e-Learning Using Wireless Ad-Hoc Networks to Support Teaching and Learning in Rural Zambia

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Abstract

Zambia is faced with a widening gap in the provision of education between urban and rural areas. E-Learning also known as online learning maybe the solution to the learning and teaching challenges experienced in rural Zambia. These challenges include among many others, the lack of qualified teachers and ICT infrastructure to provide interactive learning.

Although rural areas in Zambia are lagging behind in terms of ICT infrastructure as compared to urban,our research showed that the number of people using mobile computing devices in both rural and urban Zambiahas grown significantly. The nature of these mobile devices makes wireless networks the easiest solution for their interconnection.

This paper proposes the use of wireless ad hoc networks to provide e-Learning for people in rural and remote areas of Zambia. In our proposed system, wireless Ad hoc networks will be used for the dissemination of various types of educational data. Each of the villages or rural area should have at least a Telecentre (acts as a sink) which is equipped with computers including multimedia for storing acquired data. The necessary educational information could manually be entered into these computers. People in rural areas could then get access to this information by wirelessly connecting their mobile devices to the computers in the Telecentres. This will in turn bridge the gap between people of rural and urban Zambia and be able to provide education to the majority of Zambians in an interactive way.

Keywords

Rural Zambia, Information and Communication Technology (ICT), e-Learning; Wireless Adhoc networks, Infrastructured Wireless Networks, Mobile Access Points (MAP), Mobile Ad Hoc Networks (MANET).

1. Introduction

Zambia like many other developing countries 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 (Kurose and Ross, 2008). These mobile devices have also penetrated the remote and rural areas and a number of rural dwellers are using these mobile devices, especially mobile 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 (Demeester, P, et al. 2004). Wireless ad hoc networks could significantly contribute to the development of economically and socially lagging rural areas of Zambia. These wireless networks could be effectively used to provide e-Learning to the people of rural Zambia.

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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 (Anand, et al. 2012). The ultimate goal of e-Learning is to bring the learning to the learners, not to bring the learners to learning.

In this paper we present a detailed framework for the provision of e-Learning to rural Zambia using wireless ad hoc networks. These networks could also be used in the provision 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 provision of effective e-learning where fixed infrastructure maybe absent. The paper also discusses the practical/operational challenges that could hinder the implementation of such a framework in the rural areas of Zambia.

2. Overview of Mobile Ad Hoc Networks

Mobile Ad Hoc Networks are different from structured wireless networks, where a user directly communicates with an access point or base station. These networks do not rely on fixed infrastructure for operation. Mobile ad hoc networks can be defined as self organizing, dynamic topology networks formed by a collection of mobile nodes through radio links. The major characteristics of these networks are that they require minimal configuration, and are quick to deploy. They have a dynamically changing topology and do not rely on centralized access points. The nodes are energy constrained, that is, they are battery powered and they use multi-hop communication (Kumar& Mishra, 2012)

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.

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

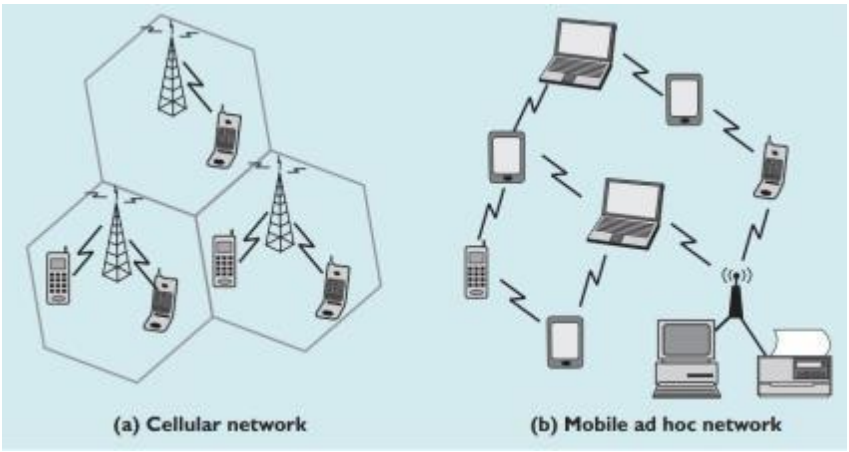

Figure 1: Cellular networks versus mobile ad hoc networks

3. The Problem Statement

Rural areas in Zambia are lagging behind because of the following challenges:

- Inadequate of ICT infrastructure,
- Lack of qualified teachers,

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- Insufficient learning resources such as books especially in science subjects,
- Less number of students from rural areas enrolling at universities.

