Design of Outdoor Wireless Networks Using Computer Simulation

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Abstract

In this paper, we design a pilot outdoor wireless network based on IEEE 802.11b standard for HealthCare Applications through computer simulation. The purpose is to demonstrate the use of computer simulation in designing outdoor wireless networks. We use a free software tool called Radio Mobile and freely available geographical elevation data downloaded from NASA to determine the radio frequency (RF) coverage of a wireless networking base-station and radio link performance. Furthermore, we demonstrate the flexibility of computer simulation in assessing design alternatives.

Keywords: *Wireless Networking, Computer Simulation, Radio Mobile.*

I. Introduction

Recently, wireless networking has become an essential part of modern telecommunications and is increasingly being deployed for various applications including campus-wide networks, municipal community networks, and healthcare applications. The process of applying wireless networking in healthcare, however, remains a challenge mainly because of security and reliability concerns. Soomro and Cavalcanti [1] argue that although some medical applications have quality of service (QoS) requirements similar to common multimedia applications, there is a significant difference in QoS for applications considered life critical. Nevertheless, healthcare can benefit significantly from wireless networking technologies provided that the technologies address the concerns raised in medical field. It is, however, expensive to design such secure and reliable wireless networks for HealthCare Applications.

Communication systems in general and wireless networks in particular can be designed through analytical methods, computer simulation and hardware prototyping [2]. The analytical methods use mathematical notations and equations to describe the system and give clear insights into relationships between system parameters and performance [3]. Analytical methods, however, may not be possible where the mathematics is intractable. Consequently, analytical approach is limited to simplified models of communication systems, implying that analytical approach is useful in the early stages of system design for

broadly exploring the design space [4].

Hardware prototyping involves building a hardware model of the system (test-bed) and evaluating the performance based on measurements obtained from the model. Although this approach is more accurate and credible, it is costly and time consuming. In addition, it is less flexible as such it is inappropriate at the early stage of system design when the number of design alternatives is large.

Computer simulation is a technique that involves designing a model of the actual or theoretical communication systems, executing the model on a digital computer and analysing the results. Firstly, it acts as a communication vehicle that provides a description of the behaviour of the system. Secondly, the simulation approach enables users to gain insight and understanding of the behaviour of the system. Thirdly, it enables development of theories that account for the behaviour of the system. Finally, it provides a means for analysing and evaluating the system and predicting the systems future behaviour.

In this paper, therefore, we demonstrate the use of computer simulation in the design of outdoor wireless networks for HealthCare Applications in the City of Blantyre. In this demonstration, we use a free software simulation tool called *Radio Mobile* and a freely available terrain elevation data to plot radio frequency (RF) coverage and predict the performance of an outdoor wireless system. The remainder of the paper is arranged as follows: Section II describes the methodology followed in the simulation of the network. Section III presents and discusses the results of the simulation, while section IV concludes the paper.

II. Methodology

The overall objective was to simulate an outdoor wireless networking for HealthCare Applications in the city of Blantyre. The network was to link healthcare facilities in the city namely: Queen Elizabeth Central Hospital (QECH), Ndirande and Limbe Dispensaries with the Malawi Polytechnic acting as a gateway to Internet. The tool used in the simulation was Radio Mobile and the procedure involved installing Radio Mobile into a computer, downloading elevation data and creating maps, defining the networks and telecommunication system used, marking GPS position for the telecommunication base-stations, repeaters and customer premises equipment on the maps and determining radio coverage and links performance [5]

(a) Installing Radio Mobile

Firstly, Radio Mobile compressed files were downloaded from its website [6] and installed in

a temporary folder in a computer. Then the compressed files were extracted and installed into a radio mobile folder.

Secondly, freely available elevation data files called srtm (Shuttle Radar Topography Mission) for the city of Blantyre were obtained from the Internet and the Radio Mobile was configured to use the srtm elevation data-files.

Finally, a topographical map for the city of Blantyre was created showing points on interest as shown in Figure 1.

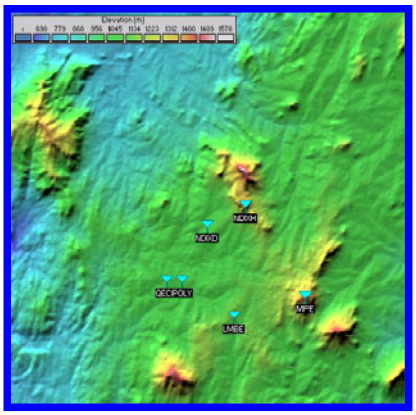


Figure 1:Elevation map for Blantyre City

(b) Network Configuration

After configuring the radio mobile and creating the elevation map for the City of Blantyre, the network was configured using the licence free IEEE 802.11b standard using parameters summarised in Table 1.

