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Design Of Wireless Networks Linking Technology for Connecting Health Centers in Rural Areas

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ABSTRACT

To connect far away regions required to link the regions with many towers by using smart antennas. Thus, based on the IEEE 802.16 standards the long distances coverage can be linked with towers of smart antennas to provide wireless network for customers. In our research paper, we provide a survey study of linking the health centers and central and Main Hospital of Nyaruguru District. For rural hospitals where some health centers are far from main district hospital need to link to the central by using powerful wireless technology which could be possible cover up to 50 km.

In this paper, the empirical data collection technique used and based on the interviews, observations, document analysis and the use of software simulation by designing. Radio Mobile software used to design wireless links. ICT officers from District and Doctors and Nurses from Health centers were interviewed to have the view of the field nature and current towers positions and fiber optic backbone to the District. Radio Mobile V 11.2.0 simulation and GPS, Spectrum Analyzer, Google Earth were used. The antenna Specification used is Rocket Dish RD-2G23, Frequency range: 2.3-2.7 GHz, Gain: 23dBi, Polarization: Dual Linear was used to help successful of wireless link design.

Keywords: - Radio Mobile Simulation, Base Station, Line of sight, GPS, Rocket Dish RD-2G23, MATLAB

I. INTRODUCTION

For the past two decades, the world in technology especially in Wireless world has discovered that it is worth to find the multi-hop technology which is cost effective solution and this would serve many users to have access to wireless network and thus, point to point as well as point to multipoint links for serving many users at once in remote areas and providing high speed internet access (Mohammed .,2016).

WiMAX meant by Worldwide Interoperability for Microwave Access has demonstrated its ability to serve many users connected to a single wireless tower. This WiMAX belongs to a family standard of IEEE 802.16 (IEEE Std, 2004). The wireless technology can be a solution for large cities and rural areas at lower cost and high-speed internet of placement (Deepika et al., 2014).

In Nyaruguru District, health centers are located in long distances far from main District's Hospital and it takes more than two hours from one Health Center to another which causes some delay in communication between nurses and doctors to serve the patient.

To find one of many solution is to design wireless network links so that the health centers be connected one another and thus WiMAX towers operates at frequency band between 2- 66 GHz and provides data rates up to 75Mb per second over long distances can be used to support the network between its towers (Gyan and Sadhana,2006; Deepika et al., 2014).

Most mobile WiMAX operators can easily convert from 802.16e to 802.16m and by updating some circuit plate units and software in their bases stations (Gyan and Sadhana, 2006). This WiMAX tower antenna can be used to connecting rural areas and cellular networks (IEEE Std,2004).

This Broadband wireless Access (BWA) is an alternative solution to Digital Subscriber Line (DSL) for Internet convenience and openness (Dhruvakumar et al., 2014). The WiMAX technology operates in licensed and non-licensed frequencies and depending upon frequency for the range up to 16 km it can serve and as well with Line of Site (LOS) and Non-line of Site (NLOS) situation (Mohammed, 2016).

Thus, this paper presents and makes an extended analysis by using Radio Mobile Simulation with the help of Google Earth, GPS to stablish Wireless network links. In this research paper, the WiMAX link followed design for rural places, the appropriate frequency band used is between 2.3 to 2.45 GHz and based on frequency regulation in Rwanda, the frequency matching our research survey study is chosen to be 2300MHz-2400MHz (Kayondo et al., 2017; RURA, 2015; ITU-R, 2016).

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II. LITERATURE REVIEW

2.1. The standard IEEE 802.16e

The standard IEEE 802.16e designed for supporting mobile wireless as portable device for example Personal Digital Assistant (*Dhruvakumar et al.*,2014). The IEEE Standard 802.20 would operate below 3.5 GHz and the mobile WiMAX would work within the 2-GHz to 6-GHz bands.

Further, as the name suggests, 802.16e is suitable for this wireless network linking, with the goal of having WiMAX transmitters which are capable to support the fixed and mobile connections with the goal of promises of lower latency and providing the higher speeds up to 150 mph (Gyan and Sadhana, 2006).

2.2. Wireless links for Telemedicine for Remote assistance

The higher speed internet provided by wireless networks links provided by WiMAX is enough to support in telemedicine and WiMAX antenna anticipated to have a range of up to 40 miles with the speed of up to 70 Mbps **(Divya Garg et al., 2017).** Normally, WiMAX technology was designed and implemented is to offer cheap and fast connectivity of both voice and data communication to support VoIP, data, Image and Video streaming **(Ramoy,2009; Divya** et al., 2017).

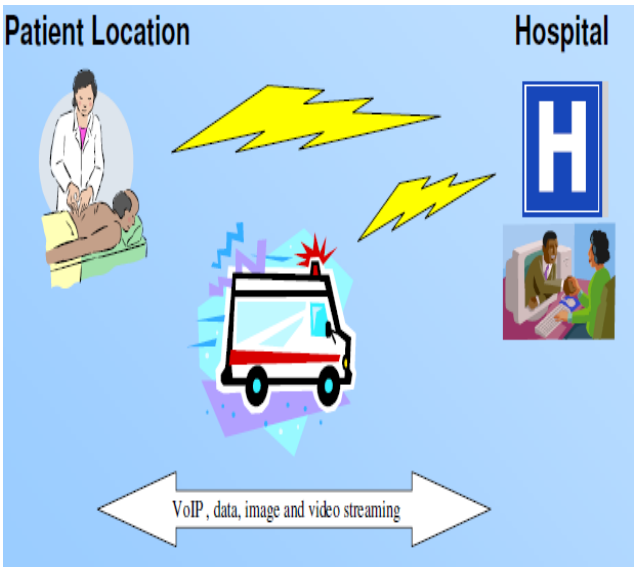


Fig 1: Telemedicine for Remote assistance **(**Eugen, 2012).

