Towards the Design of a Synchronous Virtual Learning System

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Abstract— The field of education has undoubtedly been affected by the penetrating influence of information and communication technology, characterized by improved access to the internet, and the increasing use of computing devices. However, education in Africa generally and specifically in Nigeria and other developing countries still face a 21st Century challenge in making education available and accessible to all. To this end therefore, this paper presents a conceptual approach, as to how tailor made e-learning services could be realized and integrated with a real time video conference server and any existing learning management system in order to facilitate a synchronous virtual learning environment in making education accessible and available to both remote students (distance learning students) and onsite users in Universities and other related educational institutes. It proposes a functional framework to exemplify educational services such as file sharing to enhance collaboration, a digital resource center for retrieval of both free and paid relevant academic resource. A conference room for real time classroom participation which learning platform should provide in order to enhance both teaching and learning performance of course instructors and their students respectively is also proposed. It provides an operational design which describes how custom made e-learning portal integrated with an Open source Video Conference server could be realized, in facilitating a synchronous virtual learning service. Furthermore, it proposes a Virtual Learning Network architecture to show how both remote and onsite students could optimize quality network access in realizing these electronic learning services.

Introduction

As universities and colleges increasingly embrace new technologies and leverage them not only to enhance their traditional curriculum, but also to extend course offerings beyond the college campus, opportunities for increased collaboration between students and lecturers have been greatly enhanced (Buzzard et. al., 2011). The evolvement of new way of learning in today's environment is increasing rapidly. Methods through which teaching and learning take place are gradually changing. The new ways of technological usage in the educational system has indeed open a new vista in the teaching and learning sphere. With the advent of learning technologies, the educational paradigm has experienced a shift from the use of conventional classroom materials such as pencils and notepads, to the use of tablets, palmtops, interactive white boards and personal computers for resource sharing, learning and collaboration between students and their instructors("Teaching in a Participatory Digital world", 2013). According to Zafra et. al., (2011), the educational reform in higher institution had witness a considerable increase in the usage of these systems. All these devises riding on the Internet has provided educators at all levels, including universities, a range of innovative and potentially empowering tools for teaching, learning, course management, and assessment. It has prompted significant changes in teaching and learning approaches. This is achieved through its affordances, the growth of content it provides, and also new technologies that promote and support communication and interaction between and among the students, the content providers, and the instructors (Ahamad and Bokhari, 2011). It is however not surprising, that there is a continuous increase in the use of these technologies in the educational sector, as most of this technological artifacts has its underlying bearing from the educational stream. This paradigm of electronic learning has however metamorphosed into what is known today as Synchronous Learning Systems. This type of communication is typically used for delivering lectures, answering questions and receiving feedback from the students in real time. If the teacher needs to send out an assignment, he or she can simply post a bulletin on the class website, which the students also receive via an e-mail notifying them of the new assignment. Synchronous learning is done in real-time with a live instructor facilitating the training. Everyone logs in at a set time and can communicate directly with the instructor and with each other. It is usually fixed for a specific amount of

time, from a single session to several weeks, months or even years. This type of training usually takes place via Web sites, audio- or video-conferencing platforms, Internet telephony, or even two-way live broadcasts to students in a classroom (Skold, 2012). Furthermore, the physical distance that is often seen by many as a disadvantage can have positive effects by making learners and instructors more objective, less fearful of comment or criticism, less prone to cultural barriers (Praslova, 2004).

This work therefore is poised to the realization of a virtual learning environment adopted to solve the challenges faced by academic institutions in Africa and other developing countries, so as to bridge the gap of limited infrastructure and human resource and inadequate academic resource. In another vein, this work could go a long way in making room for inclusive education. This is to mean that, universities would now be able to admit more without having to consider infrastructural capacity. As posited by Praslova et. al., (2006), post-secondary education needs to prepare to build programs for millions of emerging open learning students as it is anticipated that approximately 150 million more online learning spots will be needed in the next decade.

