Application of Wireless Ad-Hoc Networks Model to provide Education to rural Communities in Ghana

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Abstract

Ghana is faced with a broadening crack in the delivery of education between urban and rural areas as successive government since Nkrumah's times had made attempts to bridge the gap in terms of education between the rural folks and the urban folks. E-Learning also known as online learning may be one of the solutions to the learning and teaching challenges experienced in rural part of Ghana. These challenges include the lack of qualified teachers and ICT infrastructure to provide interactive teaching and learning environment. This paper proposes the use of wireless ad-hoc networks to provide e-Learning for people in rural communities in Ghana. In our proposed system, wireless Ad hoc networks would be used for the dissemination of various types of educational information/data. Each of the rural areas would have at least a Telecentre which would be equipped with computers, including multimedia for storing data and would be based at the district capital. People in rural areas will get access to this information by wirelessly connecting their mobile devices to the computers in the Telecentres. It is envisaged that successful implementation of this model by the government will turn to bridge the educational gap between people in rural and urban Ghana and be able to provide education to the vast number of Ghanaians in an interactive way.

Keywords: E-Learning, Wireless Ad-hoc Networks, Mobile Access Points (MAP), Rural Communities, I CT

Introduction

The country Ghana like many other developing countries in Africa has seen the increase in the numbers of people owning and using mobile computing devices such as mobile phones, laptops, tablets, personal digital assistants (PDAs) and others (Ghana National Communications Authority, 2016). These mobile devices have also found their way in the rural areas, and a number of rural inhabitants are using these mobile devices, especially android phones. The increased use of these devices worldwide has also seen the development of various wireless systems and applications like, wireless ad hoc networks, wireless sensor networks, ubiquitous computing, grid computing and others (Bakar & Ismail, 2012). Wireless ad hoc networks could significantly contribute to the development of rural areas of Ghana. These wireless networks could be effectively used to provide e-Learning to the people of rural Ghana.

E-Learning refers to the utilization of ICT facilities in the provision of education. Applications such as web-based learning, computer-based learning, virtual classrooms, digital collaboration and others are the examples of e-Learning methodologies (Ahmed & Nwagwu, 2006; Unwin, 2008). The ultimate goal of e-Learning is to bring the learning to the learners, not to bring the learners to learning. Rural communities in Ghana are left behind in education because of the following issues; Inadequate of ICT infrastructure, Lack of qualified teachers, Insufficient learning resources such as books, especially in science subjects, fewer number of students from rural areas enrolling at higher institutions (Appiahene *et al*., 2014).

The answer to the above challenges can be the use of Mobile Ad Hoc Networks in teaching and learning. The use of cellular phones has grown to unparalleled levels in both urban and rural areas. The cellular mobile phones normally require a fixed network infrastructure with centralized administration for their operation (Feeney & Nilsson, 2001; Giordano, 2000; Royer & Toh, 1999; Stuedi & Alonso, 2005). They require a lot of time and money to set up and maintain. On the other hand, mobile ad hoc networks require no immobile infrastructure and are less expensive to set (Giordano, 2000). We propose to use a Telecentre equipped with a server connected to the Internet using both cables and wireless connection. The figure 2 below shows the proposed design, WAMEP.

In this paper, we present a model for the delivery of e-Learning to rural Ghana using wireless ad-hoc networks. These networks could also be used in the delivery of various e-services like, e-medicine, e-agriculture and e-health care, e-business to the hard-to-reach rural areas (Arbune *et al*., 2014). Our framework ensures the delivery of effective e-learning, in case there is an absence of fixed infrastructure. The paper also discusses the practical/operational challenges that could hinder the implementation of such a model in the rural areas of Ghana.