The **Fig 1** shows how voice, data, video streaming can be available in WiMAX technology. In this way, Nurses can communicate with Doctors easier and Doctors give the feedback easier by using Voice over IP (VoIP) technology with the help of the high-speed internet.

- ***Base Station and Backhaul***

The responsibility of Base Station (BS) is to supply the air interface to the Main Station and adding that other functionality of BS is micro mobility supervision functions (Mohammad et al., 2015).

For a fixed wireless, the **Fig 2** clarifies an example of fixed WiMAX base station. The WiMAX can be used in Mesh Topology and as well in Point-to-point and also in Point-to-multipoint (Gyan and Sadhana, 2006).

The Subscriber Stations are the devices that provide connectivity to WiMAX networks and the fixed WiMAX considered as wireless backhaul technology for 3G and 4G networks in both developed and developing nations.

- ***Antenna Selection and Positioning***

In wireless network technologies, the selection of antennas to be used is very important and it asked to be careful while we chose antennas to use. We have checked antenna according to its ability, signal quality and signal intensity, accessibility and measurability to achieve to the best results (ITU-R., 2016).

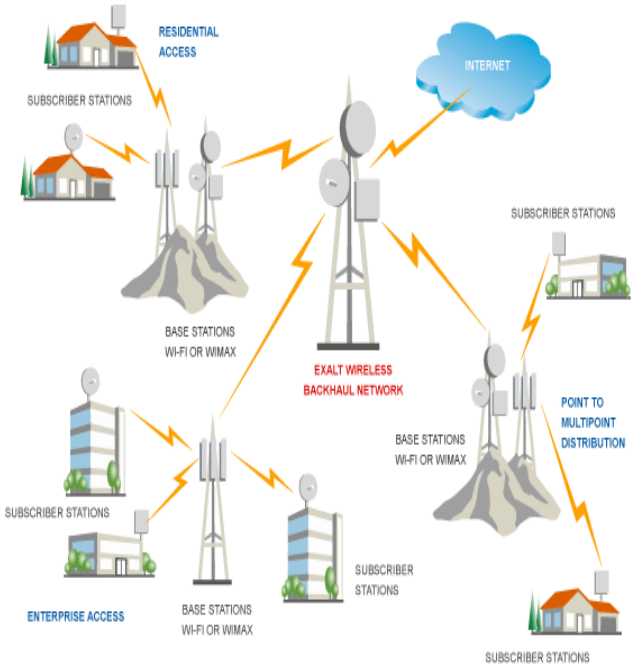


Fig 2: Backhaul. **Exalt (2010)**

- ***Input Parameters*:** This part of input parameters, demonstrate the useful parameters to be entered in the software. Network parameters which accept all main elements needed in the network and in our research the transmitted Power succeed is 20dBm and the Sensitivity threshold is set to be -85 dBm for the best type modulation 64 QAM ¾ (Tranzeo, 2012).
- ***Output Parameters*:** The output we want from software is the received power which can express whether we have a real enough signal which is able to carry out signal from transmitting to the receiving antenna.
- **Radio Link Analysis**

Before planning a link, we have to think about three important questions:

- How far can it go and what will the throughput be?
- How much power can we use?
- What kind of antennas should be use?

Received power (Rx)= EIRP - FSL + Receiver antenna gain – Cable loss.

For evaluation of the reliability of each Radio Frequency link (RF), then RF path analysis and System Operating Margin or **Link Margin** = **Power received (dBm) – Receiver Sensitivity (dBm).** We set up latitude, altitude and longitude of all health centers in Nyaruguru District with backhaul link from Munini DH to Nyaruguru District office. Rocket dish antenna with 23dBi is used. The average frequency is 2350 MHz to each link and the loss is set to 1dBi for each radio link.

The position of antenna is chosen to be at higher level point to serve an antenna which is located at very long distance from transmitter. Thus, Rocket Dish antenna operates in range of 2.3-2.7 GHZ with 23dBi is chosen as the best for a long distance. In this research, we used smart towers (25-30m) as it fitted to be considered to be used at Munini DH and at Mount Munini **(**Obreja et al.,2011). Smart antenna may also be at the repeatereater Nyantanga placed to 10.4 km from BS of Munini DH.

- ***Radio-Mobile* V 11.2.0 *Software***

To make our research survey successful, the role of software took a special case to help us design all the links related in this research. Radio-Mobile V 11.2.0 a simulation tool which is radio propagation and virtual mapping software. It helped us to evaluate and visualize the behavior of the installed radio link, and the evaluation of the link budget.

Radio-Mobile is a simulation tool, used to predict the performance of a radio system. It uses digital terrain elevation data for automatic extraction of path profile between a transmitter and a receiver. Radio mobile determined the visibility case of each radio link. In this software, we use Point to Point Mode (PTP) and Point to Multipoint (PMT) also used. Google Earth also helped us to find and located places where we put antennas after inserting the coordinates took by using GPS tool. GPS which helped to find the coordinates of all places located of health center in Nyaruguru District and Spectrum Analyzer which detected whether signal power is available from nearly antenna from any telecommunication company in Rwanda.