II. Problem Definition
Due to the escalating number of students seeking admission to Nigerian Universities and the limited classroom infrastructure to match, there has always been a challenge to effective dissemination of lectures in such condition, characterized by having overcrowded classrooms. In 2013, out of the 1.7 million students that sat for University Tertiary Matriculation Examination (UTME), less than 500 thousand can be accommodated due to limited space, this is according to the Minister for Education in Nigeria (Dailypost, 2013). Also, the situation of having different lecturers take the same course due to having very large classes divided into groups leads to disparity in the quality of knowledge delivered, which consequently affect students performance. It is also a common practice enshrined in schools' policy that lecturers are granted study leave to further their studies for a period of time, however plans are not made to absorb more instructors thus leading to reduced man power for the time in question. Furthermore, distance learning students, suffer from inadequate interaction, close collaboration and supervision with their course lecturer since the interaction between them is not in real time.

III. Goal
The proposed Synchronous Virtual Learning Environment will facilitate real time learning experience between distance learning and onsite

students in Nigerian universities and her lecturers. It would help maximize human resource especially when the available instructors are gone for further studies for career development. Additionally, it would ensure collaboration and quicker access to relevant academic resource and also has the propensity to promote knowledge delivery from scholars across the world.

IV. Design Consideration

Several applications are available for deploying a Virtual Learning Environment and they come in different forms and flavours. It could be proprietary, open-source or self-designed. However it has been discovered that information systems are more successful, when they are tailor made to meet the requirements of a particular environment (Reeves and Minocha, 2010). According to Francese et. al. (2006), certain requirements should be put in place in the development of information systems in Africa. These include sustainability, affordability, socio-economic justification and community participation. However the case is not the same when deploying proprietary software, because its design concept is built on a set of requirements relative to the working environment that its designer had in mind. Although each proprietary software comes with its own peculiarity, it however comes with a cost. The cost ranges from the

cost of its acquisition and deployment (financial cost), to the cost of maintenance and technical support from its developers. The case is not the same with self- designed applications as it affords its users to make use of applications that were developed with the peculiarity and system requirements of their environment in mind. Since it is custom made, it also makes it scalable for future advancement. It is on this premise that this paper proposes that a self-designed application be built in order to meet the peculiarity of Nigerian Universities.

V. Theoretical Framework

Virtual Learning Environments can be defined as an integrated digital environment driven by computer assistive technologies in order to support teaching, learning, academic administration and research in a collaborative learning environment (Salmon, 2009). They are often referred to as online learning environments, learning management systems or collaborative learning software that extends the traditional classroom systems by implementing a non-geographically biased classroom infrastructure. Often embedded online, but sometimes distributed as a software package (stand-alone application), virtual learning environments are "boxed" system that mediates between teachers and students. Yang (2010),

described the use of traditional classroom and technology in a half manner as "hybrid virtual-physical collaboration learning", in which he consider it not to do away with the traditional learning while virtual learning complement it. Access to the learning environment is often ubiquitous and supports nomadic learning; which implies lecturers and students alike can access it anytime and anywhere they have an internet connection or are within the virtual learning network (Deutschmann, 2009). Using this learning platform, new knowledge is established by learners during communication and interaction with learning materials, colleagues, and instructors (Lai, 2010). In a virtual classroom system, the teacher may communicate with the students in real-time using video or Web conferencing facilities. This type of communication is typically used for giving lectures and for question and answer sessions (Pankaja and Mukund (2013). Virtual communities within the eLearning environment might have the ability to rectify the issues faced by eLearning (Lai, 2010). The principal components of a Virtual Learning Environment package include curriculum mapping (breaking curriculum into sections that can be assigned and assessed), student tracking, online support for both teacher and student, electronic communication (e-mail, threaded discussions, chat, Web publishing), and Internet links to outside curriculum resources (Mursu and Olufokunbi, 2002).

VI. Related Works

Multiple studies in the area of designing virtual learning environments have arrived at strikingly similar conclusions regarding the major educational benefits of purposefully designed virtual learning environments (Ssekakubo, et al., 2011). In other words, virtual environments designed to accommodate a specific learning activity, may have positive effects on learning if it is compatible with the educational activity that takes place within the given academic institution. Conversely, a virtual learning environment that is ill–suited for a specific task might have adverse effects on the learning performance of students utilizing the platform (Meloni, 2010).

