Radio Planning and Field Trial Measurement of a Deployed 4G WiMAX Network in an Urban Sub-Saharan African Environment

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ABSTRACT

Worldwide Interoperability for Microwave Access (WiMAX) technology has gained growing interest due to its applications and advantages. It is fast emerging as a last-mile problem solution for broadband access technology. This paper presents operation scenarios for the deployment of a Fourth Generation (4G) WiMAX system in a typical sub-Saharan African environment. This has been specified based on real world conditions considering the regulatory rules specified by the National Communication Authority (NCA) for radio frequency spectrum utilization in the 2.6GHz licensed band in Ghana. Appropriate propagation models and network planning tools have been used to design the final radio network plan. Coverage prediction has been performed using Genex-U-Net to achieve the main aim of providing coverage in the predefined areas of Accra and Tema, Ghana. Simulation results for different downlink/uplink ratios with different frequency reuse schemes have been presented. A total of 11 base stations have been suggested to provide coverage of -92dBm using 32 sectors 4 transmit 4 receive (4T4R) adaptive Multi-Input Multi-Output (MIMO) antenna configuration within the Accra and Tema municipality. Finally the system performance is evaluated through field trial measurement and the results presented.

Keywords: Capacity Simulation, Fourth Generation, Network Planning, Sub-Saharan Africa, Worldwide Interoperability for Microwave Access (WiMAX)

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INTRODUCTION

Ghana has been a pioneer in African telecommunications (Broadband penetration in Ghana, n.d.):

- It launched the first cellular mobile network in Sub-Saharan Africa in 1992
- It was among the first countries on the continent to be connected to the Internet and to introduce Asymmetric Digital subscriber Line broadband services
- It led the way in market liberalization and deregulation when it privatized Ghana Telecom (GT) as early as 1996.

Since then, Ghana has become one of the continent’s most vibrant mobile markets with now six competing operators, including regional heavyweights such as MTN, Vodafone, Tigo and Airtel.

However in contrast with the enormous success in voice communication, data communication has seen little success. Internet user penetration was below 10% of the population until recently (Ghana lauded for internet penetration, n.d.), but developments are now speeding up following the introduction of wireless and 4G mobile broadband technologies such as WiMAX and Long Term Evolution (LTE). The arrival of three new international fiber links between 2010 and 2012 has ended the monopolistic pricing of international bandwidth (Ghana-Telecoms, n.d.).

In spite of the enthusiasm for broadband services in Ghana and the continent as compared to the rest of the world, Africa is seriously lagging behind in broadband penetration and that has become a source of worry for the International Telecommunications Union and the Commonwealth Telecommunications Organization (Broadband penetration in Ghana, n.d.). The introduction of WiMAX comes as a great relief to most African countries since it promises to bring broadband access to the less privileged.

WiMAX promises a maximum capacity of 75Mbps (IEEE 802.16-2004, 2004) and the minimum data rates needed to support broadband applications are summarized in Table 1.

Since 75Mbps is well enough to support all the applications listed in Table 1, subscribers are keenly looking forward to enjoying higher data rates.

It is therefore relevant to discuss the processes involved in planning a WiMAX network

<table>
<thead>
<tr>
<th>Activity</th>
<th>Minimum Downlink rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email</td>
<td>0.5</td>
</tr>
<tr>
<td>Job searches, navigating government websites</td>
<td>0.5</td>
</tr>
<tr>
<td>Interactive pages and short educational videos</td>
<td>1</td>
</tr>
<tr>
<td>Streaming radio</td>
<td>Less than 0.5</td>
</tr>
<tr>
<td>Phone calls (VoIP)</td>
<td>Less than 0.5</td>
</tr>
<tr>
<td>Standard streaming videos</td>
<td>0.7</td>
</tr>
<tr>
<td>Streaming feature movies</td>
<td>1.5</td>
</tr>
<tr>
<td>HD-quality streaming movie or university lecture</td>
<td>4</td>
</tr>
<tr>
<td>Basic video conferencing</td>
<td>1</td>
</tr>
<tr>
<td>HD video conference and telelearning</td>
<td>4</td>
</tr>
<tr>
<td>Game console connecting to the Internet</td>
<td>1</td>
</tr>
<tr>
<td>Two-way online gaming in HD</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1. Broadband speed guide (Broadband speed guide, n.d.)
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