2.3. Why we use WiMAX technology to link the Health Centers

The WiMAX technology is a part of 4G Networks and it can be easier to be upgrade for next generation of wireless and thus it has the fast speed which can send the data rate of 75 Mbps (Gyan and Sadhana, 2006). With a large area service, the WiMAX networks links can increase the area coverage by using the Mesh topology to increase area. WiMAX technology confirm both wireless and wired network including cable operator which are successful referable to core networks of WiMAX (Mohammad et al., 2015).

The Quality of Service (QoS) of WiMAX have properties work on multimedia which doesn't slow speed transfer this concept is on the Time Division Multiplexing (TDM) or Voice over IP (VoIP) or Video over IP (V2oIP). The QoS mechanism used by WiMAX is based on connections between the base station and end user device (Fazel and Kaiser, 2008). Security of the WiMAX is higher enough to encode and decode password.

Therefore, it can detect user from spyware and other an unspecified thing (Mohammed, 2016). However, Divya et al**. (2017)** demonstrated that one of many advantages of the WiMAX technology is that its flexibility. Nyaruguru District has rural areas where the health centers are far from the central hospital and it is in this way, WiMAX would the best choice to connect the rural places of the health centers regions. An example of simple wireless tower with different services for subscribers is shown in **Fig 3**.

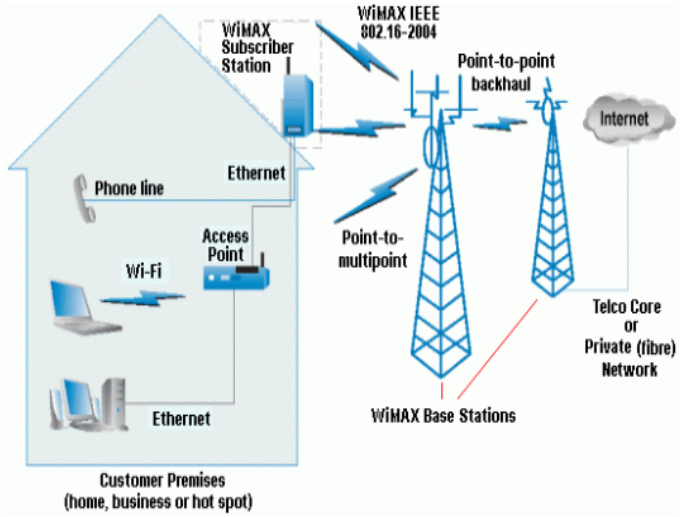


Fig 3: Simple WiMAX Subscriber (Divya et al., 2017)

III. METHODOLOGY

3.1 Data Collection Technique and Analysis

In this paper, the empirical data collection techniques used based on the interviews with nurses and doctors, observations of the terrain, checking power signal availability with spectrum analyzer, document analysis and the use of software simulation. Frequency used set to be Minimum of 2300 MHz and Maximum of 2400 MHz and Global Positioning System (GPS) used to fix the coordinates and LOS were analyzed by using Radio Mobile simulation. We collected coordinates by the use of GPS and results shown in

Table 1. GPS coordinates used

HEALTH CENTRE HC	LATITUDE	LONGITUDE	ALTITUDE
Coko HC	2^0 42’58.10”S	29^0 34’ 48.7”E	1862.2m
Cyahinda HC	2^0 44’27.0”S	29^0 36’ 32.8”E	1862.1 m
Maraba HC	$2^0$44’14.20’’S	29^0 38’38.3’’E	1748m
Nyantanga HC	$2^0$43’42.70’’S	29^0 39’11.5’’E	1681.2m
Ngoma HC	$2^0$44’36.20’’S	29^0 41’49.2’’E	1789.7m
Ngera HC	$2^0$42’49.20’’S	29^0 41’11.9’’E	1734.6m
Nyaruguru District	2^0 41’56.60”S	$29^0$34’13.20”E	1891.2m
Kivu HC	2^0 36’57.20”S	$29^0$27’35.30”E	2265.9m
Muganza HC	2^0 41’17.70”S	$29^0$29’39.80”E	1963.1m
Munini DH	2°42’47.6’’S	29°32’07.4’’E	1999.1m
Nyabimata HC	2^0 41’22.6” S	29^0 26’ 40.1”E	2108.5m
Ruramba HC	2^0 33’35. 1”S	29^0 32’ 22.6”E	2024.2m
Mount Munini	2°42’37.1’’ S	29^0 31’17.2” E	2107m
RepeaterNyantanga	2°43’31.0’’ S	29^0 37’ 43.0”E	2102m
Ruheru HC	2^0 44’51.6”S	29^0 27’ 14.4”E	2282.8m
Kibeho HC	2°38’.767’’ S	29°33’.189’’E	1902 m
Nyamyumba_HC	2^0 34’59.8”S	29^0 33’ 20.4”E	1897.9m
Runyombyi_HC	2^0 46’47.33”S	29^0 46’ 06.0”E	1931.5m

IV. SOFTWARE SIMULATION RESULTS AND DISCUSSIONS

Each link carried out a radiated power (EIRP) of 42dBm and Rx sensitivity is -85dBm. The Fig 4 shows the link between Munini DH and Mount Munini.

