



**HAL**  
open science

# Optimization Technique for Implementation of Blended Learning in Constrained Low Bandwidth Environment

Nazir Ahmad Suhail, Jude Lubega

► **To cite this version:**

Nazir Ahmad Suhail, Jude Lubega. Optimization Technique for Implementation of Blended Learning in Constrained Low Bandwidth Environment. 9th Information Technology in Educational Management (ITEM), Jul 2011, Kasane, Botswana. pp.166-173, 10.1007/978-3-642-19715-4\_18. hal-01565777

**HAL Id: hal-01565777**

**<https://inria.hal.science/hal-01565777>**

Submitted on 20 Jul 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# Optimization Technique for Implementation of Blended Learning in Constrained Low Bandwidth Environment

**Nazir Ahmad Suhail and Jude Lubega**

Faculty of Computing and Information Technology, Makerere University, Kampala, Uganda  
[nazir\\_suhail@yahoo.co.uk](mailto:nazir_suhail@yahoo.co.uk), [jlubega@cit.mak.ac.ug](mailto:jlubega@cit.mak.ac.ug)

**Abstract.** This paper proposes a novel optimization technique that addresses the most critical issue that impedes the process of technology integration in the universities in developing countries. The problem is addressed by optimizing the network efficiency and multimedia performance that matches with the challenges of constrained low bandwidth environment. The Paper also provides a comprehensive review of the existing blended learning frameworks.

**Keywords:** Blended Learning, Constrained Low Bandwidth Environment, Optimization.

## 1 Introduction

Growing demand together with flexible and cost effective higher education with increased accessibility of educational content has redefined the spectrum of university education. In response to the radically changing environment, universities are attempting to adapt new innovative methods of course delivery using increasingly available new learning technologies that exist in the world. Although the first phase of online learning embraced a number of benefits, the lessons learned proved that to facilitate a successful learning process, a single mode of instructional delivery may not provide sufficient choices and social contact [17]. As a result, blended learning, a new educational paradigm emerged as an attractive model in higher education [18].

Whilst blended learning offers a number of benefits, it is not a panacea, there are some obstacles such as; constrained low bandwidth environment which can be a key challenge to its adoption, particularly, in the context of organizations in Least Developed Countries (LDCs) [9], [14]. Although several techniques (e.g., [9], [10], [11], [12], [13]) have been proposed, the issue of implementing an effective and efficient blended learning process in constrained low bandwidth environment has not been adequately addressed. In relation to this research, the process may include optimizing the multimedia performance in an attempt to develop the content relevant to the challenges of developing countries [31] and optimizing the network efficiency. And as such there is a significant need for a new technique [16] that addresses the above issue.

After reviewing and making a comparative study of various existing blended learning strategies, this paper proposes a new optimization technique that focuses on critical factors not currently addressed that are obstacles to the adoption of

technology enhanced learning in constrained low bandwidth environment with particular focus on university settings.

## **2 Technological Concepts (TC)**

### **2.1 E-learning**

E-learning can be instructor led synchronous learning in which instructor and learners both communicate directly with each other by using electronic means, or asynchronous learning where they can communicate with time delay but not in real time. In literature, numerous terms are used to define e-learning [6]. However, the e-learning definition used in this paper is; “a combination of network and multimedia learning”.

### **2.2 Blended Learning**

The term blended learning refers to a thoughtful combination of best experiences in traditional face-to-face class room learning and e-learning to enhance the learning process.

### **2.3 Constrained Low Bandwidth Environment Multimedia (CLBEM)**

This study used a Multi Level Systematic Approach (MLSA) for identification of the most suitable multimedia compatible with the context of constrained low bandwidth environment. At level I, we identified a huge database of video formats [19] clustered into 4 groups; commonly used, very commonly used, average, and rare. At level II, we selected most commonly used video formats namely; Audio Video Interleave (.avi), Advanced System Format (.asf), Windows Media Video (.wmv), Apple Quick time Movie (.mov), Moving Pictures Expert Group 4 (.mp4), Moving Pictures Expert Group 1, 2 (.mpg), Real Video (.rv), The Shockwave (Flash) Format (.swf), and Real Media (.rm). At level III, we investigated the above selected video formats more critically using different characteristics. The level III investigation was based on the following characteristics; Developer, Platform operatability, Non-Proprietary, International standards, No packet data dependency, and Mix media encoding ability. The deep analysis of level III investigation revealed that only one video format namely, .mp4 has all these characteristics and is compatible with the prevailing constrained low bandwidth environment associated with many developing countries.

