A-VIEW: Context-Aware Mobile E-Learning for the Masses

Kamal Bijlani[1], Shivsubramani Krishnamoorthy[2],
Venkat Rangan[1], and Ranga Venkataraman[1]

[1] Amrita E-Learning Research Lab,
Amrita Vishwa Vidyapeetham, Amritapuri Campus, Kerala, India
{kamal,venkat}@amrita.edu, rangasv@am.amrita.edu
[2] MIND Lab, University of Maryland, College Park, MD 20842 USA
shiv@cs.umd.edu

Abstract. Developing countries typically have large populations in rural areas with inadequate resources for quality education. Concurrently, low-cost mobile devices are becoming quite popular in rural areas. The trends in the mobile industry show that a variety of mobile devices and choices in connectivity are becoming available and affordable. Synchronous e-learning is also starting to show immense potential with expert instructors being available to train teachers in other areas. The combination of these factors is unfolding a new era in mobile e-learning where the ubiquity of connected mobile devices has provided a tremendous potential for knowledge to reach large numbers of learners in rural areas.

In this paper, we present a case study in a large developing country like India where a major national initiative has been undertaken for providing e-learning to the masses. This program is addressing issues like nation-wide connectivity, affordable mobile devices and high-quality online content. As part of this program, we contribute a highly scalable framework called A-VIEW (Amrita Virtual Interactive E-Learning World) that provides live interaction between expert trainers and large number of learners. A-VIEW is designed to be context-aware, thus addressing the practical needs of a variety of users in various strata of society according to their available infrastructure, connectivity, bandwidth, local language and mode of learning.

Keywords: mobile learning, A-VIEW, m-learning, mobile UI, ACE.

1 Introduction

Developing countries face significant challenges when attempting to make learning more accessible by using Internet technologies for poorer populations [1]. The availability of new technologies like mobile devices has improved access from developing economies to the world market, but they have done little to help deprived groups gain access to educational opportunities. Limited Information Technology (IT) infrastructure has been a major hurdle in developing countries. There is a need to

N. Venkatasubramanian et al. (Eds.): Mobilware 2011, LNICST 93, pp. 1–14, 2012.

focus on and provide basic educational infrastructure to support low-cost, higher quality access in rural and deprived areas. This is important not only for equal access to learning, but also so that different groups may have the opportunity to contribute to the development of global knowledge.

In this paper, we present a case in India where a national program NME-ICT (National Mission on Education via ICT) is being implemented for providing mobile education for the masses. This project is a billion-dollar initiative for providing e-learning to the masses under the Ministry of Human Resources Development (MHRD), Government of India and is described on the website, www.sakshat.ac.in. The NME-ICT project has several facets for higher education. These include developing affordable mobile device, national connectivity, online content consisting of recorded lectures and other associated material like simulations, quizzes, and several other supporting projects.

As part of this NME-ICT program, we contribute a highly scalable framework called A-VIEW [2, 3] that provides live interaction between expert trainers and large number of learners. The context-aware model of A-VIEW helps a variety of users with different levels of access to IT infrastructure and connectivity to work in a collaborative manner with other participants in the education process.

In the next section, we describe the situations in developing and developed countries with regards to the education system and the potential of mobile technologies in these nations. We show that affordable basic IT infrastructure is necessary to dilute the digital divide between the rich and the poor. We discuss the issues in using mobiles in large and developing nations. In Sections 3, we present the A-VIEW framework and architecture, and show that it is able to address the needs of a wide variety of users, irrespective of their hardware and connectivity. We show that the context-aware capability of A-VIEW provides a custom solution and thus it is highly beneficial to a large variety of users. The synergistic approach of the A-VIEW server architecture with the national private educational network provides a strong foundation for making e-learning and m-learning practical and affordable to every learner in India. Initial user feedback from a survey of 300 professors around the country shows that A-VIEW is almost as good as a real class and easy to use.

