The International Digital Divide: Education and Wireless Technology in Developing Countries

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Abstract. The impact of wireless technology on society is indelible, and its implementation is vital for the advancement of developing countries. In addition to having access to localized wireless networks, the ability to take advantage of the Internet and its worldwide possibilities can provide a new medium for education, both on a local and a global scale. The social impact wireless technology can have are almost beyond imagination once the world is opened up to isolated populations. The goal of this paper is to define important wireless technologies and demonstrate and analyze the importance of wireless technology for education in a developing country such as Haiti.

Keywords: Digital Divide, developing countries' economy, Haiti Internet Initiative.

1. INTRODUCTION

Identifying the needs of the country and people is the first process to complete the concept of appropriate technology. Appropriate technology is designed to take under consideration the whole environmental, ethical, cultural, social, political, and economic aspects facing a specific country. Using appropriate technology methods for countries with very low resources is the best way to educational opportunities. Appropriate technology is very easily maintained and requires few resources. The appropriate technology is harmless to the environment and works within its confinement, i.e., unusual weather, topology or geography [1]. Appropriate technology was created under the idea that certain types of technology are often inappropriate for certain countries. Haiti, for example falls under the category of a developing country; that is, a mainstream and costly technology would be inappropriate for their current economic climate and dissembled state at this time.

The island nation of Haiti will be used in this paper as an example of a developing country with a unique situation but needs for technology and education which are universal in nature.

1.1 The Tragedy of the Earthquake in Haiti

The country of Haiti is a republic in the West Indies on the western part of the island of Hispaniola. Although a country rich in language, culture and music, it is the poorest and most illiterate nation in the western hemisphere [2].

A devastating 7.3 magnitude earthquake struck Haiti on January 12, 2010. It left approximately 230,000 people dead and more than 1.2 million people homeless [3]. It came to light that their communication system was inadequate as areas affected by the earthquake could not communicate with each other. This highlighted the differences in availability throughout the population: the communication system in Haiti was not only weak, but not available to most. The rebuilding of the country telecom infrastructure and the increase access to fixed, mobile, and Internet access have been in the forefront of the reconstruction efforts.

1.2 The Communication System in Haiti

Haiti is among the developing countries that have strived to provide the benefits of the Internet to most. The need for reliable telecommunications system in Haiti is growing due to a large expatriate community living in the United States, Canada, France, and elsewhere [4]. However, the current telecommunications system is unable to support the high demand. There are a few working telephone lines; most of the telephone services are provided by three wireless companies: Voilà, Digicel, and Haitel [5]. The Internet services are limited and available to a low percentage of users due to their expensive monthly costs. Some Non-Governmental Organizations (NGOs) provide free wireless access to their network. The rest of the population relies on "cyber cafés" to use the Internet or make telephone calls using Voice Over IP (VoIP). It is very difficult for public school students to have access to a computer system, let alone the Internet.

1.3 The Educational System in Haiti

Education in Haiti is provided according to the French educational system. Most of the schools in the country are privately run; countries like Canada, France, and The United States run some of

the private schools as well. That is, over 90% of the schools are managed by the communities, religious organization or NGOs [6]. Enrollment at the universities represents a bare 2% of the youth population between the ages of 18 through 24 [7]. However, most of the schools were destroyed by the recent earth quake; Higher education was the hardest hit with 28 out of 32 universities destroyed and the remaining 4 were severely damaged [8]. In addition, the education system is anemic of qualified teachers and professors. There is a limited pool of qualified professionals living in the country since more than 84% of Haitians with a university degree live outside of the country [9]. Again, the recent earthquake has worsened this situation with the loss of many teachers and professors.

1.4 Do Haitian students have access to computers and the Internet?

In Haiti, only the elite schools which represent a very small percentage provide computers and internet access to their students. There is about one computer for every 1,111 people and outside of the capital it is one for every 5,000 people [10]. Students from non-elite schools mostly use "cyber-cafés" for access to a computer for their homework or access to the Internet to do their research. The cost of five minutes usage of a computer is about 25 cents while the average Haitian family earns $2.00 a day. Several organizations are trying to provide computer labs and Internet access to the Haitian youths. That is the case of Educah via the *Wentworth Internet Initiative* and Hope Haiti Learning Center that provides free computer access and practical skills training [11].

