WIMAX WITH WI-FI: OPENING NEW FRONTIERS IN EDUCATION

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Key words: WiMAX, Wi-Fi, Mesh, broadband, HE

Abstract
Connectivity is vital to any country to usher in economic growth, better education and healthcare and improved entertainment services as it has done elsewhere in the world. And the solution must be wireless, to avoid the overwhelming cost and resources that would be required to deploy countrywide fixed-line broadband Internet infrastructure. Some countries, where there is not an established wired communication network, are investigating the potential of broadband wireless technologies to support learning and teaching in remote areas. In order to widen the participation in Higher Education (HE) there is a need for more flexible delivery and study of courses to satisfy the needs of this wider audience. The lack of physical connectivity or telecommunications infrastructure and the cost and lack of broadband technologies are a big hindrance to more widespread participation of people in HE. Broadband wireless technologies like WiMAX with Wi-Fi are beginning to offer reliable alternatives to fixed-line access, offering the potential for widespread, affordable connectivity to every education institutions viz Schools and Colleges, in the rural areas. This paper addresses the potential uses of wireless and mobile technologies and identifies some recent technical developments. It considers how their use might be developed within existing learning and teaching paradigms and it identifies some new models for providing connectivity to rural Educational Institutions.

1. Introduction
The education sector is being accorded top priority by governments in developing countries, as a means of building a reservoir of competent leaders and skilled personnel who will guide and sustain the region’s current pace of development. As a result, both the government and private sectors are directing huge technological inputs towards improving educational content and delivery systems and in upgrading infrastructure. Wireless is one of the most important technologies of the century, influencing the nature of business, commerce, education, and society for all time to come. WiMAX with Wi-Fi offer new ways to approach emerging learning environments that holds immense potential like lifelong learning, e-learning, distance learning, home learning, virtual classrooms and mobility between different locations of study in campus based learning. This paper will address in detail: (i) Potential uses of broadband wireless technologies like WiMAX and Wi-Fi and identifies some recent educational developments using these technologies in the world. (ii) How their use might enable education empowerment within existing learning and teaching environments (iii) how it supports connectivity to Educational Institutions in rural areas and provides mobility in campus where connectivity is already available and finally (iv) to generate awareness of the many advantages of wireless connectivity and the mobility it brings to the learning environments.

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2. Technical Overview of Major Wireless technologies
Broadband wireless technology offers a number of concrete benefits over that of wireline. They are as follows [2]:
a. reduced cost as compared to deployment of new wired infrastructure;
b. enhanced operational flexibility, in particular: more freedom in placement of equipment; reduced installation interval; lower barrier to switching or upgrading infrastructure; and ability to move and redeploy equipment as needed with minimal incremental cost.

Moreover, Broadband Wireless technology has built a bridge over some of the education gap. Let us see the technical overview of some of them.

2.1 Wireless Fidelity (Wi-Fi)
802.11 WLAN often called Wi-Fi (Wireless Fidelity) uses the license-free 2.4 GHz frequency band and has become popular for its capability to provide high-speed Internet access at low cost. The ease of use and low cost are in turn driven by the adoption of the Wi-Fi standard by equipment manufacturers, thus ensuring interoperability among Wi-Fi devices. Wi-Fi is arguably the most ubiquitous form of broadband Internet access in the world [2].

2.2 Worldwide Interoperability of Microwave Access (WiMAX)
WiMAX is a standards-based wireless technology that provides high-throughput broadband connections over long distances and it operates in a licensed spectrum. This is based on a mesh structure and it is capable of delivering broadband Internet and, extending services beyond the physical building constraints encountered with Wi-Fi. WiMAX offers a fast, affordable, convenient solution to Internet access needs [1]. As WiMAX becomes more widely available it could offer opportunities for educational use with groups interacting wirelessly within a much broader virtual classroom [3].

A key characteristic of this standard is a differentiated approach to the Media Access Control (MAC) layer; in contrast to Wi-Fi, the WiMAX MAC can support a range of physical (PHY) physical layer implementations, thus substantially freeing equipment vendors in developing solutions for different applications and vertical markets.