2 Mobile Technologies in Developing Nations - A Potential Platform

In this section we discuss about how developing nations can benefit from mobile technologies. In developing countries the penetration rate of mobile phones surpasses that of desktop computers. The number of mobile internet users especially in developing countries has grown nearly five times in the last five years. For example, India has emerged as the second largest consumer of mobile Internet, after the US. India, with its 35+ million mobile internet users, ranks No.2 in the world. Around 14 billion web pages were viewed by Indian mobile internet users in February 2010. The number of new data connections added globally this year will be higher on the mobile than on the PC. According to industry estimates total internet penetration in India is

about 7%-8% and out of that 4-5% internet is accessed through mobiles. Experts claim that mobile internet usage in India will touch 250+ million by 2015. By 2013, mobile phones will overtake PCs as the most common Web access device worldwide. According to Gartner's PC installed base forecast, by 2013, the combined installed base of smart phones and browser-equipped enhanced phones will exceed 1.82 billion units and will be greater than the installed base for PCs thereafter [4].

The numbers in Table 1 show how internet usage through mobile devices is high in developing nations, even when compared to the developed nations [5].

Table 1. Percentage of mobile web only users

Country	Percentage mobile-only	Country	Percentage mobile-only
Egypt	70%	Indonesia	44%
India	59%	Thailand	32%
South Africa	57%	China	30%
Ghana	55%	US	25%
Kenya	54%	UK	22%
Nigeria	50%	Russia	19%
Source: On Device Research (December 2010)		Survey group:15,204	

The aim of mobile e-learning in developing countries is different from those of developed countries. In developed countries, motives to widen participation and lifelong learning for non-traditional learners are closely linked to the development of a strong knowledge economy. In contrast, developing countries' motives for m-learning are to provide basic and literacy education to large numbers of poor people [6]. The so-called 'digital divide' between rich and poor countries remains unchanged. Despite significant improvements in the developing world, the gap between the Information and Communication technologies (ICT) haves and have-nots remains.

A number of factors are responsible for the low academic achievement in developing countries like India. Inequalities in access to education continue to pose major barriers in the developing world, and the delivery of cost-effective and quality education remains a persistent problem. Higher drop out ratios is being witnessed. Retaining students is an uphill task due to high teacher absenteeism, lack of adequate number of staff and low teacher motivation. There is also a lack of adequate training for teachers. Educational surveys have revealed that teaching activities are often limited to reading from textbooks, keeping children busy with written exercises, making them read aloud or memorize passages leading to student's poor performance. Most government schools lack basic amenities like electricity, drinking water and toilets, proper furniture, playgrounds or adequate lighting and ventilation in classrooms. The availability of resources is mainly concentrated in the urban regions. A mechanism that enables the rural population to tap these resources will be highly worthwhile.

Apart from the aforesaid, it's crucial to have a study into the following information. There are 2351858 primary schools, 534 universities [7], 6014 non-technical colleges [7] and 669 technical institutions in the country. In spite of this statistics, Indian education sector face the grave challenge of imparting right education to children. There is lack of adequate Infrastructure to meet the need of 26 million babies born in India each year. The enrolment ratio is 7 % in higher education. Moreover, India needs 2000-3000 universities in next 10 years. NKC puts the requirement to 1500 universities by 2015 to increase the enrolment ratio from 7 to 15%. In total, the need for educational institutions has quadrupled.

In the attempt to find viable solutions to these challenges, much hope has been placed in new information and communication technologies (ICTs), mobile phones being one example. Of the many different forms of ICTs, taking account that the vast majority of mobile phones support Internet browsing in local mode, mobile Web services have grounds to flourish; mobile phones are thought, for several reasons, to be a particularly suitable tool for advancing education in developing regions. Mobile devices now allow teaching institutions to experiment with bringing distance teaching and learning to even more remote audiences. Mobile phone, the most prevalent ICT in the developing world, are an especially good 'leap frogger' since they use the radio spectrum and has to its credit greater user population and market potential. In addition to voice communication, mobile phones allow the transfer of data, which can be particularly useful for delivering educational content over long distances, even on a real time basis.

Table 2. India's current situation on the availabilities of mobile devices based on the strata of society

Different strata in society	Mobile device	Cost in INR (Rs.)	Language	Bandwidth
Upper class	High definition mobiles such as Smart phones and high end 3G Mobiles.	15,000-35, 000	Speaks English, and other Indian languages also.	High Connectivity. 512Kbps-7 Mbps
Middleclass	Middle range 3G Phones and Edge supported phones.	4,000-15, 000	Speaks, local language but often English.	Medium connectivity. 56Kbps-2 Mbps
Rural class	Low-range mobile phones	600-4,000	Speaks only local language.	Low connectivity. 28 Kbps

Another assuring trend in developing countries like India is that mobile devices are becoming more affordable, thus becoming common even in the rural areas. Table 2 shows the current situation in India on the kinds of resources that are available on a mobile device to the masses in the different strata of the society. Based on Table 2, a graph has been plotted, Fig. 1. It shows estimation about an exponential increase in

the number of smart phone users. The NME-ICT project described earlier has an objective of providing a mobile wireless tablet device to a large number of learners at a subsidized rate. If the price of this device is brought down, millions of learners will be able to afford such a smart mobile device. Along with connectivity and good bandwidth, this will bring e-learning knowledge resources to a large number of learners. Thus mobile e-learning approach will definitely prove effective.

