Customizable Locolms Based Virtual Schooling System for Equity Learning Environment Appropriate For LDCS

IJOTM
ISSN 2518-8623

Volume 1, Issue 1
pp. 1- 9, June 2016
email: ijotm@utamu.ac.ug
http://ijotm.utamu.ac.ug

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Abstract

Through several Regional and International Declarations, it was emphasized that education should be a must for all. But the classic classroom mode of education, especially in the LDCs, cannot deliver on this premise because of low educational budgets to meet the corresponding increases in classroom space and training educators due to exponential population growth. The emergence of the ICT supported distance education provides an excellent way of addressing several such challenges. However, it still faces challenges in terms of providing equal treatment to both on-campus and on-line learners. Each category requires specific pedagogical methodologies and the institutions which offer both the traditional classroom and the distance education based courses have to design and run varying versions of the same programmes requiring parallel sets of resources and infrastructures. This paper discusses a virtual schooling model which enables the resources of the existing classroom mode to also serve remote learners. The objective is to preserve the academic culture of individual institutions and offer equity learning treatment to both the on-campus and on-line learners. The traditional classroom mode has several limitations but it has obvious advantages over the distance learning systems too, notably the face-to-face interaction between learners and instructors. This paper discusses an adoption of the characteristics of traditional classroom mode to avoid parallel sets of resources and infrastructures. It is achieved through employing the LoColms [1], a learning management system that supports the scenario of virtual schooling where online learners enjoy cheap rich full-motion video of real class sessions. The system achieves the synchronous characteristic of traditional classroom mode asynchronously. Its goal is to make university education affordable to all. The cost reduction and harmonized learning environment comes from employing Proxy Cache Servers, random selection examination questions and online banking techniques, as well as the Point-to-Point communication Protocol (PPP) Technologies over the PSTN, which may be required where data network infrastructures have not yet reached, a possibility in a number of the least developed countries.

Key Words: Customizable & Equitable Virtual Schooling, LoColms, ProCa, Video Streaming

Introduction

Education is emphasized as a fundamental right for all. The Universal Declaration of Human Rights [2], the freedom of education for all was recognized among other human rights that need to be protected - “Everyone has the right to education…”; in the World Conference on Education For All (WCEFA), 1990, held in Jomtien, Thailand, the four conveners of the conference, UNESCO, UNICEF, UNDP, World Bank, and the WCEFA participants (155 governments, 33 intergovernmental bodies, and 125 NGOs) adopted an initiative intended to stimulate international commitment to a new and broader vision of basic education to " meet the basic learning needs of all, to equip people with the knowledge, skills, values, attitudes, they need to live in dignity, to continue learning, to improve their own lives, and to contribute to the development of their communities and nations” [3].

Most developing countries are poor and represent the weakest segment of the International community. The citizens in these areas are constrained in areas such as limited human, institutional and productive capacity;

acute susceptibility to external economic shocks, natural and man-made disasters; limited access to education, health and other social services and natural resources; poor infrastructure; and limited access to information and communication technologies [5].

The ICT supported distance education provides an important way to address these concerns. There are barriers, which include the lack of resources needed for meaningful development and sustenance of technology-based learning; insufficient infrastructures to support modern technologies, and the emergence of ICT in education comes timely. Various scenarios of ICT in education address the challenges against achieving the education for all. For instance, with technology, fewer educators can be utilized to serve a large geographical area thus saving on budgets that are required to train educators, and making it possible for learners to learn at any time and from anywhere, thus making classroom space a less compulsory learning factor. In an attempt to find an all-round solution, the Local Colleges Learning Management System, (LoColms) [1] is employed and its primary goal is to empower local academic institutions to improve the learners' enrolments in qualitative and quantitative terms by virtual means. It enhances the existing resources and capabilities within individual colleges.

