Designing a Vertical Handoff Decision Making Algorithm for Wireless Heterogeneous Networks

Duduzile Zamanhlane Masuku, Khulumani Sibanda and Mamello Thinyane
Department of Computer Science
University of Fort Hare, P. O. Box 1314, Alice 5700
Tel: +27 40 6022464, Fax: +27 40 6022464
email: {dmasuku,ksibanda,mthinyane}@ufh.ac.za

Abstract- Wireless networks are increasing in popularity and new wireless technologies are being introduced. It is therefore important that more research is done on integration of heterogeneous wireless networks. Accordingly, it is becoming progressively more important to find appropriate vertical handoff solutions. Users need to be able to move within different types of networks efficiently and with no perceivable delay to the user. Vertical handoff is a seamless transfer of an ongoing user session between deferent heterogeneous radio access technologies. This research will derive a decision making algorithm for effective vertical handoff. This can be achieved by identifying decision factors, according to different characteristics of the available wireless network resources. We have chosen Siyakhula Living lab for our research, the lab is situated in an area with heterogeneous wireless networks such as Wi-Fi with high data rate but very limited coverage and WiMAX with larger coverage. Mobile WiMAX will also be introduced with a more interesting set of complementary features.

Index Terms—Heterogeneous Wireless Networks, Vertical Handoff, WiMax, Mobile WiMax, Siyakhula Living Lab

I. INTRODUCTION

Low population density, environmental constraints and low income are some of the characteristics of rural areas. These characteristics may lead to poor network connectivity [1]. There is an Information Communication Technology for Development (ICT4D) intervention called Siyakhula Living Lab (SLL), started in 2005. In this Living Lab wireless technology like Wi-Fi and WiMax are used to provide the last mile connectivity. With Mobile WiMax to be deployed soon in this area, integration of heterogeneous wireless networks is necessary. This technology support mobility which is an important factor in this research. Mobility management is done at layers such as application layer, transport layer IP layer and other layers but the most common method is to use SIP and mobile IP.

II. STANDARDS FOR VERTICAL HANDOVER

Standards to consider in this research are as follows:
IEEE 802.21: "A Media Independent Handover which supports seamless handover".
Unlicensed Mobile Access (UMA): "3GPP standard for cellular systems and unlicensed wireless networks handover" [1].
Calm: "An ISO approved framework for continuous communication across various interfaces and media for vehicular users [1].

III. TECHNOLOGICAL REVIEW

A. *Wi-Fi*

Wi-Fi is a wireless local area network technology that does not rely on wired Ethernet connection. Wi-Fi has data transfer speeds of up to 54Mbps. Wi-Fi supports the following standards IEEE 802.11a, b, g and n [2].

B. *WiMAX*

WiMAX, Worldwide Interoperability for Microwave Access, based on IEEE 802.16 Air Interface standard is a wireless technology that provides broadband connections. WiMAX provides high throughput over long distances of up to 50 KM in Line of Site (LoS) and 10KM in Non Line if Site (NLoS) [3]. With this range WiMAX may be used to provide data and telecommunications services (e.g. VoIP, IPTV, etc) and can also operate as a possible replacement to cellular technologies such as Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA) [3].

C. *Mobile WiMAX*

Mobile WiMAX is a broadband wireless solution which makes use of Orthogonal Frequency Division Multiple Access (OFDMA) to provide both mobile and fixed broadband network connectivity [3]. It defines an all Internet Protocol (IP) end-to-end network architecture [3]. "Mobile WiMAX covers 5, 7, 8.5, and 10 MHz channel bandwidths for worldwide licensed spectrum allocations in the 2.3 GHz, 2.5GHz, 3.3 GHz and 3.5GHz frequency bands" [3].

IV. PROBLEM STATEMENT

One of the key challenges in future network management is end-to-end optimization that takes into account variables such as throughput optimization, routing optimization, delay profiles for heterogeneous wireless environments and economical profitability. Figure.1 below represents the current Siyakhula living lab network.

WiMax is used within SLL to deliver the last mile, this allows the users broadband access from five schools which are currently connected: Mpume, Nondobo, Nqabara, Ngwane and Mthokwane. This means users need to walk to the Digital Access Nodes (DANs) for access of service [4].