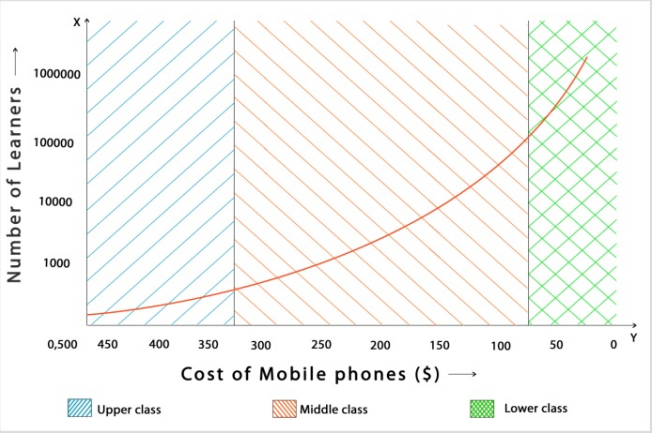

Fig. 1. Graph showing cost of mobile phones v/s number of learners in different strata of society

2.1 Challenges

Unlike developed countries, developing countries see an evident divide between the rural and urban areas in the different strata of the society; there are few critical challenges that need to be addressed.

Display. With different kinds of mobile devices available today, a different challenge of user interface is also to be addressed. Tablets and smart phones have different screen resolutions and the user interface needs to adapt to the available space and provide the education content most effectively.

Bandwidth. Urban areas have the luxury of high bandwidth connectivity. Urban India is seeing the surge of broadband connectivity with the availability of 3G networks. But the rural areas are yet to catch up. Therefore, a mobile learning system should not only be able to leverage upon the availability of high bandwidth but also should be able to perform efficiently in a low bandwidth situation.

Language. India possesses diversified languages similar to Europe. Therefore, to implement mobile learning in a country like India we have to first take up the gauntlet

of localization of mobile learning content. Information can closely be knitted to the native language reading level or learning style of the user and could tailor programmed information into the handheld device.

3 A-VIEW: Synchronous Collaborative E-Learning Framework

In this section, we present the National Mission on Education via ICT (NME-ICT) project as a case study for distributing m-learning. This project is a billion-dollar initiative for providing e-learning to the masses under the Ministry of Human Resources Development (MHRD), Government of India and is described on the website, www.sakshat.ac.in. The NME-ICT project has several facets for higher education. These include developing high mobile device, national connectivity, and online content consisting of recorded lectures and other associated material like simulations, quizzes, etc.

As part of this NME-ICT program, we contribute a highly scalable framework called A-VIEW that provides live interaction between expert trainers and large number of learners. A-VIEW is designed to be context-aware, addressing the needs of a variety of users according to their available infrastructure, connectivity bandwidth, language and mode of learning; thus providing a practical solution for the various strata of society.

With its live teaching platform, A-VIEW delivers knowledge in a collaborative environment. In this framework, we target a set of nodes or places that are physically distant to be connected by an eLearning network. It consists of a set of tools that are provided for Live Lectures. The assumption is that the class can be transmitted simultaneously to a set of nodes. Several tools are provided for the instructor to use in a live lecture. The instructor has the ability to interact with the students, and there are tools for testing the awareness and basic understanding of the students during the class. During the live lecture, each receiving node becomes a live virtual university. The instructor can interact with each location, and they can share resources. The instructor node and all the student nodes together form the virtual world during the live lecture.

A-VIEW is based on a mapping between a real and virtual classroom. It includes all the entities used in a classroom like teacher video for a real teacher, whiteboard for blackboard and documents for textbooks (with real-time automatic synchronizing feature). Apart from this, using A-VIEW, lectures can be recorded and viewed later.