Literature Review

Mobile ad-hoc networks are paradigms for mobile communication in which mobile nodes are dynamically and arbitrarily located in such a manner that communication between nodes does not rely on any underlying static network infrastructure (Giordano, 2000; Holland & Vaidya, 2002; Hu & Burmester, 2009; Royer & Toh, 1999). The communication medium is broadcast, and the nodes in a mobile ad-hoc network are usually portable mobile devices with constrained resources, such as power, computation ability and storage capacity. Since no fixed infrastructure or centralized administration is available, these networks are self-organized and end-to-end communication may require routing information via several intermediate nodes (Pelusi, Passarella, & Conti, 2006; Royer & Toh, 1999; Stuedi & Alonso, 2005).

The nodes that lie within each other's range can communicate directly over wireless links and are responsible for dynamically discovering each other's send range. In order to enable communication between nodes that are not directly within each other's range, intermediate nodes act as routers that relay packets generated by other nodes to their destination (Hu & Burmester, 2009).

Chang & Sheu (2002) in a study described the design and implementation of a learning technology project. Their purpose was to develop advanced wireless technologies for building an Ad-Hoc classroom in order to contrive a modern and new learning environment. They proposed a wireless platform for teacher and students to establish a classroom dynamically irrespective of location and time bounds. As supported in a traditional classroom, the authors used an information technology to provide a teacher with teaching materials such as marker-board, board rubber, microphone, voice recorder, etc. for course teaching and discussions in an ad-hoc classroom. According to the authors, taking lesson in a lively, vivid, and new learning environment, students are expected to enhance their learning performance without any burden like attending classes physically. Moreover, students get a more flexible scope of learning during their convenient time.

Ad-hoc network provides facilities to access devices in infrastructure fewer systems without a centralized approach (Aljohani & Tanweer, 2015). Aljohani & Tanweer (2015) in a study designed a new M-learning framework for smart learning in Ad Hoc Network architecture among Android based Wi-Fi devices. In their research, they selected android and develop Android application for M-Learning through android based smart devices. Their proposed system was tested in android ad-hoc network system, and the results showed successful and expectation for future scope in the area of mobile ad-hoc network and M-Learning. Due to the opportunities provided by the Internet, users are taking advantage of e-learning courses, and many research efforts have been dedicated to the development of e-learning systems (Oda, Matsuo, Barolli, Yamada, & Yi, 2017). Oda *et al.* (2017) designed and implemented an IoT-based e-learning testbed using Raspberry Pi mounted on Raspbian. They analyzed the performance of Optimised Link State Routing (OLSR) and Wired Equivalent Privacy (WEP) protocol in an indoor scenario. The experimental results of their study show that the nodes in the testbed were communicating smoothly.

Hoebeke, *et al*., (2004) provided an insight into the potential applications of ad hoc networks and discuss the technological challenges that protocol designers, and network developers are faced with. According to the authors, these challenges include routing, service and resource discovery, Internet connectivity, billing and security.

A study by Jan, Ullah, *et al*., (2016) suggests students agreed that mobile learning will enhance their learning practices due to low backup time of their electronic learning devices. The authors additionally showed strong support for mobile learning implementation due to other advantages associated with this technology such as mobility, reachability and flexibility; with the aim of improving communication and enriching their learning experiences.

According to Kester, *et al*., (2007), Learning in a so-called Learning Network is normally beautiful to self-directed learners, who drew their own their learning programme such as timing, pace and even venue for their studies. Nevertheless, such students may easily become lonely, which is disadvantageous to their studies. Kester *et al.* (2007) in a study proposed peer tutoring in ad-hoc transient communities as a means of solving such problems. The authors finally discussed various characteristics that such communities should exhibit.

Appiahene, *et al*., (2016) considered how Cloud Computing can be applied in the study of

ICT. Their study also looks at how one can provide quality and affordable ICT education by using cloud computing technology. The study shows that for the past decades, most public and private educational institutions in Ghana are making grant strides in the development of curriculum for teaching ICT. The model designed was found to be effective and useful for the teaching and learning of ICT and its related subjects (Appiahene *et al*., 2016).