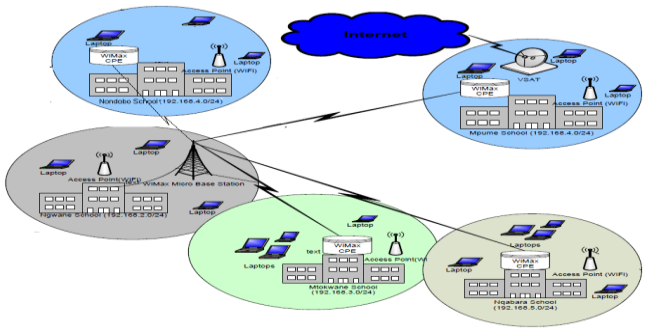

Figure.1 *The SLL network currently*

Researchers have deployed many applications on this network and more are still to be deployed. The SLL is an effort to bridge the digital divide. There is a project aimed at deploying mobile WiMax in one of the schools. This technology is also known for offering mobile devices ability to handover from one base station to another, also from one technology to the other [5]. In this research we will focus in designing a vertical handover algorithm for these heterogeneous wireless networks.

VI. TYPES OF HANDOVER

The 802.11 devices enable users to move from one place to another and keep connectivity. However this movement results in lots of handovers which are defined as de-attaching from current Access Point and attaching to another. Handoffs are categorized as vertical this process of a mobile terminal takes place among access points supporting different network technologies[6] and horizontal takes place between base stations supporting the same network technology [6] [7].

V. CHARECTERISTICS OF HANDOFF DECISION

An ability of handing over from one wireless technology to another seamlessly is becoming more important. This is more crucial for mobile users who want to access a variety of services on the move. Seamless handoff minimal delay and minimal packet loss, has become an important factor for mobile users who wish to receive continuous and reliable services. Handoff decision is one of the factors that helps in achieving seamless handing over of a session between technologies. The decision can be made by considering two main factors: connection maintenance and network condition [10]. These factors need to work together in order to make seamless handoff possible. In multi-network environments it is hard and challenging to obtain vertical handoff because there is no single factor that can provide clear indication of when to handoff. Signal strength, which is normally used as a key deciding factor for horizontal handoff, cannot be used in vertical handover decision due to the nature of coverage of heterogeneous network and a different physical techniques used by each technology [10].The following are some of the factors that we have chosen to develop our vertical hand off decision making algorithm:

1. **Cost of services:** This may be a decisive for user in choosing which network to move to.
2. **Battery consumption:** Wireless devices operate on limited battery power, when battery level decrease, handing over to a low power consuming network may provide long usage time [10].
3. **Quality of Service:** Handing over to a network with better conditions and higher performance will improve the service [10].
4. **Speed:** The velocity of the mobile device moving using a car, has a greater effect on vertical handoff decision than in horizontal handoffs [9].

VII. CONCLUSION

Seamless vertical handoff is necessary when migration needs to happen between heterogeneous wireless networks, in order to improve performance and other reasons such as high availability. Vertical handoff is first step. New wireless technologies are introduced adding further matrices for vertical handover, more matrices result in more complex decision making algorithms. In this paper we have given an overview of the technologies and matrices to be used in our research.

VIII. ACKNOWLEDGEMENT

Financial support from THRIP, Telkom, Tellabs, Saab Grintek Technologies and Easttel is hereby acknowledged.

IX. REFERENCES

[1]Musing, K. Tor,"*Vertical and Horizontal Handoff in Wireless Internet Access*", Centre for Quantifiable Quality of Service in Communication Networks Dept. of Telematics, NTNU,2009,

[2] Ranga, M "*Exploring a Cost Effective Reinforcement for Rural Telecommunication Networks: Dwesa Case Study*", SATNAC, 2010, Spier – South Africa

[3] University Information Technology, "*Knowledge Base"* Available on: "*http://kb.iu.edu/data/aick.html*

[4] Shumba, Z "*An Investigation of the Viability of Mobile WiMAX in Rural Context*"SATNAC2010, Spier-South Africa

[5] Ingrid Siebörger, Barry Irwin,"Dwesa Networking Document", Unpublished document, February,2008

[6] Z.Becvar, J.Zelenke, "*Handovers in the Mobile WiMAX*", Czech Technical University, 2008

[7] A.Makemelainen,Prof R.Jauntti, Helsinki University of Technology,"*Analysis of Handoff Performance in Mobile WiMAX Networks*
Available:lib.tkk.fi/Dipl/2007/urn010154.pdf ,2007

[8] Ajeet Nabkani,"*Horizontal Handoff within Wlans*" Master of Science Thesis Stockholm, Sweden ,2005

[9] Muhammad Amir Latif ,"*Quality of Service Vertical Handover Wireless Networks",* Blekinge Institute of Technology,2009

[10] Ahmed Hasswa, Nidal Nasser, Hossam Hassanein,"*Generic Vertical Handoff Decision Function for Heterogeneous Wireless Networks*",Second IFIP International Conference,2006