Table 1: Network Parameters

Parameter	Values	Units
Minimum frequency	2412	MHz
Maximum frequency	2462	MHz
Antenna type	Omni-directional	
Antenna gain	8	dBi
Antenna height	10	m
Cable loss coefficient (LMR-400)	0.2	dB/m

(c) Network Simulation

Firstly, we obtained GPS positions for location of interest using a handheld GPS equipment (Etrix-12 channels GPS). The GPS positions for locations of interest are summarised in Table

2. The network was then simulated by plotting radio coverage and determining links performance.

Table 2: GPS positions for telecommunication equipment.

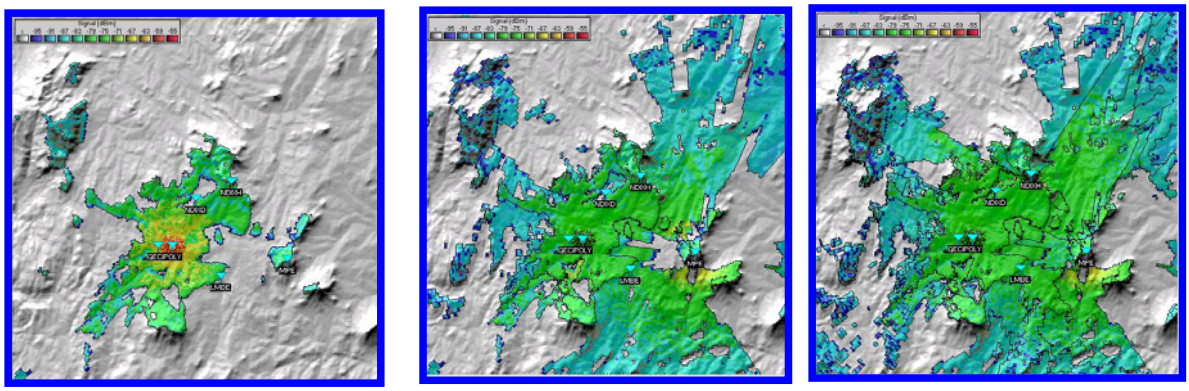
Location	Longitude (S)	Latitude (E)
QECH	15^0 48' 06.0"	35^0 01' 13.1"
Polytechnic	15^0 48' 05.7"	35^0 01' 38.7"
Mpingwe	15^0 48' 29.9"	35^0 05' 11.0"
Ndirande Hill	15^0 46' 11.8"	35^0 03' 28.6"
Ndirande Dispensary	15^0 46' 42.7"	35^0 02' 22.6"
Limbe Dispensary	15^0 49' 00.4"	35^0 03' 08.0"

III. Results and Discussion

The overall objective of this study was to simulate a pilot outdoor wireless network for HealthCare Applications in the City of Blantyre. Specifically, the study sought to determine the RF coverage of base-stations located in different places in Blantyre and to predict the performance of various wireless links to assess their viability.

(a) Radio coverage

Figure 2 shows RF coverage for base-stations located at Polytechnic (a), Mpingwe Hill (b) and Ndirande Hill (c) assuming that the transmitter power was 26 dBm and the receiver sensitivity of -95dBm.



(a) (b) (c)

Figure 2: Radio coverage (a) Polytechnic, (b) Mpingwe Hill, (c) Ndirande Hill base stations

The results show that a base-station located at Polytechnic will cover the least area (53sq km) and will not be able to cover some locations of interest. On the other hand, base-stations placed at Mpingwe and Ndirande hills will cover most of Blantyre City (179 and 164 sq km, respectively) and that locations of interest will be covered. This means that using Radio Mobile and elevation data, we can predict the coverage of radio base-stations and choose an appropriate location for a base-station that offers the best coverage. However, the elevation data used in this study does not take into account physical infrastructure and vegetation that may block RF signals.

(b) Links Performance

Figure 3 shows the profile and performance of the Polytechnic and Limbe dispensary link. Firstly, it shows the terrain profile and plots the Fresnel zones for the link. Furthermore, it shows that the link is 3.14 km and it is not valid because it is obstructed at 2.83km from Polytechnic, resulting in a total path loss of 154dB and very small received power of -113dBm against the receiver sensitivity of -95dBm.