The key technologies that support these customizable virtual schooling systems are the Proxy Caches (ProCa) systems which help to lower educational costs substantially. LoColms integrates distance learning scenario into the main stream of colleges' operations, avoiding many unrelated players as well as keeping the colleges to stay focused on their core missions of providing quality education. It aims to achieve both cost-effectiveness (cheapness of educational provision – usually expressed in terms of per student costs) and cost-efficiency (the optimal balance between cost, student numbers, and educational quality) for each college operating the virtual schooling system. In considering sound educational investment, it is essential to distinguish effectiveness from efficiency. LoColms virtual schooling system addresses the financial considerations from the perspective of both the providers and recipients of the educational exercise. The providers and the remote learners on the virtual schooling system are only required to download their respective software for free.

The remote learners' software is "ProCache" server and the university's learning management system is "LoColms" server. The only cost involved for each is the system activation charges. For universities only the investment is in the acquisition and installation of the virtual school system equipment and subsequent activation costs. Although the individual universities have the liberty to set their own educational charges, the cost for tuition for remote learners would have to be substantially subsidized because of the low investment. As well, since the costs due to Internet connectivity will almost be eliminated through the use of the Proxy Caches on the side of the remote scholars, the affordability will be high. The remote scholars who do not possess laptops will be organized in study centers (SCs). Since the system would be commercially implemented for the colleges, the SCs operators, Internet service providers and banks, this solution is sustainable. Therefore, because of low costs and low investments, the system users will grow by a logistic growth order:

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{k}\right)$$

Where: **P** represents numbers of colleges or online scholars;
r represents the maximum per capita growth rate for users of the system
K represents the carrying capacity of the system

The growth would have an exponential characteristic but constrained at K, which will depend either on distances from the SCs or the handling capacity of all existing colleges.

The paper advances the argument that the LoColms solution can quickly improve the per capita learners' educational deficit in low income countries, even though the rest of the world will benefit from it as well. In this way the pressure of training great numbers of educators and the need for additional space for educational purposes to support increasing learning demands will get eased, and the learners will enjoy a more learning friendly mode of Full Motion Video study contents.

Background and Motivation

Studies reveal that education in the LDCs continues to be a privilege for most due to a couple of constraints:

Budgetary constraint: According to "UNESCO's Mid-Term Review On Education and Training in the LDCs, (1995)", [7] the majority of educational systems in developing countries, especially the LDCs, are confronted with major setbacks, mainly due to the use of inadequate, inappropriate, often inefficient and most always costly educational strategies. The links between cost-benefits, cost-efficiency, and cost- effectiveness remain weak in most of these countries because of high costs of educational materials and services, burdensome procedures and mechanisms for educational spending, and the use of inappropriate technologies and educational methods.

Unsustainable supporting technologies constraint: According to Hilary Perraton & Charlotte Creed in a review on the use of information and communication technology to support basic education (2000) [8], it is stated that there cannot be a practical substitute for Primary schools - Children need to learn within a social environment. However, the paper observes that technologies may play a part in meeting the needs of children or adults who cannot get to school or conventional class and it makes sense to look at the technologies together. Even though the International Community such as World Bank, USAID, UNESCO, funding agencies, NGOs and respective governments showed great concern to improve the educational situation in the LDCs through numerous initiatives, often these noble efforts offered a temporary solution as the sustainability of those initiatives will always pose a challenge. Most will struggle after the project support has expired due to insufficient capacity and budget. This can be deduced from the example of an ambitious attempt to use technology to raise the quality of basic education and widen access using the television project in Côte d'Ivoire. The program was launched in 1971, with the intention of reaching 21 000 1st grade children in the first year and with the other 5 grades added every year which by 1975 was reaching 235 000 children but, in 1981 the government of Côte d'Ivoire closed it down. Probably because the government realized it would not be able to take over the task in the event the funding agencies withdrew their role.