2.3 Wireless Mesh Networking (WMN)
A WMN is a communications network made up of radio nodes organized in a mesh topology. Meshed networks self-configure and self-heal by dynamically sharing information, almost in real-time, between all the access points in a wireless network. If a mesh link becomes obstructed in the event of a device failure, client traffic is dynamically re-routed, ensuring uninterrupted communication through the other available access points. In the mesh network, the core configuration is an array of access points or base stations, all managed by a mesh routing protocol which determines the optimal path across the network at any given time [2]. The advantages of a mesh topology are route diversity and redundancy, thus maximizing the performance of the network. Wi-Fi/WiMAX mesh uses such concepts as cellular-equivalent "picocells" for node proximity and non-line-of-site mesh routing around obstacles.

2.4 UltraWideBand (UWB)
Ultra wideband is a wireless technology for transmitting large amounts of digital data over a wide spectrum of frequency bands with very low power for a short distance. UWB signals are usually very difficult to detect. The amount of spectrum occupied by a UWB signal, i.e. the bandwidth of the UWB signal is at least 25% of the center frequency. Thus, a UWB signal centered at 2 GHz would have a minimum bandwidth of 500 MHz and the minimum bandwidth of a UWB signal centered at 4 GHz would be 1 GHz. High data rate UWB can enable wireless monitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for an intervening personal computer, and the transfer of files among cell phone handsets and other handheld devices like personal digital audio and video players. Intel researchers are working on a variety of UWB technologies, including a platform for next-generation development efforts, and believe it will be a critical step in enabling advanced communications for a wide range of uses in the
future [7].

2.5 Free Space Optics (FSO)

FSO is a telecommunication technology that uses light propagating in free space to transmit data between two points. The technology is useful where the physical connection of the transmit and receive locations is difficult, for example in cities where the laying of fibre optic cables is expensive. FSO uses lasers to transmit data, but instead of enclosing the data stream in a glass fiber, it is transmitted through the air. Unlike radio and microwave systems, FSO is an optical technology that operates in invisible parts of the optical spectrum at near-infrared wavelengths and no spectrum licensing or frequency coordination with other users is required, interference from or to other systems or equipment is not a concern, and the point-to-point laser signal is extremely difficult to intercept, and therefore secure. Transmission is highly directional making it far more secure than RF technologies but also requiring that the two points to be connected be within line-of-sight of each other.

2.6 Virtual Fiber

Virtual Fiber Connectivity is a line-of-sight technology that uses lasers to provide optical bandwidth connections [9]. This is a point-to-point wireless system using very high radio frequency (71-76 GHz and 81-86 GHz) to transmit up to 2.5 Gbps of data, voice, and video communications. For example a ninety minute movie will download in one second.

3. Impact of Wireless Technologies in Higher Education

The emergence of wireless technologies and various solutions to extend the capability of the wired world to a mobile secured environment in and out of the classroom is rapidly becoming the norm in providing education programs to students of all ages. At the same time, teaching methodologies have also evolved to encompass concepts such as e-learning, distance learning, home learning, and lifelong learning. To support these different types of learning the modern curriculum has been reformed. Such emerging learning environments and the need for flexible hours in learning environment are driving forces to advocate for wireless networking technologies and hence wireless campuses. This will result in some learners moving between school, workplace and home. Mobile and wireless technologies offer new ways to approach both learning and assessment. They could provide the following: [3]

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a. both synchronous and asynchronous communication with peers and teachers
b. collaborative features enabling the sharing of material
c. the facility to access resources, including online communities from local and worldwide repositories via the internet
d. delivery of multimedia content.

The integration of technology in assessment activities has led many universities to use an online Learning Management System (LMS) to present electronic content and control aspects of course management relating to assessments and organization etc. that will facilitate online learning. Wireless is clearly exploding across university campuses as it has in the corporate and consumer sectors and educational applications, IT services and management solutions are growing fast in higher education. Below are some scenarios that how higher education must address the contribution of wireless beyond convenience to its potential impact on teaching, learning and research.

3.1 Conventional networked Campus

Some of the most mobile and connected people in our society can be found in the education community. So broadband wireless technology has become the present and the future of education. It has changed the way instructors teach by relieving them from having to rely on the book and straight lecture as the only tools. It has made learning much quicker than
looking for a book or something. Wi-Fi solutions within campus allow the possibility to extend the physical space of the classroom in to other areas while maintaining access to online resources. Wi-Fi goes from buildings to green spaces to the football stadium and other athletic facilities. Thus WLAN solutions provide the necessary functionality, simplicity, and trust to ensure an enriched learning environment.