2. FEASIBILITY OF WIRELESS TECHNOLOGY IN HAITI

The telephony system, longed dominated by the state-run Teleco, was opened up to private companies in 2000. Today, two main companies, Digicel and Voilà, capture more than 95% of the overall market. The state is fighting back by allowing a joint public-private partnership (PPP) to make Teleco more competitive. Such a strategy aims at modernizing Teleco's infrastructure and provides more services to its customers. It will enable the new venture to provide telephony and Internet access to remote areas and to low income citizens [12]. John Stanton, who owns the second wireless company in the country, Voilà, would like to see Haiti become "copper free" [13]. That is, the first-all wireless country in the world. Those remarks were echoed by former President Bill Clinton. Stanton envisions that "Haiti can have a first class telecom infrastructure without landline service-based completely on wireless technology [14]."

2.1 The Technological Climate

The World Wide Web (WWW) and the world's internet usage have increased dramatically in recent years. World internet usage increased by an annual average of 14.1% between 2004 and 2009, reaching above 1.8 billion users worldwide [15]. High speed internet, or "broadband," is becoming the dominant technology for internet distribution in developing countries [16]. With internet usage being in such high demand, it is hoped that the educational systems in developing countries will advance. It is vital that the proper products and services be available and at hand. Internet access in third world countries will likely be driven by wireless technologies due to geographic distances and differing topologies. Wireless technology is less costly than wired connections and fits the model of economic need. As a result predictions have it that near universal mobile telephone access is likely to be achieved by 2015-2020 in third world countries [17].

In many different rural environments around the world satellites are being implemented to provide access to remote parts of countries. The speed with which an online or hybrid educational-delivery solution can be deployed means that more villages and schools can be brought into the system. Many of the rural environments in developing countries have created affordable broadband and wireless technologies which allow new and improved ways of teaching and learning [18]. Wireless technology has been proven to work fairly well in the rural environment of the developing countries. It is often used to connect rural schools and colleges to many different urban institutes. This will facilitate the spread of education in a persistent manner.

Today, information can be transmitted from remote areas to anywhere in the world. For example, wireless internet technology has brought together communities in Costa Rica, Rwanda, and India. By using scooters, bicycle messengers or buses, wireless internet is brought to people in remote places. In each village there is a terminal that stores a web browser and e-mail information on a local server. When a vehicle moves into town, it gathers all of the information wirelessly. When the vehicle gets to a town with a nearby connection to the Internet, it sends out the data to the internet. This means that all the information stored in each town's terminal is updated each time the vehicle comes around [19].

3. CURRENT WIRELESS TECHNOLOGY

Advances in Wireless technology make it appealing to provide Internet access to places where there is limited infrastructure. There are

many different types of technologies available today:

3.1 Fixed Wireless

Fixed wireless refers to the process of connecting fixed locations –most of the time antennas mounted on top of buildings—using radio or Laser Bridge [20]. It uses transmission towers that communicate with each other via directional antennas to send and receive data signals. They send their signals through the air using the microwave spectrum. However, line-of-sight is needed to communicate with each other. That is, antennas cannot be installed anywhere; hills and trees must be avoided [21].

Fixed wireless can be used for broadband access to the Internet in areas where there is a lack of wired- infrastructure such as fiber-optic cable, Digital Services Lines (DSL), or cable television. It does not require the presence of satellite or telephone service to be operational. It brings broadband bandwidth to remote areas where there is little to no infrastructure. Due to the quick deployment and affordable cost, this technology is in high demand especially in developing countries [22].

3.2 Wi-Fi

Known as Wireless Fidelity, Wi-Fi is mostly used by end system devices like personal computers (PCs) or smart phones to connect to the Internet while within range of a wireless access point (WAP); the signal is diffused around the access point. Wi-fi is used to create a wireless local area network (WLAN) by covering a large area and creating overlapping regions between the access points known as hotspots. They are often used by organizations and businesses to provide free-of-charge public access in order to attract customers. Wi-Fi is convenient to provide wireless access in spaces where cables cannot be run like historical buildings [23].

Wi-Fi-enabled devices can create their own network when connecting to each other, known as an ad-hoc wireless network. It creates a peer-to-peer (P2P) communication network where each client or node can forward data to the next.