The Virtual Schooling Mode

Virtual Schooling Concept

As pointed out in [9] the related terms "virtual", "virtually" or "virtuality" imply that something exists having a potential effect but this something is not tangible. In classical organizations the boundaries are clearly defined while virtual organizations are characterized by fuzzy boundaries, flexible structures and the ability to include new partners as the need arises. In a nutshell, virtuality can be defined as a temporary or permanent coalition of geographically dispersed individuals, groups, organizational units or entire organizations that pool resources, capabilities and information to achieve common objectives, while decisively relying on information and communication technology (ICT).

A virtual school is based on the concept of networking learning environment and the technical possibilities offered by new information and communication technology, which is able to deal with all the tasks of school without the need for a physical school building. A virtual school, thus, does not exist according to an ontological analysis as a concrete building with classrooms, office rooms, teachers, other staff, or students. A virtual school is a logical extension of the use of computers in teaching [10]. We can thus regard virtual school defined narrowly as a school without a building but still connected to society [11]. Independence of time and place and historical neutrality is central to the concept of virtual school. A virtual school can work as a virtual extension of ordinary school or classroom activity.
If we regard a virtual school as a symbiotic extension of ordinary school, part of the activities of physical school may be moved to virtual school and carried out there with the aid of ICT technologies.

The Customizability and Equity of LoColms Virtual Schooling System

LoColms supports virtual schooling environment. Its goal is to help colleges, especially from LDCs, to support big numbers of learners without incurring substantive additional investments and effort. It endeavors to preserve the culture of individual institutions as well as providing similar treatment to the remote learners as their resident counterparts. The colleges operating the virtual school system will be able to apply equal learning procedures to both the on-campus and remote learners. The objective is to make accessing university education affordable to most. This will be a solution for those living far from the colleges or family people who don't wish to leave their families in search of university education from distant places.

The sizes of the colleges will virtually increase without overstretching their existing limited resources: the qualified academics will serve both categories of learning audiences seamlessly. Potentially, it is a commercially viable system for all parties involved which provides sustainability for the facility. Both the institutions and remote learners will need to download their respective software for free from the "Virtual Schooling Management System Website". Once the system software has been downloaded, installed and activated, it will be ready to work. Figure 1 shows the architecture of the LoColms virtual schooling system. The universities will be required to download the "University teaching management software" and the remote learning audience will be required to download the "Learners Proxy Contents software". Both the university and the remote learners will be required to activate their software through banks.