The solution 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 unprecedented levels in both urban and rural areas. The cellular mobile phones require a fixed network infrastructure with centralised administration for their operation. They require a lot of time and money to set up and maintain. On the other hand mobile ad hoc networks require no fixed infrastructure and are less expensive to set up (Tonnesen, n.d.)

We propose to use a Telecentre equipped with a server that is connected to the Internet using both cables and wireless connection. The figure 2 below shows the proposed design.

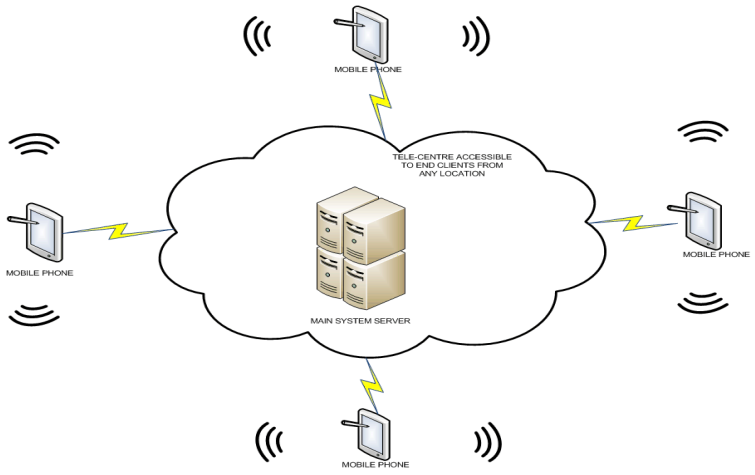

Figure 2. Proposed Mobile Ad Hoc Network diagram

The mobile devices can be tablets, personal computers, laptops, smart phones, personal digital assistants and others.

Data or information is loaded in the main server manually or can be downloaded 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 level one. This means that they are within each other's sender range. If level 2 mobile phones are introduced, the level one mobile phones will serve as routers. This set up can serve one, two or three rural secondary schools depending on the distance between the schools. The idea is to replicate such a set up to every district so as to provide interactive 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. Students sense a greater depth when they use 3D visualization than 2D. 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 (The value of 3D to Education and Learning, 2012).

Our proposal does not alienate the teacher from the process of teaching and learning. Possible mobile ad hoc technologies that can be used include among others:

- IEEE 802.11b,
- IEEE 802.16,

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- IEEE 802.16e.

3.1 Routing Protocols

Unlike multi-hop in infrastructure based wireless networks where there is a base station or access point, in mobile ad hoc networks there is no base station that is responsible for sending and receiving data to and from a wireless host that is associated with that base station (Omari & Summari, 2010) The nodes may have to relay messages among several other nodes in order to reach a destination (Ghandhi & Upadhayaya, 2009). The nodes may also be mobile, with connectivity changing among the nodes. All the same, for any communication to take place between any two or more nodes there should be a communications protocol.

The following routing protocols are popular with MANETs:

- Table driven (proactive),
- On-Demand (reactive),
- Hybrid (is a combination of table driven and on-demand).

The operation of the above protocols can be explained with the help of figure 3.