3.3 WiMax

WiMax stands for Worldwide Interoperability for Microwave Access. It is the telecommunications protocol that allows access to fixed and mobile wireless; its standards are set by the IEEE 802.16. [24] Existing WiMax technologies can provide between 30 to 40 Megabits/sec. WiMax devices are used to implement wireless networks. WiMax differs from Wi-Fi in that:

1. It is similar to Wi-Fi but can go over longer distances. It provides wireless connectivity access across cities and countries.
2. The access of WiMax network is based upon a scheduling algorithm while Wi-Fi users compete for access.
3. WiMax uses a connection-oriented MAC (Machine Access Code, the unique address of the network interface card) protocol while Wi-Fi uses a connectionless CSMA/CA protocol.

Because of its low cost, long distance range, and ease of deployment WiMax is widely used to establish WLAN. It is a more cost-effective last mile broadband access than cable and DSL [25]. As of last October, the WiMax consortium claims that over 592 WiMax networks are deployed in over 148 countries [26].

3.4 Wireless Mesh Networks

A wireless mesh network is based on a mesh topology where each device represents a node in the network. Mesh devices use a small radio to connect to each other via their wireless access point. Each node receives data from adjacent nodes to forward to the next nodes sometimes far away which result in a larger network. Instead of having a centralized system that is responsible of forwarding data, each node routes the information along. Unlike a centralized system, if one node fails, adjacent nodes will forward the data [27]. Because of its non-centralized and redundant nature, wireless mesh topology is quite reliable. Fixed Wireless, WiMax, and Wi-Fi technologies can be used in tandem to create a mesh topology. Due to its low cost, ease of implementation, and adaptation to geography, wireless mesh is appropriate for a developing country like Haiti to provide Internet access to urban, remote places at an affordable price.

4. OUR CONTRIBUTION WITH THE HAITI INTERNET INITIATIVE

The Haiti Internet Initiative recycles used servers and network devices into networks created by Wentworth students in the Computer Networking Systems major. These networks will be deployed in Haiti to support educational goals and job creation. It will also address the issue of the "Digital Divide," or the limited access to technology based on poverty. The network will be extended to more schools until a mesh WAN is able to be created. Through the annual networking seminar course, students will continue to be

engaged to contribute to its evolution as well as encouraging donations of obsolete networking equipment. Having a network system in Haiti will enable collaborative work with Wentworth and provide a medium for distance learning.

A typical wireless mesh network is made up of a set of 802.11 compliant wireless routers running one of the link state wireless mesh routing protocols. All nodes are connected with each other and arranged in full or partial mesh topology. Wireless Mesh Network (WMN) is very scalable and it can handle hundreds of nodes. This network is connected through a set of border routers to wired or satellite connections that will facilitate connection to the internet. To reduce cost and bandwidth usage our students decided to implement proxy servers throughout the network to allow for content caching.
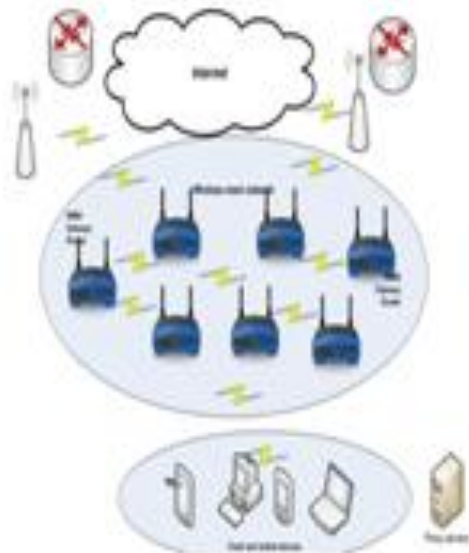

Fig. 1. Here is a diagram of a typical WMN.