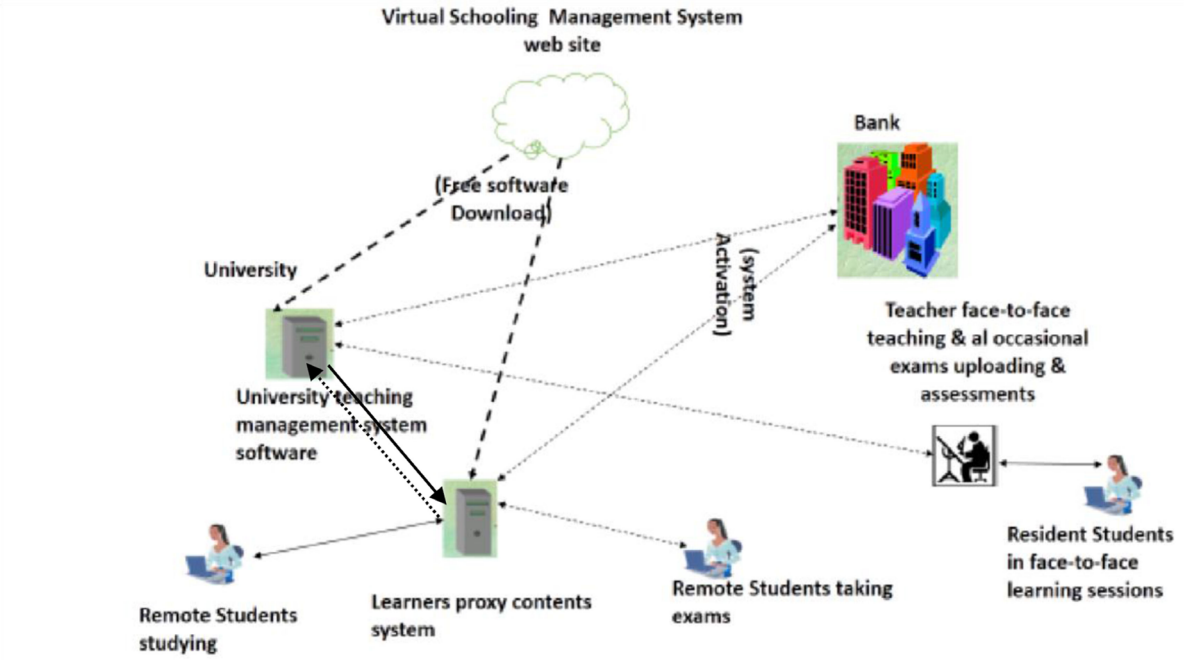

Figure. 1: *LoColms virtual schooling system architecture*

The teaching entity is mainly concerned with the on-campus learners, although the video of their entire sessions are simultaneously captured into the university system. The on-campus learners don't need the services of the virtual schooling facility. The remote learners using the learners' system (ProCache) will be able to study and occasionally sit for online exams. The solid arrows signify regular activities and the broken arrows signify occasional or transparent activities. The bold broken lines are for downloads and are supposed to be done only once. The remote learner will view the class in a form of full motion video as in the example in figure 2.

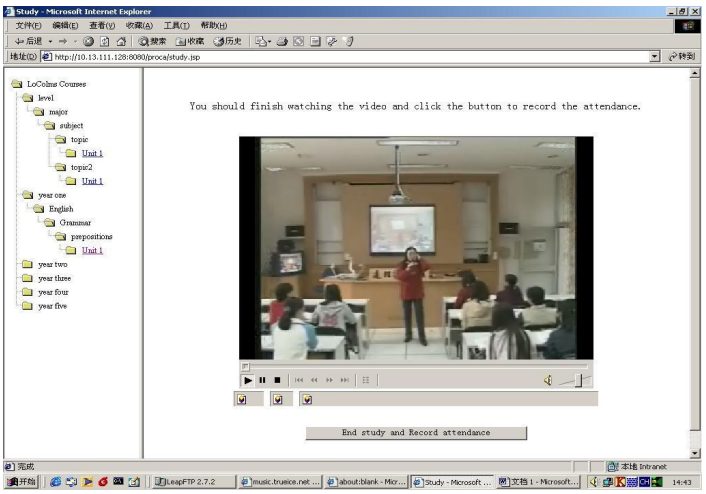

Figure. 2: *Full motion video class session*

The major advantages of the full motion video contents are to give: 1) remote learners a sense of entertainment during the learning process; and 2) remote learners have the illusion of being a part of the class. The remote scholars will also have the access to the other e-learning platforms of the university just as the on-campus scholars. It enables each university to preserve its unique academic culture, and for the online learners to have similar treatment as their resident counterparts, in terms of modules' delivery and assessment practices. The system would provide for diverse educational systems because it would adapt to the local colleges' educational standards. As well, the system localizes individual nations to ensure that their qualification frameworks are conformed to by the universities. It aligns online education to the on-campus situation of every country and university.

Since the contents are the unedited version of taped class sessions, both the on-line and on-campus learners are having the same version of the materials. Basically, the system addresses two asynchronous pedagogical concerns: 1) tracking the online learners' attendance; and 2) providing an online support mechanism for online evaluation. It allows the server to monitor online learners. The system will gather all the information related to: 1) authentication and payment verifications; and 2) providing the required service, either to study or take an exam. If the student's intention is to study, the LoColms will first check to ensure that these contents are not already in the ProCa before downloading fresh contents from the university's LoColms server, and then release the transmission channel. Then the learner(s) carries on from the ProCa of the SC's LAN.