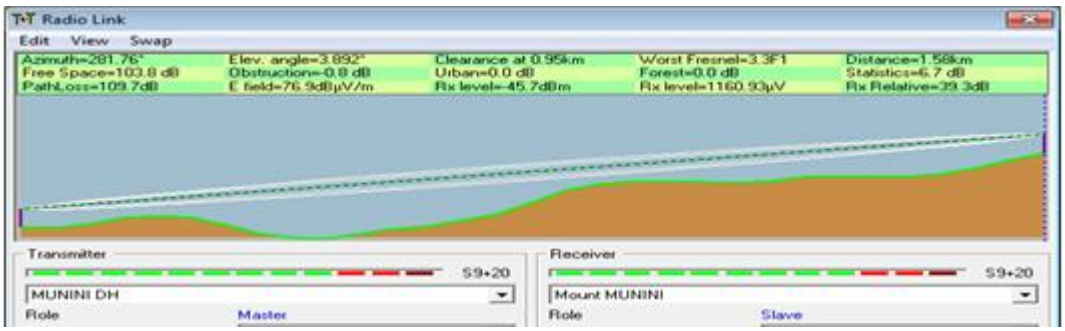


Fig 4: Munini DH and Mount Munini link

Here the Mount Munini used also as the repeater to the nearest health centers. The findings showed that propagation mode is line-of-sight, minimum clearance 3.3F1 at 0.9km. This means that WiMAX link is possible and it would provide the wireless to the customers between two towers and the one is fixing at Munini District Hospital and other tower is fixing at Mount Munini acts as the repeatereater to connect to Muganza Health Center. The Fig 5 shows the link between Mount Munini and Muganza HC

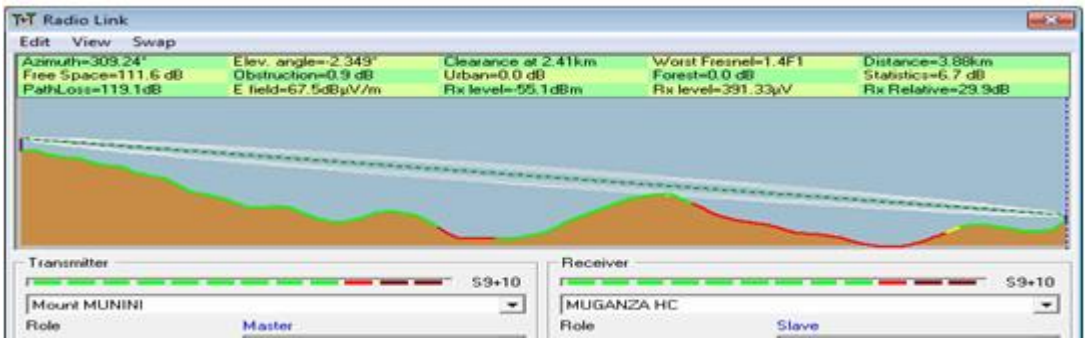
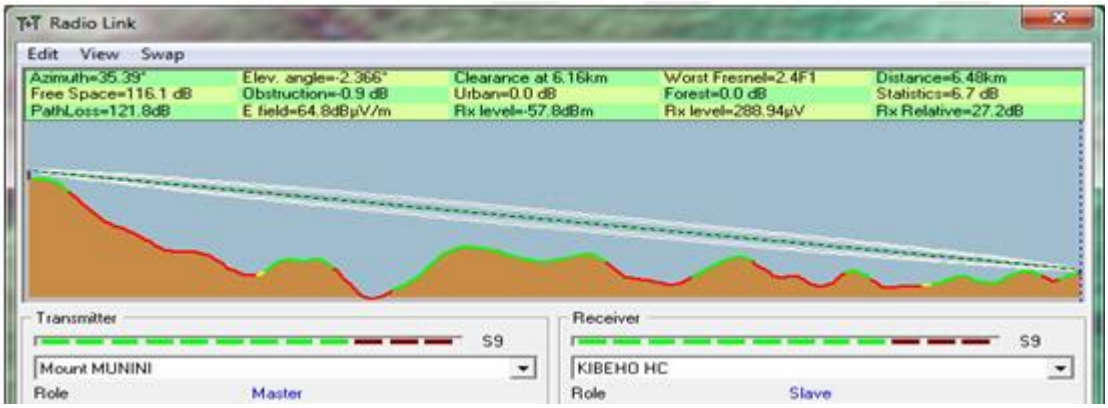


Fig 5: Mount Munini to Muganza HC Link.

The findings from simulation showed that Distance between Mount Munini and Muganza HC is 3.9 km and the propagation mode is line-of-sight, minimum clearance 1.4F1 at 2.4km. The following figure shows the link between Mount Munini and Kibeho HC.

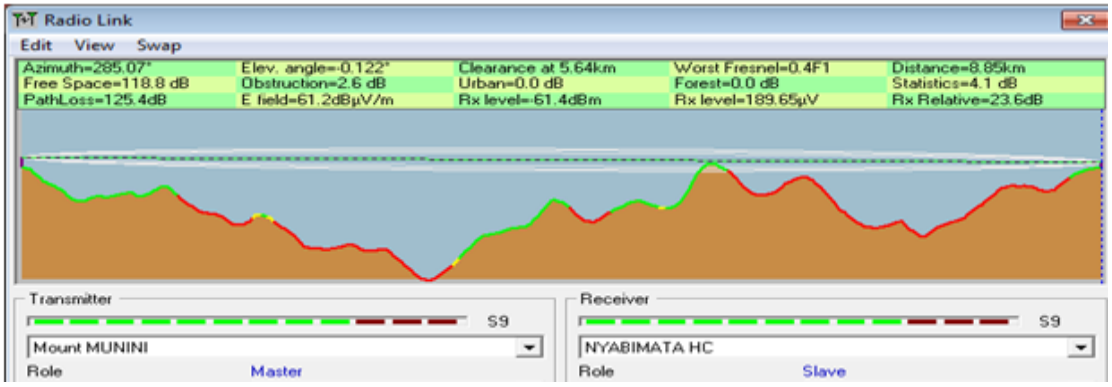
To connect Kibeho Health center ,we used Mount Munini and the link was successful.