3.2 Extended networked Campus
Not only within campus connectivity is needed, but extended campus offers more flexibility. This supports both synchronous and asynchronous communication and collaboration. We can build-out an Education Network linking schools and universities with Wi-Fi network. This Inter-campus Wi-Fi network will facilitate students and educators of K-12 and higher education campuses to seamlessly log into any other member campus' educational wireless network. This will allow the educational community to extend their learning experience by leveraging wireless networks of other schools and universities across the country. Every member campus will become accessible to students, staff, and faculty via this network. This single interconnect will allow the institution's IT department to dedicate scarce resources just once, effectively growing the access available to their students and faculty without having to dedicate additional IT resources and without changing the existing deployed architecture[4].

3.3 Connected Rural Schools
Connectivity is important for the rural schools to participate in the extended campus environment. Some countries where there is not an established wired communication network must find ways to use cost effective hybrid wireless networks for education to reach the unachieved sections of the society. This will increase the opportunities for students to do online learning, to participate in audio/video conferencing, to research by accessing resources from other schools and universities etc.. WiMAX plays a major role in providing cost effective access to rural areas.

4. Need for Connectivity and Mobility in Higher Education
In the world today, we have the potential to know and be able to access any kind of information that has ever existed. While students may not want to have all that information every minute, they do want to be able to access it whenever they need. So for colleges and universities to attract the Mobile (M)-generation of students, it is mandatory to provide wireless connectivity and mobility with broadband technologies like WiMAX with Wi-Fi. Connectivity and mobility in Education is a necessity for the following reasons:

(i) Traditional campus based education often reaps the benefits of the proximity of groups of learners. Even then connectivity and mobility are required in the campus to fulfill student expectations to generate self-help groups, opportunities for informal discussion, and support prescribed group work. Wi-Fi access will provide campus educational wireless network.
(ii) Today's educators and students demand an always-connected, everywhere wireless campus environment [4]. WiMAX provides the backhaul for Wi-Fi access points and provides anytime, anywhere connection.
(iii) Internet services provide a means for students to stay connected with their friends in another campus through e-mail, audio or video chat, and to browse the Internet for job and academic opportunities.
(iv) Over 55 percent of all educational documents are electronic at this point [1] and broadband connectivity is very important to access these educational materials.
(v) Schools and libraries in rural or remote areas without wired infrastructure or broadband services can be cost effectively connected to broadband using WiMAX, so that the students in rural areas could videoconference with educators across the country, and use Internet
telephony services, like Voice over Internet Protocol (VoIP) [1].

(vi) Lecture classes from urban schools and top universities can be broadcast to rural students, and the students could use the broadband facilities of WiMAX for communicating with teachers and with their remote classmates. This will allow the educational community to extend their learning experience by leveraging wireless networks of other schools and universities across the country.

(vii) Universities providing distance education is increasing its use of online collaborative activity and content and an online LMS to present electronic content and control aspects of course management relating to assessments and organization etc. With higher bandwidth and faster speeds, broadband Internet can make education more accessible by delivering interactive distance education at a low cost.

(viii) Broadband wireless technologies help to bring our education customers the power of being linked together. This will allow them to provide new services that give their students more educational value while keeping operational costs low.

5. Broadband Hybrid Wireless Network (BHWN)

The potential of wireless communications is to break down traditional wired boundaries, bridge digital divides and stimulate economic growth [2]. Although a range of new technologies have emerged, including WiMAX, Wi-Fi and WMN, each one addresses a specific network segment or application, and that no single technology fits all applications, and also the necessary complementary technologies have differed in terms of stages of development. So it will be critical to use these technologies in tandem to create truly scalable broadband wireless networks. One limitation is that many vendors focus on selected technologies and applications, thus increasing the complexity of evaluating, procuring, installing, managing and maintaining different parts of the network. However, standards based broadband wireless technologies particularly Wi-Fi, WiMAX, WMN are interoperable and have matured to the point of being deployable in a single, connected network, and furthermore such solutions can now be sourced from a single vendor. This is the concept of a scalable Broadband Hybrid Wireless Network (BHWN).