Since the system mainly uses video materials of the recorded class sessions saved into the LoColms servers of the university, broadband links (Optical fiber or DSL,) between the SCs' LANs and the colleges' LANs are required. There is an after-topic assignment which the learner has to complete before he can be allowed to move on. It means that the online scholar will not be permitted to proceed to the next topic or module before completing the current one. The elements block, Assignment Unit au, and objective will satisfy the prerequisites and completionReq of the Course Structure Format (CSF). The learners from the SCs will be served with topic assignment units (Tau) according to the prerequisites and completionReq procedure, (Tau1&Tau2 &…&Taux) studied sequentially according to the order the units were taught to the on-campus scholars, with an after Tau exercise to mark the completion of the Tau, and the finished Tau is recorded in the LoColms server against the topic of the respective module. The remote learners will be required to do what the resident learners are doing. The system will not permit a slow remote learner to skip ahead. Since the contents are big video recorded class session files, the management of the storage is addressed in the future paper "Using Video Adaptive Compression techniques to manage the Virtual Schools Video Contents".

For online examinations, the module is as in fig. 3. Its database has four components: questions bank; finished exams; marked exams; and examinations results. Local examiners input exam questions and examination formats into the questions bank. When the online candidates download examination papers from questions bank, the question papers are according to format of the respective institution. The candidates' finished examination answers are uploaded into the finished exams part. Some of the exams or questions will be marked manually and others may be marked automatically by the system. The mark sheets will be in the marked exams part, from where results will be produced. The templates will reflect each institution's examination's format.

The downloaded examination papers have time stamps. When the examination time has elapsed, the answers will automatically be sent back to the university system. But no two separate examination question papers downloads will present the same set of questions. Even when the candidate decides to cancel the sitting and postpones it for a later time, the future questions will be different even though it is the same examination paper. This is one of the measures to check cheating behaviors. This is in addition to surveillance mechanisms that are implemented. However, the examination format and the paper standard will be the same. It is the responsibility of the examination & random setting functionality to randomly select questions from the question bank. For ease of examination invigilation, candidates will sit from designated places like SCs or examination halls of collaborating universities in proximity or use web cams for the siting alone candidates.