3.1 A-VIEW Client-Side Architecture

Fig. 2 shows the client-side architecture for A-VIEW. This is the overall process for synchronous live interaction between the instructor and the learners. The instructor video is processed and encoded at multiple bitrates. This can be received by the learners at different bandwidths depending on their available infrastructure. For example, the high-quality stream can be received by a large class room or seminar

hall in which multiple large displays are available to be handled independently. The four major display components are the instructor video, the whiteboard, the presentation slides and an interaction window for chat and hand-raise facility. These four components can also be combined together as a single display. Figure xxx shows how the components can be viewed in multiple displays. The single display can be viewed on a desktop, laptop, tablet or a mobile phone. The A-VIEW system provides adaptive bitrates according to the available bandwidth. Thus, the image quality is dynamically adjusted so as to achieve optimum performance.

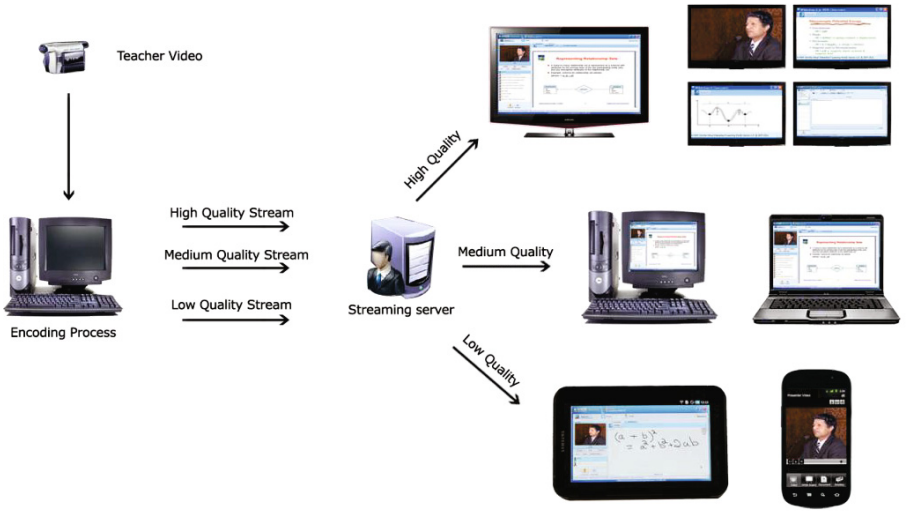

Fig. 2. A-VIEW Client-Side Architecture

3.2 A-VIEW Server-Side Architecture

The ACE (Architecture for Collaborative Environments) framework that is discussed in our previous work [8], is implemented based on a distributed client-server architecture, primarily consisting of two server clusters (active and passive servers as shown in Fig. 3), that communicate among each other. The active cluster consists of live media servers and content servers, while the passive cluster consists of database servers and content servers. Users who are logging into A-VIEW get connected to passive servers and download all the needed files (e.g. 2D/3D graphics and documents needed for the session); after successful downloading, they are connected to active server. In short, the active cluster serves the live users and the passive cluster initializes the newly logged in users. This provides a practical way for load-balancing the servers. As the content in the active servers get updated by the live users, it is incrementally transmitted to the passive servers. Thus, the passive servers maintain an updated copy of the multimedia content.

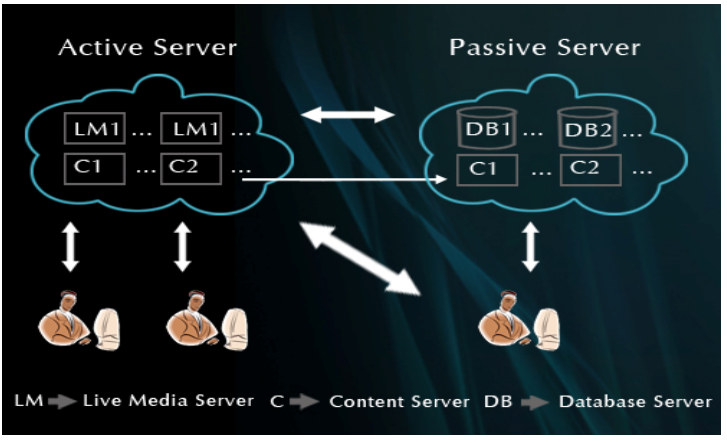

Fig. 3. A-VIEW Server-Side Architecture

As a part of the NME-ICT project, the clusters of servers are strategically placed all over the country to provide accessibility, minimize latency, and improve throughput. Various heuristics are used to minimize the use of bandwidth in the A-VIEW application [2].