Finally, Aruna and George (2017) proposed a dynamic mobile ad-hoc e-learning system, which enables divergent wireless communication devices to support mobile ad-hoc network learning environment that needs less physical infrastructure. This proposed system by Aruna & George, (2017) aims to support and enhance students learning in the form of online, virtual and collaborative learning environment. This work also provides mechanisms to establish a virtual-learning environment for the students located around a certain distance to form a mobile ad-hoc network and to share their knowledge. This proposed system was implemented as a pilot project in Periyar Maniammai University, Thanjavur, India and results shows that technology has added new dimensions to teaching and learning.

Cellular network against mobile ad-hoc network

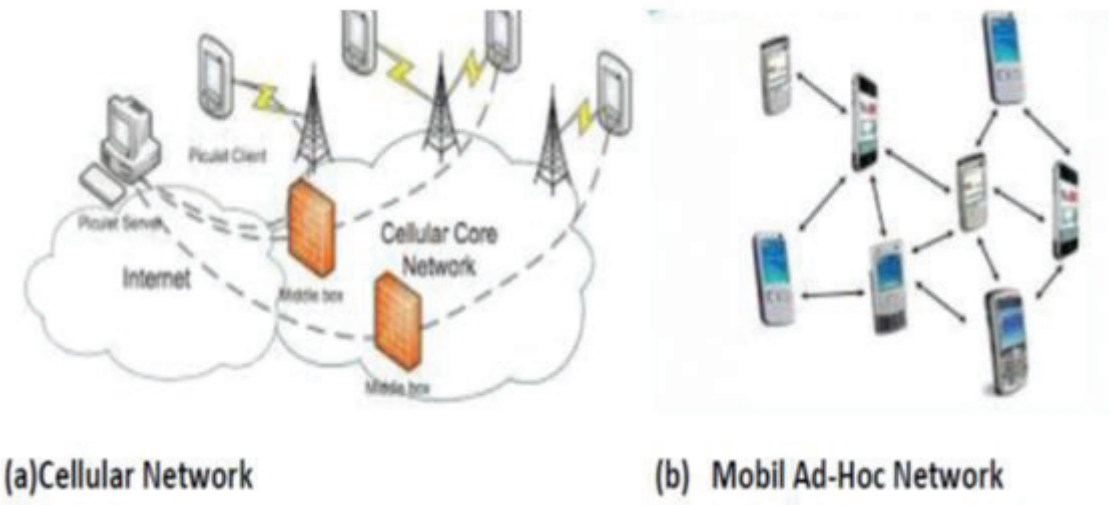

Figure 1 below shows the difference between Cellular networks (a) and mobile ad hoc networks (b).