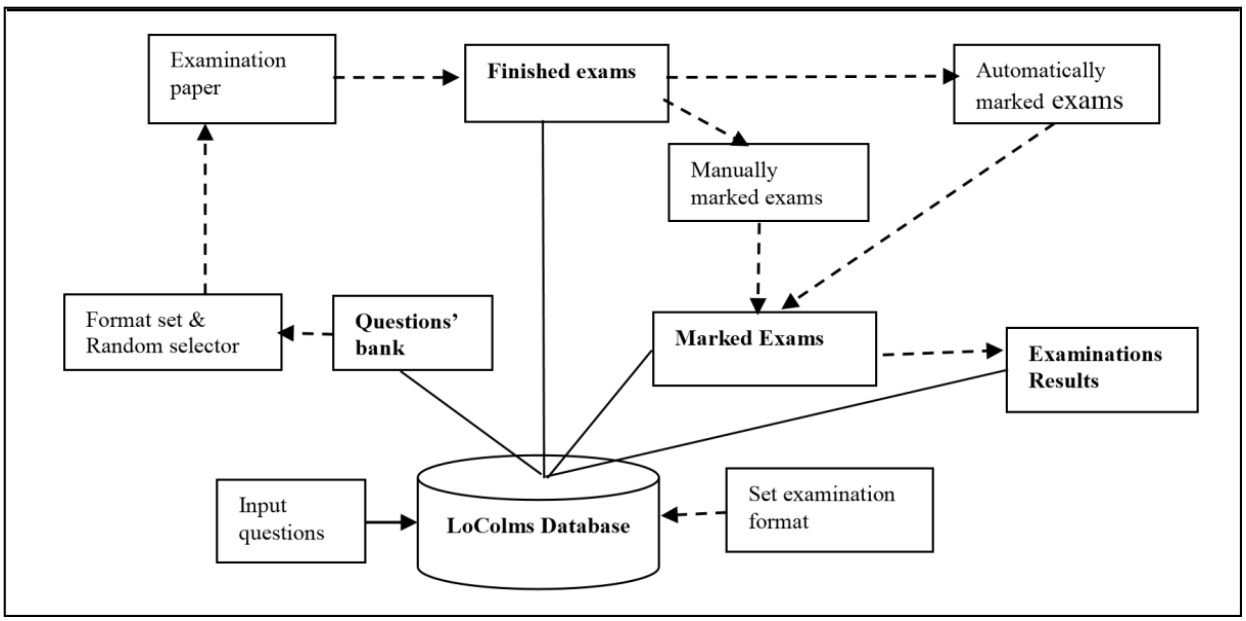

Figure. 3: *LoColms Examination Model*

Economicability of the System

The objective of LoColms system is to provide an educational solution that is both sustainable and economical, mainly suitable for the LDCs. The investments and efforts are expected to be minimal so that the university education may become affordable to all.

The remote learners will be required to go through the login procedures for the authenticity and payment verifications as well as registering attendance of the learner to the class. This phase will track the learner's habits. During the login, the system gathers all the information before contacting the college server or the SC server. If the study contents from the college servers had been downloaded, they are temporarily stored into the SC's proxy caches for the subsequent learners to access before being replaced by successive course packages, either by automatic prefetch or by more frequently shared resources, according to the Course Sequencing Prerequisites or Completion Requirements. It is expected that many courses will be shared so that the remote learners on the same SC may be studying the same Assignment Units (Aus) according to the CSF.

The basic Internet client-server model (where clients connect directly to servers) wastes resources, especially for the often-repeated transfer of highly popular information. The ProCa facility allows for the requesting of popular contents to be done once and later be served to a large number of clients. Because the ProCa facility usually has a large number of users behind it, it helps to reduce latency and traffic as well as the associated costs: 1) latency reduction due to the request being satisfied from the cache (which is closer to the client) instead of the origin server - it takes less time for the client to get the object and displays it; 2) traffic reduction due to each object being obtained from the server once - it reduces the amount of bandwidth used by a client. This saves money for the clients since paying for traffic will not happen and it keeps bandwidth requirements to the minimum. Freshness and Validation of the contents are controlled by the Last-Modified or If-Modified-Since common validators' properties to avoid having to download the entire object once they already have a copy locally but are not sure if it's still fresh.

The system supports a combination of technologies, which make the system affordable and adaptive to the existing situations and brings economic benefits to the hosting universities, and the entrepreneurs operating the SCs. The system mainly addresses the following concerns:

- The financial constraints: no government funding is required. Probably the governments would only come in to regulate the service to ensure the smooth operation of the educational system over commercially run SCs, as well as providing preferential treatment to the operators of LoColms

- The system's sustainability: it is achieved through the means of involving local resources, such as familiar technologies with already experienced technical staff, the local universities being sole supporters of the educational system, and operators of the SCs being the local entrepreneurs - every entity in the supply chain is commercially rewarded

- The system's affordability: the remote potential learners would not require any of the university's facilities for accommodation, feeding, healthcare, classroom space, physical library services, and network resources such as bandwidth are required only for a very short time - their costs are almost eliminated. The tuition charges will be grossly subsided.

ProCa will keep only the copy of the contents of the more frequently studied contents. The less frequently used ones will be removed, employing the least frequently used (LFU) replacement policy. Since the basic purpose of caches is to encourage sharing of contents, for the management of the contents let's consider a subject A (SA), having several Taus:

SA = {Tau1, Tau2, ..., TauN} ....(1)
For a certain Tauj, a certain number of students (Nai) may access it (sharing the copy). The bigger the Nai for Tauj, the fewer the copies of contents residing on the ProCa. By definition thus;

$$(Tau_j) = \begin{cases} Na_i = 1 \ (\textit{unshared contents}) \\ Na_i > 1 \ (\textit{shared contents}) \\ Na_i = 0 \ (\textit{no contents in cache}) \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Tauj = (Nai > 1)+(Nai = 1) .... (3)