### 3 Existing Blended learning Frameworks (Techniques) (EBLF)

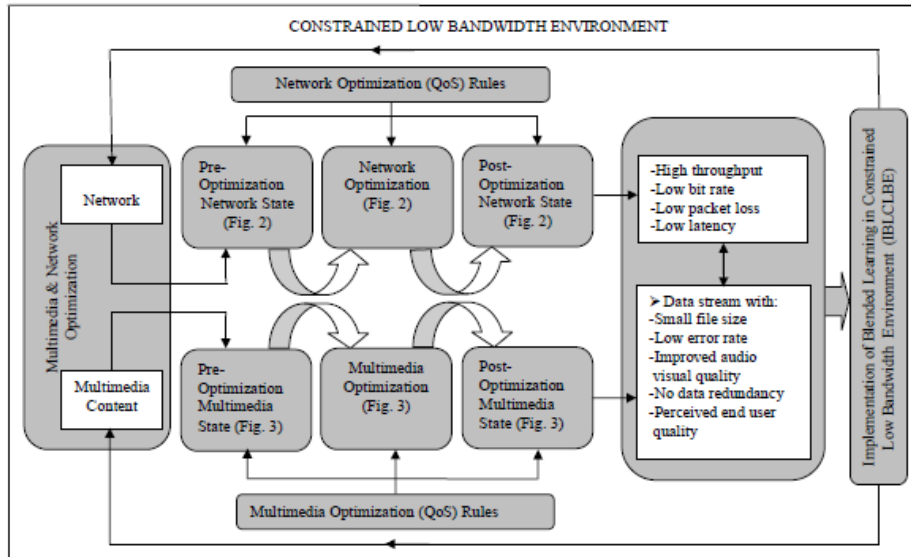
This study identified several blended learning implementation strategies such as; 4 Factor Blended Learning Framework (4FBLF) [9], A Framework For Success (FS) [10], A Blended Learning Framework (BLF) [11], The National Youth Development Learning Network (NYDLN) [12], and A Blended Learning Model (BLM) [13]. The reason for selecting these techniques among others is that they are inter-related and pinpoint the essential factors related to three main categories; educational, managerial, and technological required for introducing a successful blended learning intervention in a Higher Education Institution [15].

**Table1. An overview of identified existing blended learning frameworks**

Indicators	FS	BLM	BLF	4 FBLF	NYDLN
Institutional (Organizational readiness, administrative & academic affairs etc.)	x	✓	✓	✓	✓
Learnners & lecturers concerns (Audience analysis; characteristics & needs)	x	✓	✓	✓	✓
Pedagogical (Content analysis, design & learning objectives)	x	✓	✓	✓	✓
Technological infrastructure (Hardware & software)	✓	✓	✓	✓	✓
Learning Content (Teaching, learning or training material)	✓	✓	✓	✓	✓
Management & evaluation (Logistics, learners support service, registering, and assessment)	✓	✓	✓	✓	✓
Ethical (Copy rights, cultural diversity & equal opportunity)	x	x	✓	x	✓
Communication (Marketing & change management communication)	✓	x	x	x	x
Resources (Human & financial resources)	✓	✓	✓	✓	x
Constrained low bandwidth environment	x	x	x	x	x

The issues addressed by these frameworks seem to fall under the titles shown in the first column of the matrix in Table 1. An analysis of the indicators of the reviewed literature suggests that important similarities exist between them; they address the similar issues under different titles and do not address the issue of constrained low bandwidth environment. Hence justifying the need to develop a new blended learning technique which addresses the core issue not addressed by the existing blended learning frameworks effecting the implementation of a new educational paradigm in low economies [16].

