concept, "performance of multimedia content can be improved by optimizing both network and application" (Suhail, Lubega, and Maiga, 2011) has been validated as well, successfully and one of the main objectives of the study has been achieved. The user-oriented metric 'latency' was used to evaluate the multimedia performance. At the same time, the study has shown that an imortant institutional resource (bandwidth) can be saved if time-sensitive applications are prioritized to minimize delays that would contribute to increment of the perceived level of user-satisfaction (Palmieri, 2003). Furthermore, to deliver a high performing multimedia content to users in the context of constrained bandwidth environment is a big milestone indeed, as in return it would enhance the process of blended learning adoption in developing countries.

This study has addressed the question of high practical value, rooted into the realistic and idealistic gounds that led to increased usefulness of knowledge created to guid researchers. The paper evaluated the performance of multimedia, a subset of e-learning that is an integral part of blended learning process, linking practical to theoretical foundations and to the relevant literature in an attempt to make both practical and scientific contribution. The findings of the study is of reference value for information system developers, e-learning solution providers, and instructional designers to increase the perceived level of user satisfaction when delivering multimedia content to the users in LDCs.

Future research may include conducting similar studies in different contexts, finding a method to reduce latency factor more than shown in the paper to improve further the multimedia performance to increase the level of user satisfaction (Suhail and Lubega, 2011).

REFERENCES

Azizan, F. Z. "Blended Learning in Higher Institutions in Malaysia". Proceedings of Regional Conference on Knowledge Integration in ICT, 2010.

Adegoke, B.A. "Effect of Multimedia instruction on Senior Secondary School Students' achievement in Physics". In European Journal of Educational Studies, Vol 3, No.3, 2011.

Astleitner, H., & Wiesner, C. (2004). "An integrated model of multimedi learning and motivation". Journal of educational Multimedia Hypermedia, 13, 2004, 3-21.

Abdelfattah, E., Mohiuddin, A. "Performance Analysis of Multimedia Compression Algorithm". In International Journal of Computer Science & Information Technology (IJCSIT) Vol.2, no.5, 2010.

Abbasi, A. A., Iqbal, J., Malik, A. N. A. "Novel QoS Optimization Architecture for 4G Networks". In: World Academy of Science, Engineering andTechnology 2010.

Begg, J., Thede, D. "Designing Web Audio: Chapter 5 Introduction to Streaming Media" , January, 2001. http://oreilly.com/catalog/sound/chapter/ch05.html.

Bersin and associates: 4-Factor Blended Learning Framework, What Works in Blended Learning. In: ASTDs Source of E-learning, Learning Circuits, 2003. http://www. bersin.20.com/ 510.654.8500

De Vries, J. "E-learning strategy: An e-learning Framework for Success". In Blue Streak learning, quality learning solutions , 2005.

Faridha, M. "Towards Enhancing Learning with Information and Communication Technology in Universities". MCS Dissertation report, 2005, Makerere University, Kampala.

http://www.bottomlineresults.elearningcentre.typepad.com/ whatsnew/2005/08/strat.html

Khan, B.H., Ealy, D. "A framework for Web-based authoring systems". In: Khan, B. H. (Ed.) Web-based training, 2001, 355–364.

Optimizing Internet bandwidth in developing countries higher education." INASP, 2005.

Palmieri, F. "Streaming Networks: A Differentiated Service Approach" In: EC-VIP-MC.4th EURASIP Conference focused on Video Image Processing and multimedia Communications, Zagreb, 2003. http://www.atics.info

Radient Systems. "A Blended Learning Model. In Training: A Critical Success Factor in Implementinga Technology Solution". North America Radiant Systems, 2003. http://www.radiantsystems.co

Suhail, N. A., Lubega, J., and Maiga, G. "Multimedia to Enhance Blended Learning Experience in Constrained Low Bandwidth Environment". In Cheung, S. K. S., Fong, J., Kwok, L., Li, K., and Kwan, R.: Lecture Notes in Computer Science, Springer-Verlag Berlin Heidelberg, ISBN: 978-3-642-32017-0, Vol. 7411, 2012, 362— 372.

Suhail, N. A., Lubega, J., Maiga, G. "Optimization Base Multimedia Performance to Enhance Blended Learning Experien in Constrained Low Bandwidth Environment". In Kwan, R.., Fong, J., Kwok, l. and Lam, J.: Hybrid Learning Lecture Notes in Computer Science, Springer-Verlag Berlin Heidelberg, ISBN: 978-3-642- 22762-2, Vol. 6837, 2011, 188-199.

Suhail, N. A., Lubega, J."Optimization Technique for Implementation of Blended Lea ning in Constrained Low Bandwidth Environment". In Tatnall, A., Kereteletswe, O. C., and Visscher, A. IFIP Advances in Information and Communication Technology. Lecture Notes in Computer Science, Springer- Heidelberg, ISBN: 978-3-642-19714-7, Vol. 348, 2011, 166-173.

The file extensions resource. File info.com 2003-2005. http://www.fileinfo.com/filetypes/video