Following the line of reasoning, as cited by Ssekakubo et al., (2011), the architectural design of a virtual campus should manifest the pedagogy–related features of a given university in order to encourage a desired educational approach among students and staff.

However, it is important to draw a line of disparity between what type of virtual learning system an entity is, in the context of its design and use. While some are designed to

facilitate asynchronous communication between students and lecturers, classified as the learning management systems, others are designed to facilitate synchronous (real time) communication classified under the category of video conference servers.

A learning management system as cited by (Robert, 2014) is defined as a software application or Web-based technology used to plan, implement, and assess a specific learning process, while Synchronous e-learning involves online studies through chat and videoconferencing done in real time (Mindflash, 2014). Either of the aforementioned systems could be used as e-learning platforms depending on its context of use.

Konstantinidis and Tsiatsos (2008), focused on the computer supported collaborative learning virtual environment, to which a virtual world was created to teach students. However, users' difficulties were experienced while examining the tools and services.

Sawyerr and Hobbs (2014), worked on creating a means to strengthen condition of virtual environment applications within requirement engineering activities and later stage of development. Their research was due to issues of usability of 3D virtual environment user interface and designing 3D virtual environment for limited access

groups. Sawyerr and Hobbs (2014), later observed that, what was referred to as 'designing virtual environments' was actually implementation and later deployment of the platforms. However, their research addresses formalising the characteristics of virtual environment applications and user interface by using a generic software development approach so as to have a reference point that leads the development process. This was done in order to formally treat it as the software development like other platforms such as mobiles and computers. In their work, they suggest more effort should be on design so that usability of virtual environment application can be improved and reduced usability problems usually found after deployment has taken place.

University of Nairobi has implemented three different learning management systems in the last five years: Wedusoft, Chisimba and Claroline. Wedusoft was specifically developed by a member of staff for the university while Chisimba was adopted and implemented through collaboration with development partners. Currently, the university is using Claroline LMS. However, none of the LMS have been utilized to their potential, and the success of LMS-supported e-learning at the university is described as minimal (Ssekakubo et al., (2011).

Currently, the University of Cape Town is using Sakai as the major LMS. This has been customized and branded Vula. In the past, the university has deployed Moodle and WebCT as well. However, they still continue to seek for virtual learning platforms that would satisfy most of their requirements (Ssekakubo et. al., 2011).

Share-point, a Microsoft content and document management system was used at, Nelson Mandela Metropolitan University to make courses available for sharing and collaboration in a blended environment. However, the platform was found to be less flexible, and had limited interactivity options. As a result it migrated to Moodle, and currently uses it as its Learning management System (Ssekakubo et. al., 2011).

In the University of Ilorin Moodle (a learning management System) was deployed in 2013 to facilitate learning and correspondence between the lecturers of university of Ilorin and its open distance learning students (Post-Doctoral Diploma in education). Via this platform lecturers can post lecture notes, send assignments, information notice, grade students and send results to every registered student on the platform. Although this platform has been in used for a while now, it has not been fully maximized and explored to cater for other courses in

the open distance learning sector. More importantly it does not yet support a real time communication between the lecturers and the students (Center for Open and Distance learning-University of Ilorin, 2013).

From the generally held positions and observations described above, universities in Africa have invested in the use of LMSs like Moodle, Sakai, Blackboard etc. These LMSs has only been successful in maintaining the learning process between the students and their lecturers; but with little or no provisions and capacity to solve peculiar challenges such as overcrowded classrooms, and limited human resources as experienced within the Nigerian academic system. Hence, the need to have self-designed learning systems which takes into cognizance the peculiar challenges faced within an instructor-led classroom in the Nigerian context.

VII. Methodology

The Current Learning System in Nigerian universities assumes the following pattern. For regular students, at scheduled time, students of a particular course meet with the assigned lecturer to receive the course instruction within the confine of classroom structure at predefined period. However the presentation style is relative to the lecturer's choice of delivering his lectures. He

could deliver his lecture via the white board, with the use of a board marker and eraser or make a projection of his lectures via a projector from a well prepared power point slides. However for its remote students(Distance learning students) the assigned lecturer for the given course could interact with his students via any learning management system like Moodle, Sakai, Blackboard, Canvas, OLAT and the likes; via which course interactions is facilitated between the students and the lecturer.