#### 4 Proposed Technique for Implementing Blended Learning in Constrained Low Bandwidth Environment

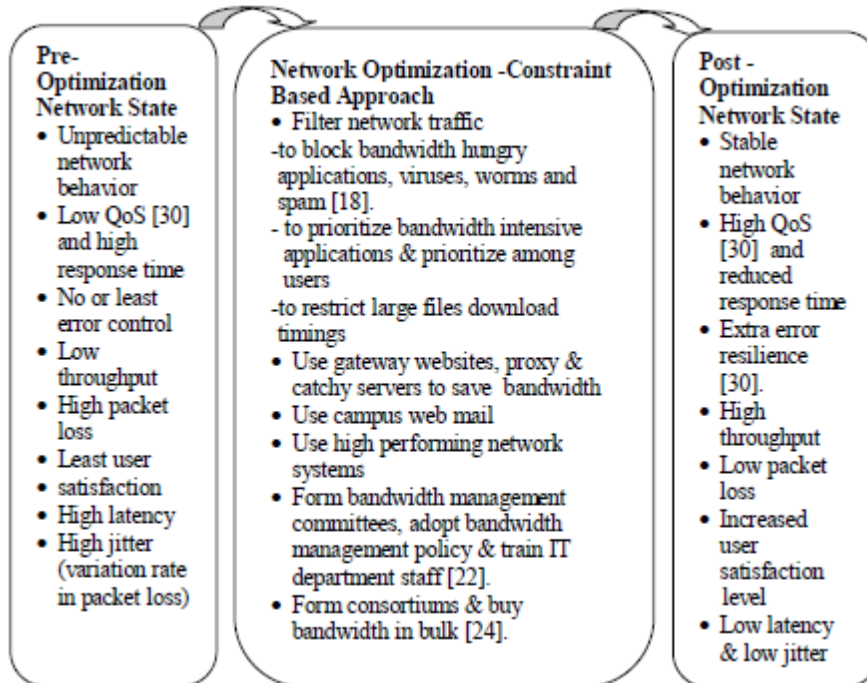


**Fig. 1. Constrained Low Bandwidth Environment Optimization Technique for Implementation of Blended Learning**

The proposed technique is an extended form of Khan’s framework [11], [17]. Fig. 1 shows the pre-optimization states of network and multimedia which act as an input to the optimization process governed by both Network and Multimedia Quality of Service (QoS) Rules, followed by their outputs which turn into inputs for the next process of interaction between optimized states of the two components of the technique, facilitating the process of implementing an effective and efficient blended learning process in a constrained low bandwidth environment.

##### 4.1 Network Optimization

Fig.2 provides the details of three network states mentioned in the proposed technique, and in subsequent sections, the technical details of network optimization process are discussed briefly with an emphasis on filtering the traffic passing through the network to reduce network congestion caused by; Internet worms, viruses and spam, misuse and mismanagement of bandwidth [18] due to non-existent or ineffective bandwidth management policies [22], [23]. Network congestion is an overloaded network state when resource (bandwidth) demand exceeds the supply resulting into huge consecutive packet loss [7].



**Fig. 2. Three Different Network States**

**Packet Filter Firewalls and Access Control Lists (ACLs).** Information over the network system travels in form of discrete packets (cluster of bits) characterized by many attributes. Packet filter firewalls are devices used to enhance the security of the network system that filters the inbound and outbound network traffic based upon the rules that may be called Quality of Service Rules (QoSR), commonly known as Access Control Lists (ACLs) [1], [2].

*Authentication.* User Authentication System (UAS) can be introduced by issuing log in passwords to authorized users to restrict the access to network resources from unauthorized users under the policy rules [3].

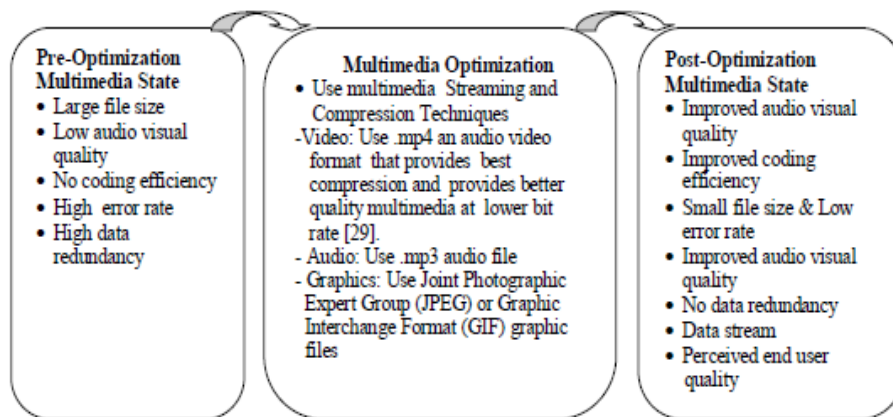
*Prioritizing network traffic.* Prioritization technique is used to enhance the Quality of Service (QoS) for real time applications such as VoIP and video by processing it before all other data streams. Similarly, the technique is used to prioritize among various categories of users based upon their associated privileges [3], [4].