The Fig 6 shows the link between Mount Munini and Kibeho

Fig 6 showed that Distance between Mount Munini and Kibeho HC is 6.5 km and Terrain elevation variation is 322.2 m and propagation mode is line-of-sight with minimum clearance 2.4F1 at 6.2km. The following shows the link between Mount Munini to Nyabimata.

The Fig 7 shows the link between Mount Munini and Nyabimata Health center where Mount Munini used as the repeater.



The Fig 7: Mount Munini to Nyabimata link.

This link shows that that the terrain elevation variation is 304.4 m. Distance between Mount Munini and Nyabimata HC is 8.8 km. The propagation mode is line-of-sight, minimum clearance 0.4F1 at 5.6km. Here the Receiver antenna height is 10 m.

The link between from Mount Munini and Kivu Health center is shown in Fig 8

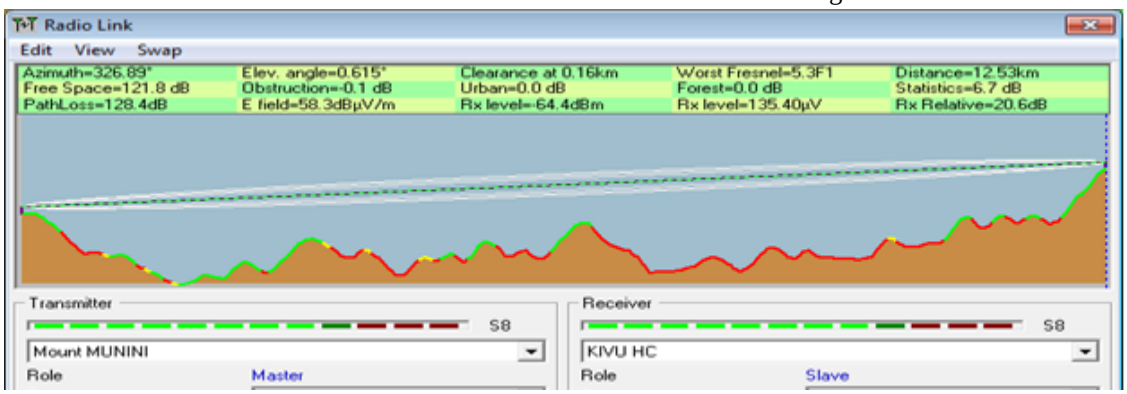
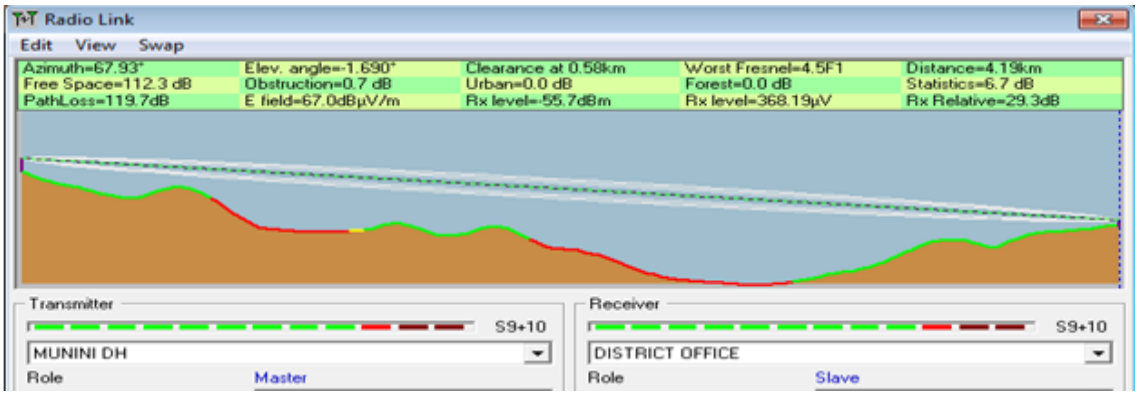


Fig 8: Mount Munini to Kivu HC wireless link.

This link shows that distance between Mount Munini and Kivu HC is 12.5 km and the terrain elevation variation is 384.4 m. The propagation mode is line-of-sight, minimum clearance 5.3F1 at 0.2km.

The link between Munini District Hospital and District Office where District Office used as the backhaul is shown in Fig 9.



The Fig 9 : Munini District Hospital and District Office (Backhaul)

This wireless link shows that distance between Munini DH and District office is 4.2 km and the terrain elevation variation is 222.6 m. The propagation mode is line-of-sight, minimum clearance 4.5F1 at 0.6km. Which means that the wireless network is possible.

The wireless link between Munini District Hospital and Coko Health center is shown in Fig 10.