A. *Conceptual Design*: the entire concept of the proposed e-learning system is based on three major sub-systems. These are Video Conference Server, Resource Center and Potal System sub-systems. For each of these subsystems, requirements will be gathered, its design and implementation will be carried out, and the subsystems will be evaluated and tested. All these activities are designed to be carried out in iterative order. The successful integration of of theses three will give rise to the conceived system. This is as presented in Figure 1.
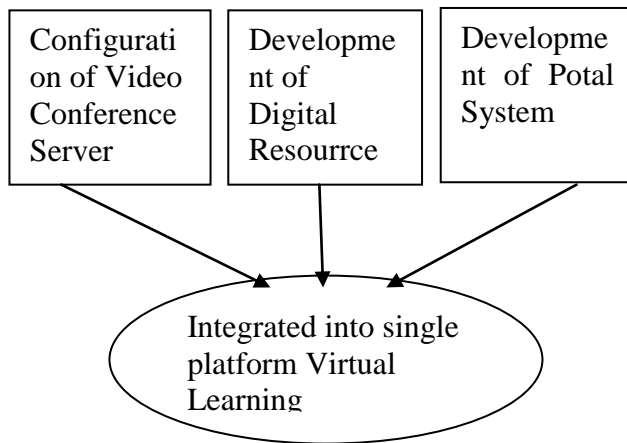

Figure 1: Conceptual Design of the Proposed System

B. *Functional Design***:** The proposed e-learning system could be designed as a web based e-learning portal to reflect custom classroom requirements as exemplified in figure 1. When adapted with BigBlueButton

(which is an open source video conference server), it provides synchronous communication between students and lecturers. Also it could be integrated with any Learning management system, in order to enhance the

learning process. Functionally, the services provided by the

entire system are as depicted in the Figure 2.
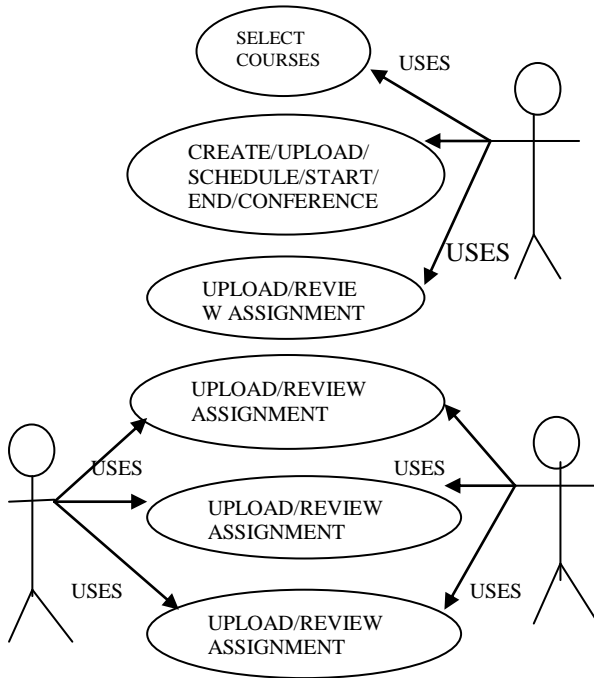
Virtual Learning Environment

Figure 2: Use Case Diagram for the Functional Architecture of the Proposed System

As expressed in the functional design, the new system would allow lecturers to create assignments, share files, schedule and attend conferences and download academic resources from the resource center.