*Time Based ACLs (TBA).* Time-Based ACLs are configured on router interfaces in the network to restrict the heavy file download timings to save the bandwidth.

**Cache and Proxy.** Cache and proxy are local memory devices that can considerably save bandwidth in low bandwidth environments [5]. The cache stores the digital contents most frequently required by the students. While proxy servers save the recently or more visited Web Pages. When using cache and proxy method, all user requests pass through cache and proxy servers.

## 4.2 Multimedia Optimization (MO)

Fig. 3 describes the details of three different multimedia states stated in the proposed new technique. In education, multimedia refers to present information using variety of media which includes; text, graphics, audio, and video [28]. The transmission of multimedia applications such as; video and audio over the network in the context of a constrained low bandwidth environment is still a challenge. However, the course performance can be enhanced by using multimedia streaming and compression techniques [20] explained in the following sections.



**Fig. 3. Three Different Multimedia States**

**Multimedia Streaming.** Streaming techniques are applied for delivering audio and video files efficiently that start playing one after another in the form of a stream on the client's computer when full contents are not downloaded completely. However, before streaming, multimedia contents must be compressed as these files are very large and data is again decoded (decompressed) before viewing by the user.

**Multimedia Compression.** Multimedia compression refers to reducing of the multimedia file size that can significantly reduce the bandwidth requirements.

*Video.* For digital videos, compression is achieved by removing the redundant data from the video files until the minimal compression level is achieved under Quality of Service rule. MPEG-4 (.mp4) [25] as identified in section 2.3 is to be used as the standard compression format that can efficiently encode (compress) mixed media and is "error resilient to enable robust transmission of compressed data" [24]. And has an inbuilt technique where many macro blocks are grouped together such that there is no packet data dependency on the previous packet [26], [27]. In addition to that MPEG-4 also provides better quality media at low bit rate [29].

*Audio.* Audio files should be saved as Mono Audio Files (MAF) because they are smaller as compared to Stereo Audio Files (SAF). For compression MPEG-3(.mp3) format should be used.

*Graphics.* Optimize the performance of graphics by reducing size, resolutions and number of colors. Joint Photographic Expert Groups (JPEG) and Graphic Interchange Format (GIF) type graphic files provide better compression.

## 5 Conclusion

This paper has proposed a novel technique showing how to implement a successful blended learning intervention in low bandwidth economies by underpinning the most critical issues not addressed by other techniques. Currently, most organizations in LDC's have not strategically implemented online learning or blended learning in their programme offerings, although there is need [8], and therefore this research besides the scientific, has its highly pragmatic justification. The implementation of the proposed technique will lead African Universities to increase access to their own demand-driven programs in a "sustainable and cost-effective manner" and to convert millions of human resources from liability to become pivotal in their country's economic development [21].

## References

- [1] NISCC National Good Practice Guide on Firewall Deployment for SCADA and Process Control Networks (2005)
- [2] Recommendations of the National Institute of Standards and Technology. In: Special Publication NIST 800-41 (2002)
- [3] Kaminsky, M.: User Authentication and Remote Execution Across Administrative Domains. Doctor of Philosophy Thesis, Massachusetts Institute of Technology (2004)
- [4] IPhighway#1. Introduction to Policy Based Networking & QoS. IPhighway (2000) <http://www.iphighway.com>
- [5] I-Hsin, C.: Strategies for dealing with high and low bandwidth connections (2000)
- [6] Hadurat, S.: Applying a System Development Approach to Translate Educational requirements into E-Learning. In: Inter. J. K. & L. O. Vol. 3 (2007)
- [7] Frost, V.S.: Quantifying the Temporal Characteristics of Network Congestion Events for Multimedia Services. In: IEEE Transactions on Multimedia, Vol. 5 (3) (2003)
- [8] Sife, S., Lwoga, E.T., and Sanga, C.: New technologies for teaching and learning: Challenges for higher learning institutions in developing countries. In: Inter J. of Edu and Dev. using ICT Vol. 3(2), 57--67 (2007)
- [9] 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.20com/> 510.654. 8500.
- [10] De Vries, J.: E-learning strategy: An e-learning Framework for Success. In: Blue Streak learning, quality learning solutions (2005) <http://www.bottomlineresults.elearningcentre.typepad.com/whatsnew/2005/08/strat.html>
- [11] Khan, B. H., and Ealy, D.: A framework for Web-based authoring systems. In: B. H. Khan (Ed), Web-based training, pp. 355--364 (2001)
- [12] PDSEN.: Professional Development Series E-News letter. In: The National Youth Development Learning Network, A Blended Learning Strategy for the Professional Development of Youth workers (2005). <http://www.nasembly.org>