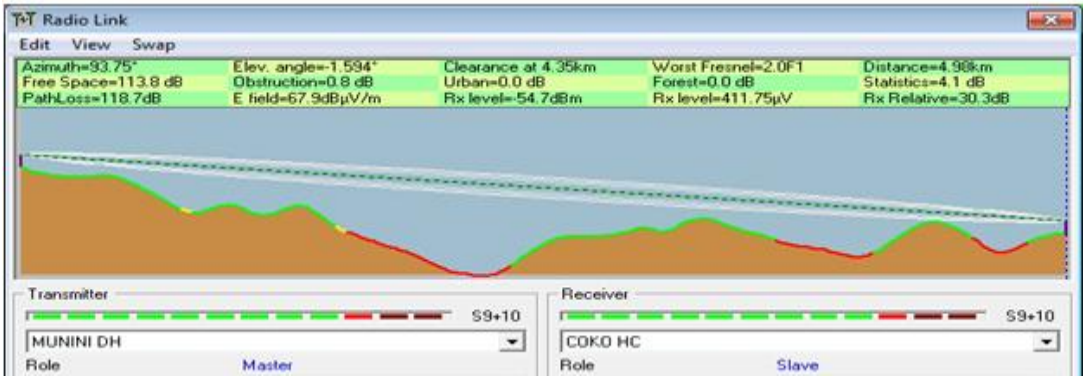


Fig 10: the link between Munini DH and Coko HC.

The wireless link in Fig 10 shows that distance between Munini DH and Coko HC is 5.0 km and the terrain elevation variation is 220.0 m. The propagation mode is line-of-sight, minimum clearance 2.0F1 at 4.4km. The wireless link between Runyombyi Health center and Ruheru Health center is possible as seen in the Fig 11.

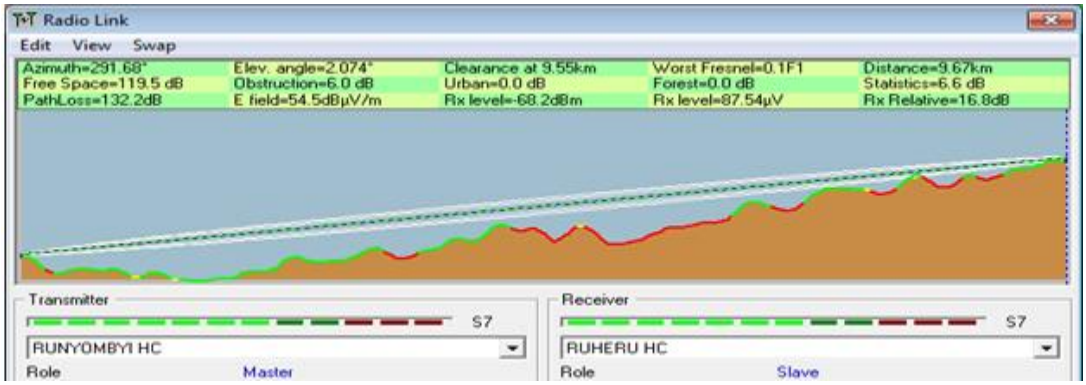


Fig 11: Runyombyi HC and Ruheru HC wireless link

The Fig 11 shows that Distance between Runyombyi HC and Ruheru HC is 9.7 km and the terrain elevation variation is 447.7 m. The propagation mode is line-of-sight, minimum clearance 0.1F1 at 9.6km.

During survey, we set also Nyantanga to play the role of repeater to make connection easier with Munini District Hospital

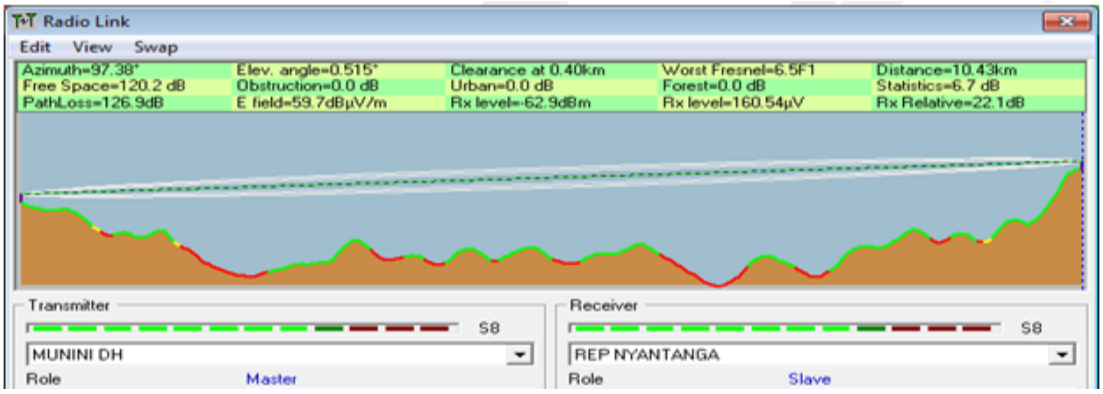


Fig 12: Wireless link between Munini DH and Nyantanga HC

The fig 12 illustrated that distance between Munini DH and Nyantanga is 10.4 km. This Fig 12 also shows that the terrain elevation variation is 363.8 m and the propagation mode is line-of-sight, minimum clearance 6.5F1 at 0.4km. Nyantanga tower is used also as the repeater to support far regions.