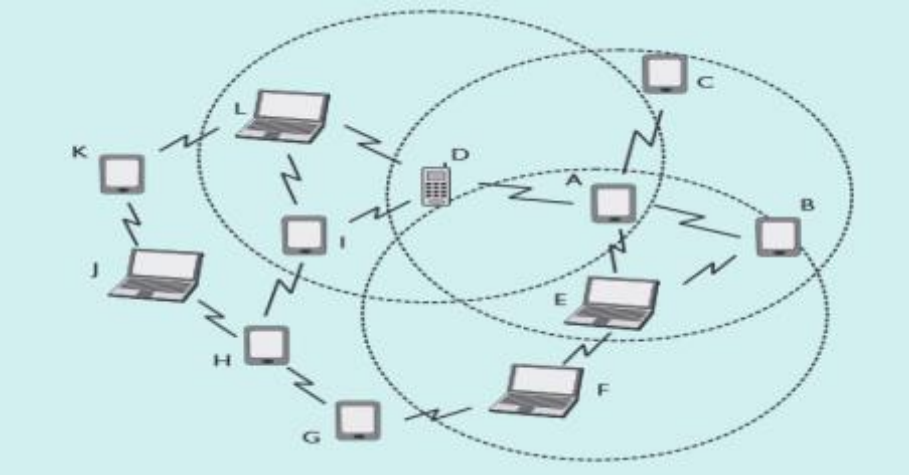

Figure 3. Routing knowledge of node A when it communicates with nodes B, F and J

3.2 Table Driven (Proactive)

When using this protocol, a node must first of all learn the network's topology before it can transmit. So eachnode has one or more tables that contain the latest information of the routes to any node in the network. In the above figure 3, this means node A has a table that contains the latest information of the routes to each node. In this case, A has knowledge of the routes to B, C, D, E, F, G, H, I, J and L. In cases where a node can be reached via several routes, choice of the chosen route is based on cost.

Examples of the table driven (proactive) include:

Destination Sequenced Distance Vector (DSDV)(Cheng, et al, 2011).

Optimized Link State Routing (OLSR) (Jacquet, P, et al. 2001)

3.3 On-Demand (Reactive)

The protocols in Ad hoc On-demand routing do not maintain or constantly update their route tables with the latest route topology, instead when a source wants to transmit a message; it

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floods a query into the network to discover the route to the destination. The discovered route is maintained until the destination node becomes inaccessible or until the route is no longer desired. In figure 3 above, node A wants to communicate with B, F and J, it has the route knowledge of nodes B, F and J.

Examples of On-Demand protocols include:

- Dynamic Source Routing Protocol (DSR) (Jonhson, et al. 2007],
- On-Demand distance Vector Routing Protocol (AODV)(Das and Marina, 2001).
- Temporally Ordered Routing Algorithm (TORA) (Hiertz & Weiss, 2005).

3.4 Hybrid

Since this is a combination of table-driven and on-demand protocols, it attempts to assimilate the advantages of purely proactive and reactive protocols (Gupta, A et, al.2012). The key idea is to use reactive routing procedure at global network level and employ proactive routing procedure in a node's local neighbourhood. For example, if our framework covers three schools, communications within a school will be done using proactive routing procedure and inter-school communication will be done using reactive routing procedure. In figure 3 above, A has route knowledge to B, C, D, E, F, I and L proactively and J reactively.

Examples of hybrid protocols include:

- Zone Routing Protocol (ZRP),
- Hybrid Ad Hoc Routing Protocol (HARP)(Khatkar &Singh, 2012).

We propose to use the hybrid protocol in our framework.

4. Benefits of Wireless Ad Hoc Networks

Wireless ad hoc networks 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 WIFI standards (IEEE 802,11a, b, g and 802.16e) which are already in place for wireless networks (Sarao n. d.),
- 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.

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5. Technical/operational challenges for implementing such a framework

Implementing such a framework would require support from the Ministry of Education, Science, Vocational Training and Early Education. The Ministry of Education is the custodian of all educational programmes run in primary and secondary school, so their approval and financial support is 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 organizations such as National Research and Education Networks(NRENs),Zambia Research and Education Network(ZAMREN) and UbuntuNet Alliance.

6. Conclusion and Future Work

1.1 Conclusion

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

- Bring ICT to rural secondary schools on a wider scale,
- Reduce the digital gap between rural and urban secondary school,
- Improve teaching and learning in rural schools,
- Improve grade 12 results from rural school and subsequently increase the number of students enrolling at universities.

1.2 Future Work

In future, the project would also be used for training teachers on the use of ITC. Teachers these days often travel long distances from the rural areas to attend ICT courses in and around urban areas. They incur transport as well as accommodation costs in addition to payment tuition fees.These same facilities could be used to conduct regular workshops on the ICT new trends. ITC technology is fast changing and there is need for constant sensitization on these new changes.

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Biographies

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