- [13] A Blended Learning Model. In: Training: A Critical Success Factor in Implementing a Technology Solution, North America Radiant Systems (2003)  
<http://www.radiantsystems.com> (Retrieved 28 June, 2007)
- [14] Suhail, N.A.: Assessing Implementation of Blended learning in Constrained Low Bandwidth Environment.: In: Special Topics in Computing and ICT Research: Strengthening the Role of ICT in Developing Countries, Vol. I. pp.377--390. Fountain Publishers, Kampala (2008)
- [15] Faridha, M.: Towards Enhancing Learning with Information and Communication Technology in Universities. Master of Science Thesis, Faculty of Computing and IT, Makerere University, Kampala (2005)
- [16] Ronghuai, H., and Yueliang, Z.: Designing blended learning focused on knowledge category and learning activities: Case Studies from Beijing Normal University (2005)
- [17] Harvey, S.: Building Effective Blended Learning Programs. In: Issue of Educational Technology, Vol. 43 (6), 51--54 (2003)
- [18] Optimizing Internet bandwidth in developing countries higher education. In: INASP, (2003)
- [19] The file extensions resource. File info.com. 2003- 2005  
<http://www.fileinfo.com/filetypes/video>
- [20] Bruce, B.: Developing media for Low Bandwidth. In: ASTD's Source of E-learning circuits (2001)
- [21] Dzvimbo, K.P.: Access Limitation and the AVU Open, Distance and e-Learning (ODeL) solutions. In: Proceedings of The Association of African Universities Conference, Cape Town (2005)
- [22] Belcher, M.: Strategic bandwidth management: Enabling ICTs for optimal impact. In: INASP (2008)
- [23] Bandwidth management position paper, Aptivate (2007)
- [24] African Tertiary Institutions Study and lessons for the Future Camp (2004)  
<http://www.atics.info>
- [25] Spasiac, A., and Nestic, M.: Informing Citizens in a Highly Restrictive Environment Using Low Budget Multimedia Communications: A Serbian Case Study. In: Info. Sc. J. Vol. 8 (2005)
- [26] Raman, A., and Babu, M.: A low complexity error concealment scheme for mpeg-4 coded Video sequences. In: Proceedings of the Tenth Annual Symposium on Multimedia Communications and Signal Processing, Bangalore (2001)
- [27] ISO/IEC 14496-2 MPEG-4 Video Coding Standard, ISO/IEC 14496-2, Information technology coding of audio-visual objects –Part2: Visual ISO (2000)
- [28] Natadjaja, L.: A usability of graphic design with local content in the interactive multimedia design for Indonesian story telling. In: Nirmana, Vol. 6 (2) 114 --131 (2004)
- [29] Liang, J.: New Trends in Multimedia Standards: MPEG4 and JPEG. In: Info. Sc. Special issue on multimedia informing technologies-part 1, Vol. 2 (4) (1999)
- [30] Fong, A.C.M., and Hui, S.C.: An end-to-end solution for Internet lecture delivery. In: Campus-wide Information Systems, Vol. 19 (2), 45--51 (2002)
- [31] Omwenga, E. J., Waema, T. M., and Wagacha, P.W.: A model for introducing and implementing e-learning for delivery of educational content within the African context. In: Afri. J. of Sc. and Eng. Series, Vol.5 (1), 34 -- 46 (2004)