The wireless link to connect to Ruramba Health center, we used repeater Nyantanga and the wireless link is shown in Fig 13

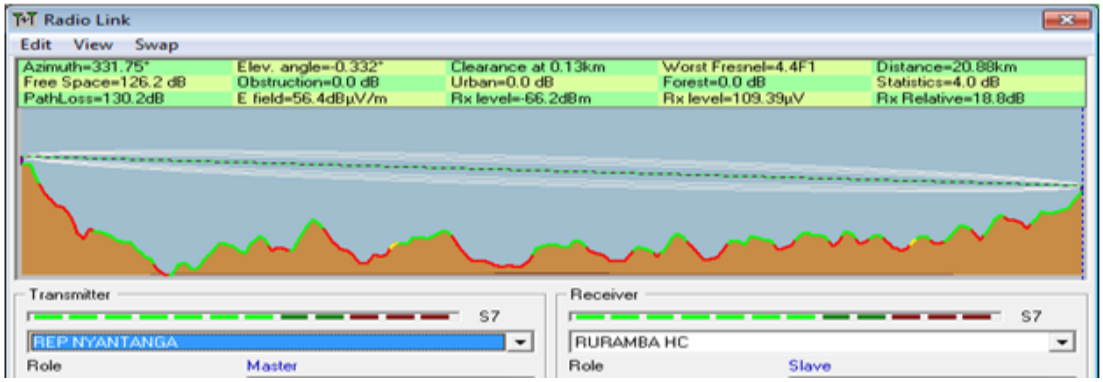


Fig 13: Wireless link between Nyantanga and Ruramba HC

The Fig 13 shows that distance between Repeater Nyantanga and Ruramba HC is 20.9 km and the terrain elevation variation is 356.5 m. The propagation mode is line-of-sight, minimum clearance 4.4F1 at 0.1km.

To connect to Nyantanga Health center, we used Nyantanga Mountain as repeater and the wireless link is possible as shown in Fig 14

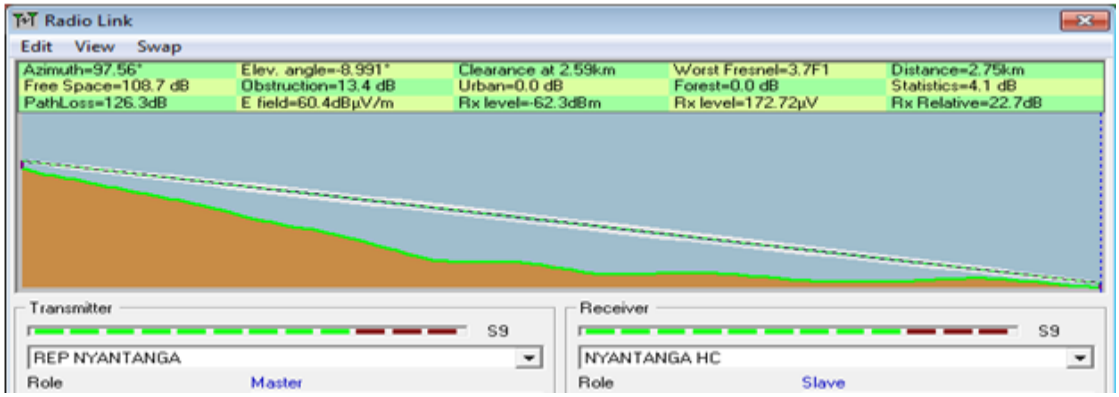


Fig 14: Wireless link between Nyantanga Mount and Nyantanga HC

The Fig 14 shows that distance between repeater Nyantanga and Nyantanga HC is 2.8 km and the Terrain elevation variation is 423.3m and the propagation mode is line-of-sight, minimum clearance 3.7F1 at 2.6km.

To connect to Kabirizi HC, we took the connection from repeater Nyantanga and the wireless link is shown in Fig 15.

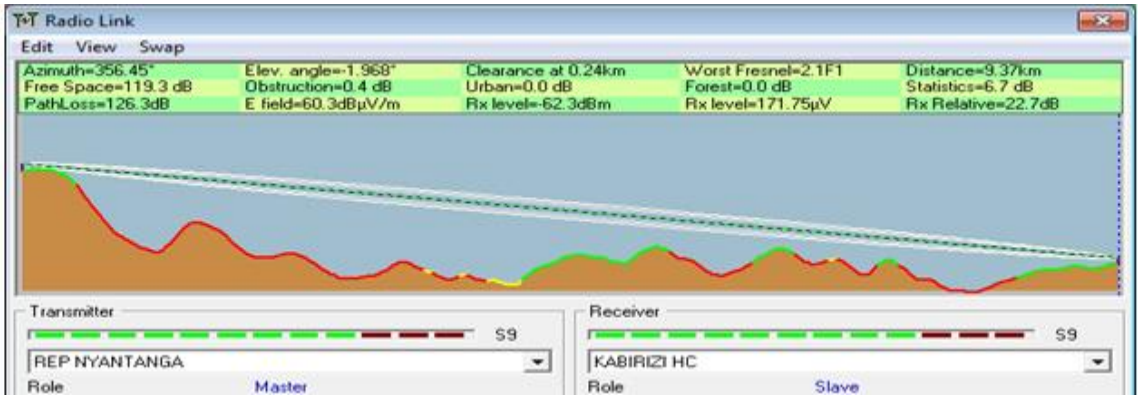


Fig 15: Repeater Nyantanga to Kabirizi wireless link

The fig 15 shows that distance between Repeater Nyantanga and Kabirizi HC is 9.4 km and the terrain elevation variation is 414.0 m. The propagation mode is line-of-sight, minimum clearance 2.1F1 at 0.2km.