3.3 A-VIEW and Its Features

Some of the distinguishing features of A-VIEW are:

- **Configurable Multiple Displays (One to Many).** A-VIEW can be run on any number of displays/screens based on the need of the user.
- **Adaptive Bandwidth Usage (56k to 2MB).** Depending on the available bandwidth, video quality will be adjusted automatically
- **No Proprietary Hardware:** A-VIEW uses existing hardware that is available like desktop, webcam, microphone
- **Crystal Clear Live Document Sharing.** Documents or presentations can be shared with the available best quality at real time
- **Multi Device Compatible Whiteboard.** To share users' annotations with other users using mouse or writing pads
- **2d/3d based animation/collaborative elements.** To share animations (2D/3D) preserving their quality at real time

3.4 A-VIEW on Mobile Devices

A-VIEW has been designed to work in a variety of devices like desktop, laptops, tablets and mobile phones. Irrespective of the device on which A-VIEW is used on, it imparts the same experience to the users. One important aspect of A-VIEW is that it takes into consideration the context of the user and the device used for running the same. Fig. 4 shows A-VIEW running on an Android Tablet.

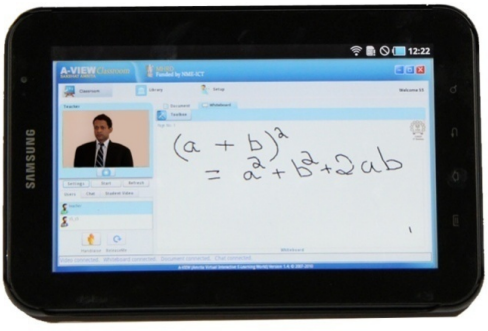

Fig. 4. A-VIEW in Tablet (Android)

2D, 3D based contents & animations can be given as a complete package of collaborative elements which can be customized for the different versions of mobile in an effective approach which could serve mobile learning in a better way. Fig. 5 shows a 3D model of human brain in mobile A-VIEW; it helps students to have a 3-dimensional look and feel of the brain.

Fig. 5. 3D animation content (human brain) on Mobile A-VIEW (Android)

3.5 Mobile Quiz (On Simple Mobile Device)

Students can answer a quiz using desktops or mobile phones with internet connection or through SMS(Short Message Service). Mobile Quiz enables students to answer a quiz even when students are not present in their classrooms/centers. The student has to use the same number given during the initial registration process of A-VIEW. This feature helps the students in rural areas to attend the quizzes from their home or school on a simple mobile device, where internet connectivity is not provided.

The list of quizzes that the student has enabled as part of their course will appear on the client display once the teacher has done the settings for the same. The quiz can be answered through online or offline, through SMS. The application will evaluate responses to the quiz questions online & will display results at the end of the session, along with correct answers. For teacher, it also shows the number of students that have marked the correct answer, which can be used for knowing the level of understanding o the students about that particular course or topic.

Fig. 6. Quiz on simple mobile using SMS

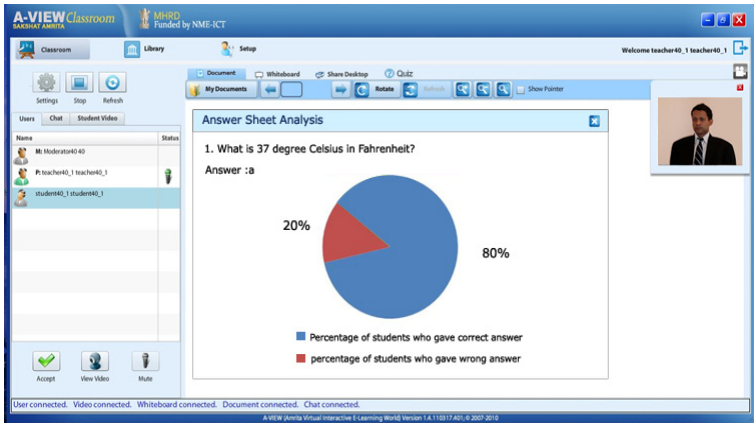

Fig. 7. Answer sheet analysis: A feature of quiz module which provides the percentage of students who gave the correct answer

3.6 Mobile User Interface

Designing user interfaces for various devices of different sizes poses a challenge. When the overall space available for the user interface is minimal, like a mobile device, the traditional design for user interface may not be effective. We completely abide with the *Visual Info seeking mantra: Overview First, Filter and then Details-on-Demand,* as proposed by [9].