The Proposed Model

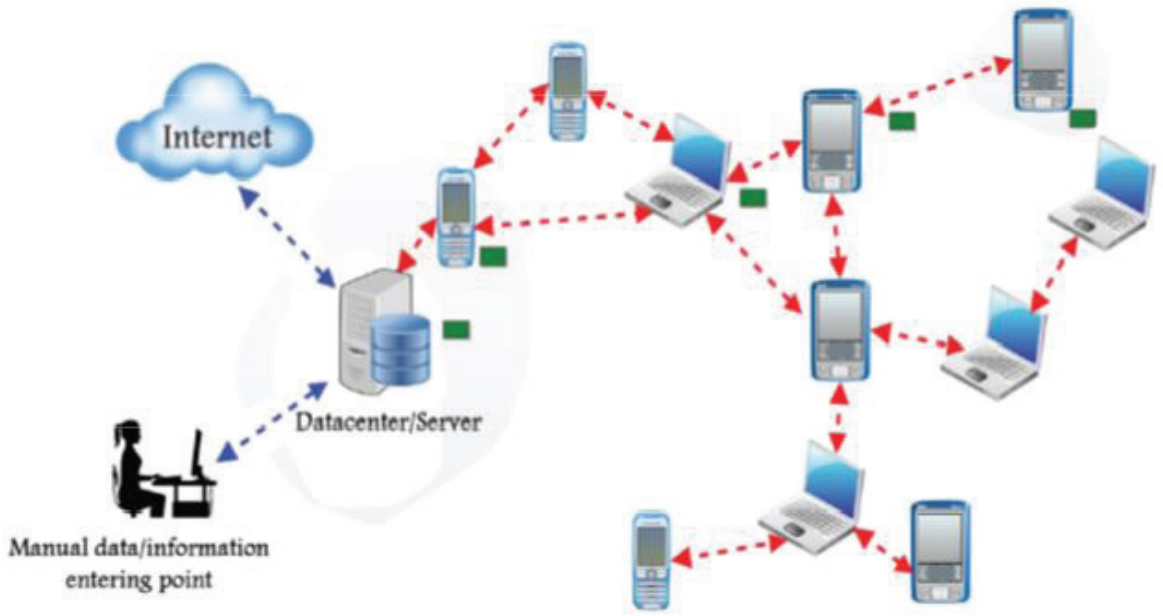

Figure 2: Proposed Mobile ad-hoc network, WAMEP

The mobile devices can be tablets, computers, laptops, smart phones, personal digital assistants, etc. Data or information is loaded in the main server manually or from the Internet. The mobile devices can access this material on the server and can also access the Internet via the main server. The mobile devices shown in the diagram are in different levels. This means that they are within each other's sender range. If level two (2) mobile phones want to access the main server, the level one mobile phone will serve as routers. This setup can serve one, two or three rural schools depending on the distance between the schools.

The idea is to replicate such a set up to every district in the country to provide interactive teaching and learning to schools in rural areas.

Interactive learning is encouraged because the way human beings understand, learn, grow and adapt is based on the ability to perceive, view and conceptualize thoughts and ideas. The terms used by people to describe the process of learning and understanding revolve around the word "see," for example, when a new concept moves from static jargon to understandable knowledge, we "see" it.

ICT realizes virtual reality in the learning process which improves the learner's understanding of concepts. It brings with a variety of technologies that make images, and moves appear more life-like in print or on the computer. This enhances understanding of the learners (Ahmed & Nwagwu, 2006; Gerolimos & Konsta, 2011; Unwin, 2008). Our proposal model does not distance the teacher from the process of teaching and learning but serves as supplement.

Proposed Benefits of the implementation of the Model, WAMEP

Successful implementation of the proposed Wireless ad hoc networks would offer the following among the many benefits:

- **Ease of Deployment**: Ad-hoc networks are easily deployable as they do not need any fixed infrastructure of central administration. They rely on the same Wireless Fidelity (WIFI) standards, which are already in place for wireless networks.
- **Speed of Deployment**: Ad-hoc networks are deployable on the fly. They are autonomous and infrastructure-less or semi-infrastructure,
- **Cost of Deployment**: There is no incremental cost for deployment; however, costs may rise depending upon the nodes associated with the network,
- **Anywhere, anytime**: Wireless ad hoc networks could be deployed anywhere, anytime especially in the hostile or geographically harsh areas where fixed network deployment is difficult,
- **Less Transmission power**: Ad-hoc Mobile Networks use less transmission power compared to wireless infrastructure networks. The nodes operate on batteries.

Technical and operational challenges for implementing such a framework

Implementing such a framework would require support from the Government and other partners. The Ministry of Education is the custodian of all educational programs run in primary and secondary school, so their approval and financial support are vital for such a framework to become a reality. The framework will require support from cooperating partners such as headmasters and teachers in secondary schools and support and advice from other organizations in and outside the Ghana. The unreliable power supply currently hitting the country will hinder the successful implementation of the model.

Conclusion and Future Work

The successful implementation of this project will return the following benefits:

1. Bring ICT to rural secondary schools on a wider scale,
2. Reduce the digital gap between rural and urban secondary school,
3. Improve teaching and learning in rural schools,
4. Improve examination results of most rural schools and subsequently increase the number of students enrolling at higher institutions.

In future, the project would focus on the how cloud computing technology can also be incorporated, and a comparative analysis would be carried on.

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