Since the (Nai = 1) would be removed from the ProCa, the net content will approximately be;

Tauj (Nai > 1)-- (4)

According to the Zipf's law [12], the popularity of a content will determine its frequency of being shared. We can expect a very high hit ratio for colleges and programmes which are most popular for remote learners. Even in the Tauj = (Nai = 1) situation, the cost of downloading a fresh content is still economical, on broadband infrastructures, because the download time are short.

Video Streaming Technique

The remaining challenge is the downloading of video contents. Probably the most straightforward approach to deliver videos over the Internet similar to downloading a file, only that the video contents are large files. This approach allows the utilization of established delivery mechanisms, such as TCP as the transport layer or FTP or HTTP at the higher layers. However, this has a number of disadvantages. Since videos generally correspond to very large files, the download approach usually requires long download time. This would require patience for the remote scholars. The issue of very large video files that would take a very long download time is solved by employing Video-Streaming technology. Streaming is the act of sending audio and video (media files) over the Internet from one computer to another so that the media plays as it is being delivered. Video delivery by video streaming techniques overcomes the problems associated with video file download. The first parts of the video are viewed before the entire video download is completed. The basic idea of video streaming is to split the video into parts, transmit these parts in succession and enable the receiver to decode and playback the video as these parts are received, without having to wait for the entire video to be delivered. Video streaming conceptually is thought to consist of the follow steps: 1) Partition the compressed video into packets; 2) Start delivery of these packets; 3) Begin decoding and playback at the receiver while the video is still being delivered. Video streaming enables simultaneous delivery and playback of the video.

Even though the delivery over broadband media makes the downloading time much shorter, still video streaming

allows the on-line students to start viewing even before the downloading has completed, once the content gets to the ProCa. This is in contrast to file download where the entire video must be delivered before the playback can begin. In video streaming there usually is a short delay (in the order of 5-15 seconds) between the start of delivery and the beginning of playback at the client. The length of the delay is given by the time duration of the pre-roll buffer. For those with intermediate Internet connections supported by DSL infrastructure, the picture might be 320x240 pixels and 15 frames per second or 640x480 pixels for full motion video. The video streaming is required when being received by the ProCa system, but within the ProCa LAN, streaming is not required.

There is diverse range of different video communication and streaming applications, which have very different operating conditions or properties. For example, video communication application may be for point-to-point communication or for multicast or broadcast communication, and video may be preencoded (stored) or may be encoded in real-time (e.g. interactive videophone or video conferencing). The video channels for communication may also be static or dynamic, packet -switched or circuit switched, may support a constant or variable bit rate transmission, and may support some form of Quality of Service (QoS) or may only provide best effort support. In our particular case, we might switch between two parts: the first part may be over circuit switched network, the section between the colleges and SCs LANs, the situation where no data networks exist, and the second part is the packet switched networks, particularly for the section over the SCs' LANs.

Conclusion

This paper discussed the virtual schooling based on Local College Learning Management System (LoColms), whose objective is to provide both a sustainable and economical educational solution, suitable for educational situation in the LDCs. The system is a web-based system, and aims at improving the traditional form of education by empowering local educational institutions, while protecting their educational culture and a similar learning treatments to the on-campus and online scholars. Its economicability comes from minimizing costs due to Internet connectivity for learners and investments for academic institutions offering study programmes over the virtual schooling facility.

The work discussed is an innovation, whereby different technologies are combined to make web based education a realizable dream especially in the least developed countries, with the characteristic of enabling all potential university going people to undertake the opportunity. By this approach a lot can be achieved: 1) the WWW infrastructure would be economically utilized; 2) individual colleges' student enrolments would exponentially rise; 3) the local resources would be helped to develop; and 4) the web-based educational system would be sustainable.

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