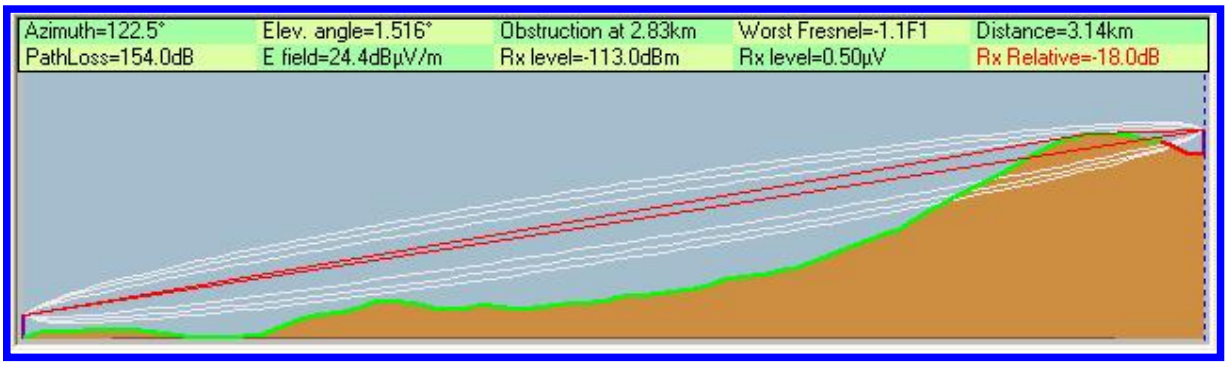


Figure 3: Polytechnic-Limbe Dispensary link profile

Similarly, the performance of other links was assessed and the results are summarized in Table 3. The results show that the Polytechnic-Limbe link is not valid (received power is -113dBm), while the Mpingwe-Ndirande dispensary and Polytechnic-Ndirande dispensary links were marginally valid (received powers are -91.1dBm and -92.7dBm, respectively). This means that using Radio Mobile and elevation data, we can predict the performance of various links and assess their viability. As stated earlier, the elevation data used in this study does not take into account physical infrastructure and vegetation that may block RF signals

Table 3: Links performance measures.

Link	Path loss (dB)	Received power (dBm)	Distance (km)	Fresnel zone	Obstruction location (km)
Poly-Limbe	154	-113	3.14	1.1F1	2.83
Poly-Ndirande dispensary	133.7	-92.7	2.871	0.2F1	190
Poly-QECH	104.4	-63.4	0.76	2.4F1	None
Poly-Mpingwe	120.2	-79.1	6.35	1.2F1	None
Mpingwe-Ndirande Hill	124.1	-83.2	5.24	2.8F1	None
Mpingwe-Ndirande Dispensary	132.1	-91.1	6.0	0.2F1	None
Mpingwe-Limbe dispensary	115.5	-74.4	3.77	1.8F1	None
Ndirande Hill-Ndirande Dispensary	113.8	-72.8	2.18	4.7F1	None

IV. Conclusion

In this paper, we have designed an outdoor wireless network based on IEEE 802.11b standard for HealthCare Applications through computer simulation. The purpose was to demonstrate the use of computer simulation in designing outdoor wireless networks. We have used a free software tool called Radio Mobile and freely available geographical elevation data downloaded from NASA to determine the radio frequency (RF) coverage

of a wireless networking base-station and radio link performance. Furthermore, we have demonstrated the flexibility of computer simulation in assessing design alternatives. However, the elevation data used in this study does not take into account physical infrastructure and vegetation that may block RF signals.

V. Reference

[1] Soomro A. & Cavalcanti D. (2007). Opportunities and Challenges in Using WPAN and WLAN Technologies in Medical Environments. *IEEE Communication Magazine*, 45(2), pp 114-122.

[2] Tranter, W.H.; Kosbar, K.L. (1994). Simulation of communication systems. *IEEE Communications Magazine*.32 (7) pp.26-35.

[3] Fishwick P.A. 1995 *Simulation Model Design and Execution: Building Digital World*. Englewood Cliffs, Prentice Hall.

[4] Jeruchim, M.C., Balaban, P., and Shanmugan, K.S., (1992) *Simulation of Communication Systems*, London, Plenum Press.

[5] Bur GA (2006) *Using Radio Mobile for Windows* <www.pizon.org/radio-mobile-tutorial/index.html>

[6] Coudé R (2007) *Radio Mobile for Windows 95, 98, Me, NT, XP, 2000*, <http://www.cplus.org/rmw/english1.html>