C. *Operational Design*: The system is primarily proposed for lecturers and students in Nigerian Universities. The Virtual Learning system would be made to extend the existing portal system of the University; hence

both lecturers and student can use their existing login details to gain access into the Virtual learning portal. However all lecturers would be required to dynamically add all the courses they would take for each academic session. For the students, courses are dynamically added, after courses registration on the existing school portal. To have live classes the lecturer would have to open the conference room for the students to join. The conference room

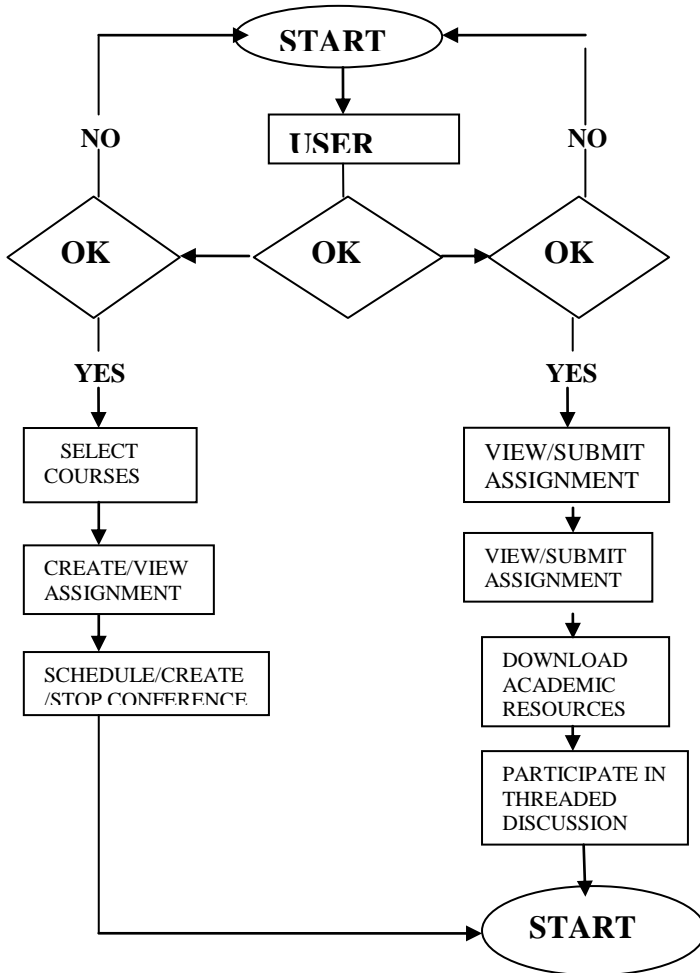utilizes BigBlueButton for its real time instructor-led learning

process.

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Figure 3: Flow Chart of the Proposed System

D. *E-Learning Network Architecture*
As part of the conceptual design, a virtual learning network architecture is proposed for Nigerian Universities to support both onsite users (Regular students within the campus) and remote users (Distance learning students). Thus a Video conference server (BigBlueButton), configured with a live IP address is to be hosted on a dedicated server at the campus network operating center, in order for both onsite and remote users to gain access to the e-learning system.