6. Proposed BHWN for Connectivity to Rural Schools

Schools and libraries in rural or remote areas without wired infrastructure or broadband services can be cost effectively connected to broadband by combining several broadband wireless platforms.

In this proposed hybrid wireless network the traffic from the large fiber optic backbone from the urban area is carried over the last mile via a high speed point-to-multipoint distribution system based on the features of WiMAX that is, enhanced data rate and range. In the point-to-multipoint network, the core configuration is a single access point or base station communicating with one or more clients, and a larger network can be comprised of several such separate cells joined by a common backbone. WiMAX serves as a backhaul for Meshed Wi-Fi Local Area Network. Figure 1 below shows WiMAX connecting to Wi-Fi access points located in rural school buildings. The access points in turn will serve a mesh array LAN which is not shown in the figure. With a robust backhaul system in place, coverage of the network is practically just a function of the number of Wi-Fi access points installed at the edge. The access points reside in a mesh array, with one radio available for access and a second radio connecting into the array. In the figure the customer premise equipment (CPE) serves as the access points.

Thus by combining Wi-Fi mesh and WiMAX could provide the rural population with the most extensive and complete broadband wireless coverage. Though both technologies are distinct, each with unique characteristics, they often are deployed in tandem using WiMAX.
for backhaul and Wi-Fi mesh to provide access to the growing base of Wi-Fi enabled LANs. Until now, the only solution was to install two separate units, one WiMAX and one Wi-Fi mesh but nowadays companies have come with solutions of integrating these technologies in a single compact outdoor enclosure.

7. Suggestions
(i) National level conferences should be organized to generate awareness of the many advantages of wireless connectivity and the mobility it brings to the learning environment.
(ii) This concept needs to be promoted from the early stages of school, given its importance in achieving better broadband Internet connectivity, and its role in linking homes to virtual classrooms, libraries, campus networks, and Internet labs and in delivering elearning courses.
(iii) Wireless should not be considered as a replacement for the wired technology, rather it should be considered as a supplement to enhance the effectiveness of the learning environment.
(iv) Research should be done on new methods and new approaches to learning with ICT because ICT is an integrated part of learning process.
(v) Using BHWN with the convergence of multiple wireless services, using different frequencies necessitates the creation of a campus wide spectrum Management group to plan to use any form of wireless and then to work on coordination this with strategic directions of IT, teaching, learning and research.

Figure 1: WiMAX with Wi-Fi mesh on the Customer premise side for rural connectivity

8. Challenges in adapting Wireless Technologies
The challenges to adapt to wireless technologies by educators and students, however, is one of understanding and exploring these resources to support teaching and learning.
(i) The most challenging problem facing higher education systems incorporating wireless devices into their classrooms is technical support. Schools must have an in-house support or outsourcing the support for the effective use of the wireless devices [11].
(ii) Speed plays a factor when there are several students competing for the same website and the broadband width is not enough.
(iii) The use of wireless devices in classroom can be a challenge for faculty trying to get the attention of students to a particular lecture when the students are engaged in the World Wide Web [11].
(iv) IT security is still a reality in only a small minority of schools. This is one of the biggest challenges of wireless technologies in classroom. With more data and information transmitting frequently through the airwave, makes transmission of data easily accessible by hackers and intruders.
(v) Allowing outside laptops onto the school network increases the risk of the spread of computer viruses and hacker attacks. Therefore, there is a need for security software updates to protect end-users from viruses and hackers.

9. Conclusion
In conclusion, the opportunities of wireless technologies greatly outweigh the challenges. Wireless is important to higher education for some of the same reasons it is important to other areas of the society. It is believed that using wireless technologies in classrooms not only improves teaching and learning but provides the accessibility of resources to students and teachers. From this paper it is clear that convergence is inevitable, whether on a wireless campus backbone or extended campus connectivity or rural connectivity. Though it is too
early to determine the impact of this converged wireless network concept on teaching and learning, but this brief paper argues that in many aspects we are already envisioning the possibility of students’ access to information by any device, from anywhere and at any time has become very important in learning environment. The BHWN suggested combining WiMAX with Wi-Fi and Mesh has the potential to provide the rural Educational Institution with widespread Internet access that can usher in, better education, economic growth and health care and improved entertainment services as it has done elsewhere in the world.

References