Fig. 8. Cluttered conventional UI of A-VIEW in mobile phones

Using this paradigm the A-VIEW user interface has been designed exclusively for mobile phones. The overview is provided first; for example every feature like video, chat, whiteboard, document sharing etc can be viewed as a separate window with a single movement on the icons. The idea behind this simple User Interface is to save space and give better accessibility. Also the details are given as needed.

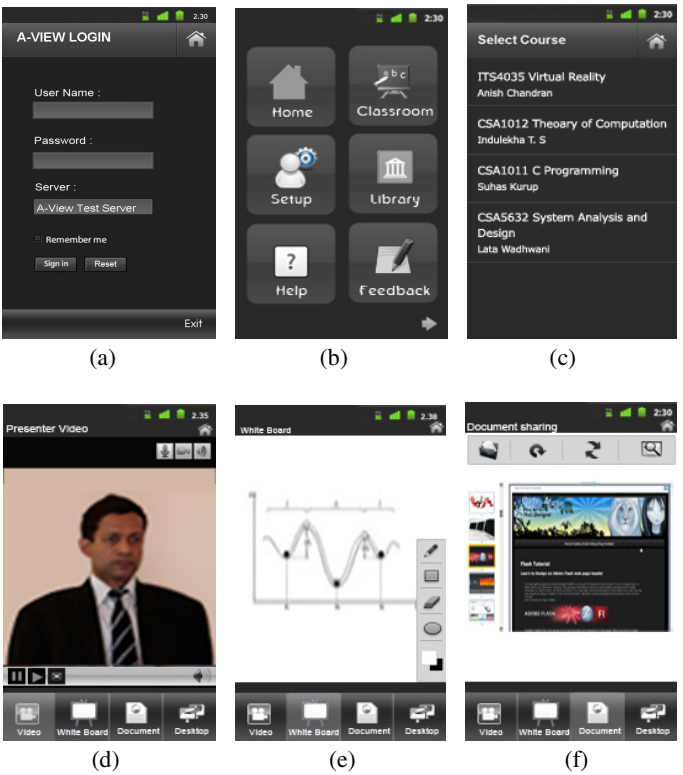

Fig. 9. Screen shots of the redesigned user interface of A-VIEW for MOBILE: (a) Login screen; (b) Home Screen; (c) List of Courses Screen; (d) Video Screen; (e) Whiteboard Screen; (f) Document Sharing Screen

3.7 Multiple Language Support

India possesses diversified languages similar to Europe. Therefore, to implement mobile learning in a country like India we have to understand localization of mobile learning content. Information can closely be knitted to the native language reading level or learning style of the user. The user interface controls can be made available in different languages. Also, the content is made available in different languages.

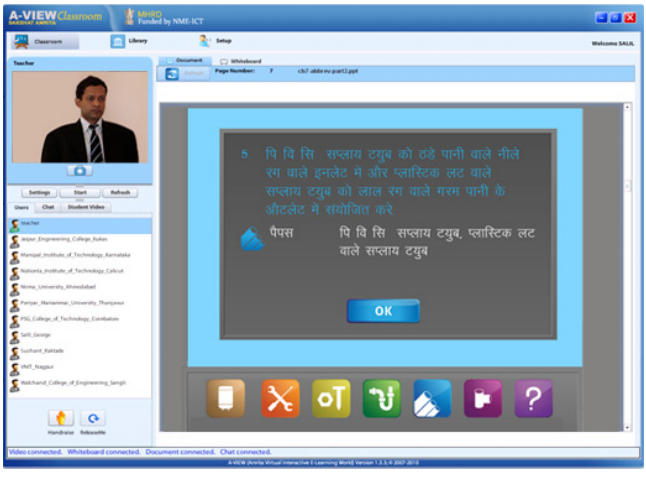

Fig. 10. A teacher taking classes in Hindi using A-VIEW

3.8 Context-Aware Mobile E-Learning

As described in the previous sections, A-VIEW is designed to be context aware so that every user receives optimum performance based on their available infrastructure like the type of hardware, number of displays, connectivity and the available bandwidth. This allows all types of users in various areas to access an A-VIEW live and interact seamlessly with the instructor.