To compensate for Quality of Service metric deficiencies, universities deploying such services should make provision to facilitate high speed fiber optic networks, which enhances efficient propagation of video traffic and enables the local users to enjoy a maximum service level. However, traffic coming from a remote domain to access the e-learning system should be prioritized on the campus core router in order to increase the user's access privilege. Also administrators could configure the quality of video stream on the video configuration module of the video conference server (BigBlueButton) to the barest minimum, in order to help optimize network access in underserved areas with significantly low network bandwidth. Moreover, a link to a short guide could be placed on the landing page of the conference room, instructing the students to reduce the quality of videos being streamed out in such unfavourable network condition. Additionally, it is recommended that TV white space technology - which takes advantage of the available spaces in the UHF and VHF broadcast frequencies, in addition to its ability to penetrate unsuitable terrain environment will be of great advantage (Faruk et al., 2014).
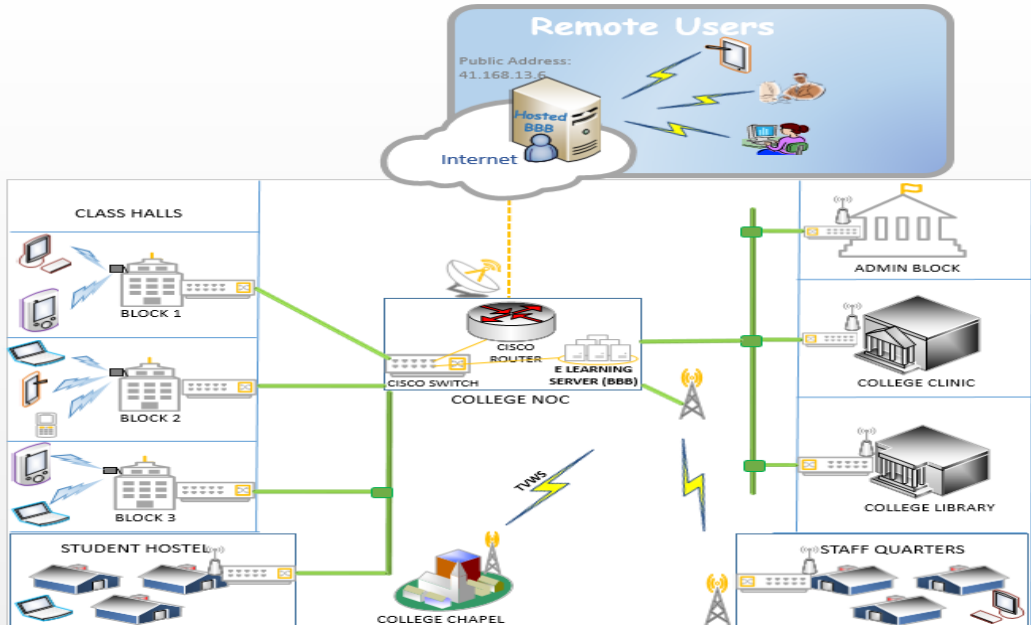

Figure 4. Proposed E-Learning Network Architecture

VI. A Comparative Analysis

In an attempt to make comparison between the proposed system and existing systems, the initial test run

of the conceptualized design, was assessed using the following parameters: Scalability, Deployment, Cost, Software Requirement and Network Requirement. This comparison was made against three top web conferencing software: AdobeConnect, CisoWebEx and DimDim

Scalability: while the proposed learning system can scale to hundreds of participants, depending on the processor and hard drive of the media server. The free version of AdobeConnect, CisoWebEx and DimDim free could scale up to 20, 25 and 10 participants respectively.

Deployment: the proposed system supports both local and cloud hosting of the server, AdobeConnect, CisoWebEx and DimDim supports cloud hosting of its server on their respective media server.

Cost: the proposed system does not require a service charge per user, and it is easy to install and maintain with little or no technical constraint, whereas AdobeConnect, CisoWebEx and DimDim requires service charge per user in addition to deployment and the fee for technical support and maintenance. By the time this cost is figured out in the context of a university, this could be turning to several millions.

Software Requirement: the proposed learning system requires adobe flash to run and can be run all browsers, while CiscoWebEx and DimDim would require certain plugins to be rendered on browsers effectively.

Network Requirement: for the proposed system, onsite users rely on the institutions network to participate in the virtual classroom, while remote students would require internet access, of which there are provisions to help optimize the quality of network access coming from areas with relatively low network bandwidth on BigBlueButton's Video configuration file. Whereas for AdobeConnect, CisoWebEx and DimDim both onsite and remote students would require a relatively good internet service

VII. Conclusion

In this paper, efforts has been made to show the logical structure and feasibility of implementing a synchronous learning system in order to mitigate the challenge of limited classroom infrastructure, inadequate academic resource and limited human resource associated with the Nigerian academic system. It exemplifies the operational design, network architecture and functional model required to implement a synchronous e-learning service, for future deployment. It recommends that tailor made e-learning applications which facilitates real time learning process be built, so that challenges of overcrowded

classrooms and limited human resources could be appropriately dealt with. Furthermore a comparative analysis was carried out to justify the need to have self-designed applications built on an open source video conference server, as opposed to using proprietary softwares. Additionally, lecturers can utilize the desktop sharing

functionality to teach practical oriented courses to students, in situation where laboratories have limited facilities. Consequently when this environment is provided to distance learning students, it has the propensity to ensure greater collaboration and commitment between the students and the lecturers.

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