The Wentworth Institute of Technology's Haiti Internet Initiative is a significant, vital and multifaceted project that will be an ongoing feature of the curriculum. This provides benefits to everyone involved. Faculty is able to maintain up-to-date skills by working on a functioning telecommunications system. The students are able to participate in a meaningful experience and sharpen their skills just before graduation. Educational goals for Haiti's youth will be more effectively supported and new skills can be introduced to them. Job creation will occur as the different locations are brought into the WAN.
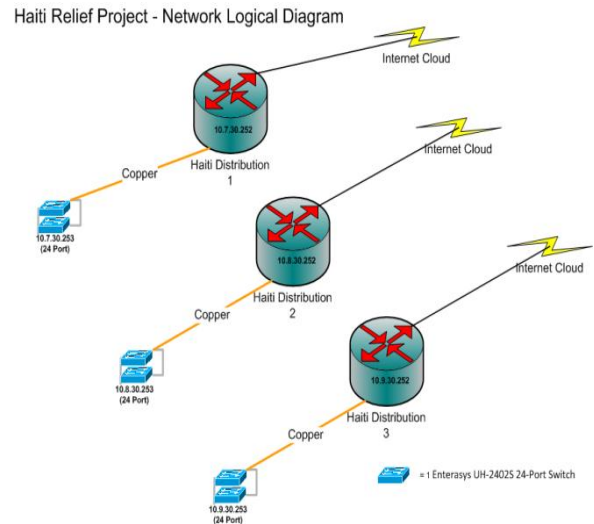

Fig. 2. A WAN topology for the *Haiti Internet Initiative* Three Pilot Sites

4.1 How can access to a wireless LAN network impact The Digital Divide in Haiti?

Being online will empower Haitian students. With online libraries and online resources students will be able to complete their assignments, conduct research, and take online courses. A non-profit organization like the University of the People has been providing access to tuition-free online post-secondary education. This initiative is aimed at qualified students that are impeded access to higher education due to geography and financial hardship [28]. They have recently launched a program with the Clinton foundation to offer online associate degree in Business Administration land Computer Science to 250 qualified Haitian students.

4.2 Collaborative Initiatives between Wentworth and Universities in Haiti

A year after the devastating earth quake not much has been done. Students are being taught under tents. Yet, they are motivated to learn, knowing through education they can reach the sky of opportunities. The Wentworth Institute of Technology has a longstanding tradition of hands-on education. It also maintains a strong commitment to community service and service-learning. The Institute is assisting the Haitian students in making their aspiration a reality through the Microsoft Imagine Cup Competition.

Microsoft organizes a yearly international competition for students to present software solutions to existing problems. The competition gathers the best designs for the final at the end of each year. A national competition will be held for Haitian students to come up with new concepts. They will work in teams of five to come up with solutions of existing problems that they are facing,

work on proposed problems, or present their own innovations. The different categories will be: web applications, desktop applications, game applications, and phone applications.

Graduating computer science students from different universities will be working on the winning projects. Out of this group, we will select the best two prototypes. Students will be provided with appropriate tools like: Microsoft.net, SQL Server 2000, and Windows phone 7 toolkits to complete their projects. The two teams selected will be working directly with students at the Wentworth Institute of Technology. Given available technology, our students will be able to collaborate over the Internet with those in Haiti mostly through an established wireless LAN.

4.3 Collaborative projects

This network system can be used to teach our students taking Network Administration how to manage a network remotely; it can be used by our students in the network security courses to learn how to compromise and secure a network remotely. Finally, as Wentworth is contemplating providing remote classes to the citizens of the world, doing collaborative work with schools and universities in Haiti via our network, will be a good model to test the effectiveness of the content delivery.

5. CONCLUSION

Wireless technologies are expanding and becoming increasingly better: higher speeds, lower costs, greater accessibility. Wireless access devices are no longer limited to PCs but include devices such as highly functional mobile telephones. The proliferation of new wireless technologies, smart phones and PDAs can be used to create new learning communities and provide for more opportunities for the underprivileged in developing countries. This also provides opportunities for those who wish to make a significant impact in their lives and the lives of others: teachers and students at home and abroad collaborating together to create synergy and build active learning communities. Using wireless technology will allow underdeveloped areas to "leapfrog" past many of the developmental stages of technological advances. Countries such as Haiti can reap the benefits of a reliable, available and extensive communications network without heavily investing in the costs of fixed-line telephone infrastructure or other guided media technology. These cutting-edge devices such as iPads and Internet-ready cell phones not only allow connection to the Internet but can become nodes for propagating the network themselves. Efforts such as Wentworth Institute of Technology's *Haiti Internet Initiative* will provide educational and economical benefits quickly and efficiently, bringing underdeveloped and struggling nations into the next century.

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