The context-aware mechanism enables switching between the different media modalities to provide a more wholesome experience for the end-user. The context-aware framework is best suited for the rural areas with the *adaptive bit-rate mechanism*, according to the bandwidth available. The application is also available in different regional languages such as Hindi, Malayalam, etc....

3.9 Train the Trainers: Reaching the Masses

The A-VIEW network can be used by an expert trainer for imparting professional training in any field to the novice or inexperienced trainers. For example, the Teacher Empowerment program was initiated by IIT- Bombay for improving the quality of teachers. The vision for this program has been provided by Dr. Deepak Phatak. Over 1000 college teachers from around 500 professional institutions gathered at 32 nodal centers across the country and attended a 2-week online workshop from 13th to 22nd December 2010. The session was led by Dr. Sudarshan, IIT Bombay Professor and a renowned author of the standard international textbook on Database Systems. These 32 remote centers used the A-VIEW (Amrita Virtual Interactive E-Learning World) system developed by Amrita University.

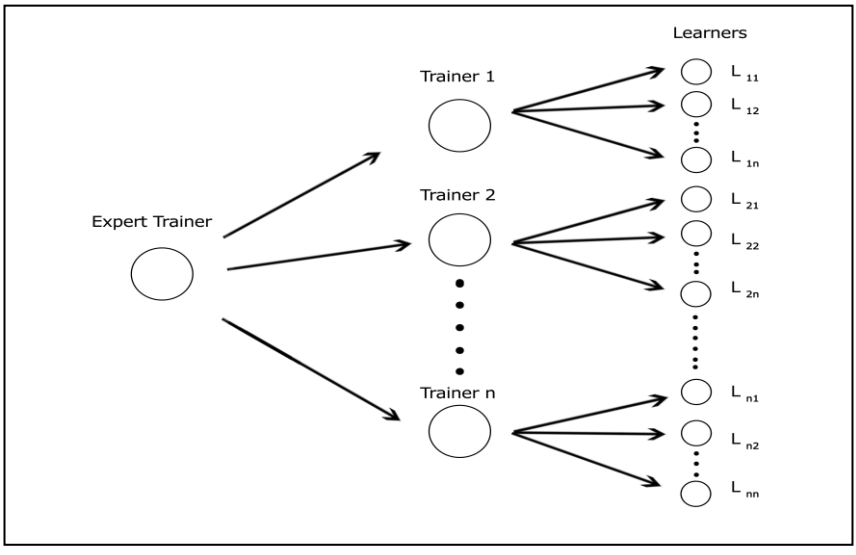

Fig. 11. "Train the Trainers" can result in large number of trainees

4 Conclusion and Future Works

Previous works have indicated that lack of proper IT infrastructure is a major hurdle in providing e-learning for the masses. In this paper, we presented a case study in a large developing country like India where a large national initiative has been undertaken for providing e-learning to every interested learner. This program is addressing issues like nation-wide connectivity, affordable mobile devices and high-quality online content. As part of this program, we contribute a highly scalable framework called A-VIEW (Amrita Virtual Interactive E-Learning World) that provides live interaction between expert trainers and large number of learners. A-VIEW is designed to be context-aware, thus addressing the needs of a variety of users according to their available infrastructure: hardware, connectivity, bandwidth, language and mode of learning; thus providing a practical solution for the various strata of society.

Although cheap mobiles are getting very popular in developing nations, affordable smart mobile devices and connectivity are also needed so that m-learning can be effective. Expert teachers are few in number, yet, synchronous e-learning is starting to show immense potential with 'Training the Trainers' type of programs becoming practical with distance and location no longer being a barrier. In this regard, the role of context-aware ubiquitous mobile devices is pivotal to tap into the pools of global knowledge and quench the thirst of education in the large numbers of learners in rural and deprived areas in developing countries.

Thousands of learners are using the existing A-VIEW system in higher education, and the initial feedback is extremely promising. We are conducting several empirical studies with a large number of users. The use of mobile A-VIEW is being extended to vocational training, schools, and governance of rural communities.

Acknowledgments. The research and development for A-VIEW has been funded by the National Mission on Education (NME-ICT [MHRD]) and Amrita Vishwa Vidyapeetham. In particular we would like to thank Mr. N.K. Sinha (NME-ICT) for his vision, support and enthusiasm. We are grateful to Dr. Kannan Moudgalya and Dr. Deepak Phatak (IIT Bombay) for their constant feedback and close partnership.

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