To fix wireless link to connect Ngoma HC, we use also repeater Nyantanga Mount and the wireless link is possible as shown in Fig 16.

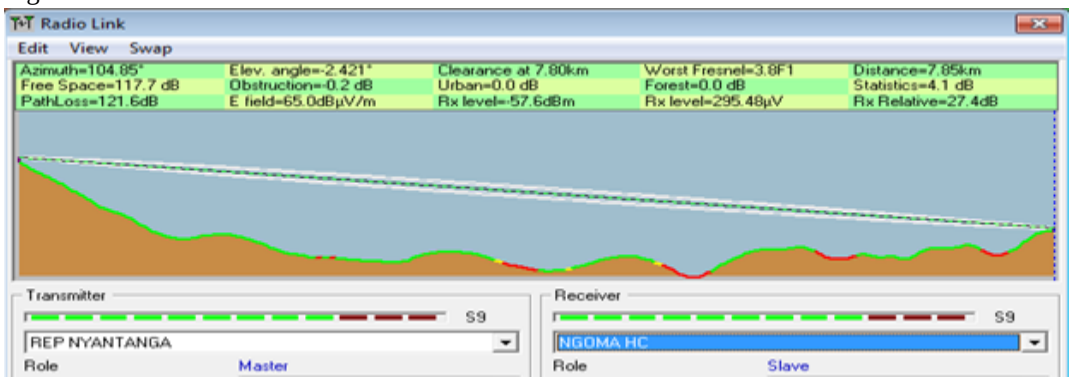


Fig 16: Nyantanga Mount to Ngoma HC Wireless Link

The Fig 16 shows that the distance between Repeater Nyantanga and Ngoma HC is 7.9 km and terrain elevation variation is 518.7 m. The propagation mode is line-of-sight, minimum clearance 3.8F1 at 7.8km

To connect Ngera HC we used also repeater Nyantanga and wireless link is shown in Fig 17.

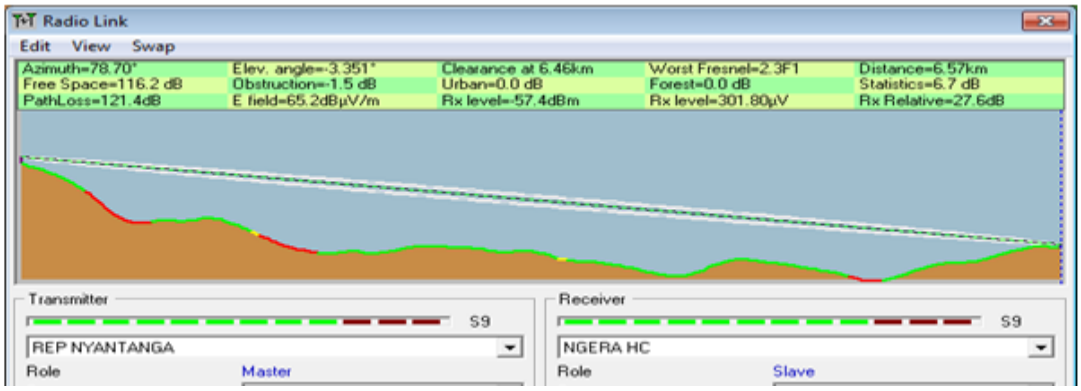


Fig 17: link between Repeater Nyantanga and Ngera HC.

Fig 17 shows that distance between Repeater Nyantanga and Ngera HC is 6.6 km and the terrain elevation variation is 509.4 m. The propagation mode is line-of-sight, minimum clearance 2.3F1 at 6.5km.

To connect Maraba Health Center, we also used Repeater Nyantanga and the wireless link is shown in Fig 18.

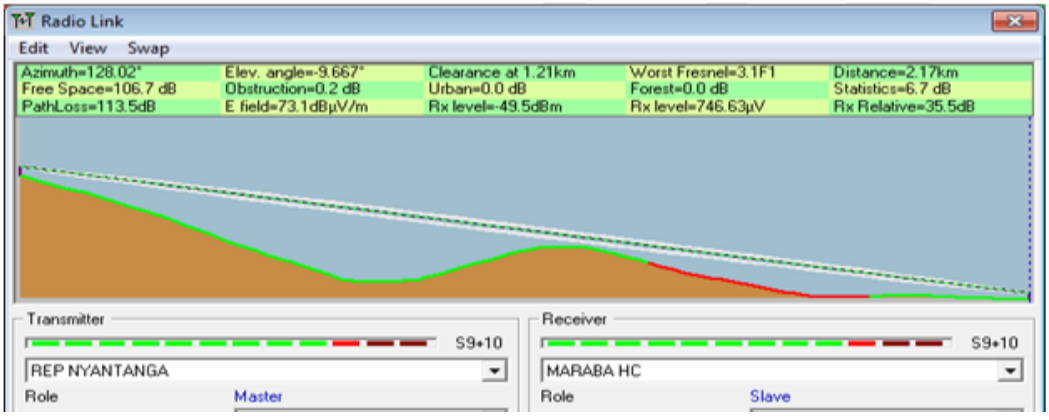


Fig 18: Repeater Nyantanga to Maraba HC wireless link

The Fig 18 shows that distance between Repeater Nyantanga and Maraba HC is 2.2 km and terrain elevation variation is 352.6 m. The propagation mode is line-of-sight, minimum clearance 3.1F1 at 1.2km. To connect Nyamyumba HC, repeater Nyantanga is used and the wireless link is shown in Fig 19.

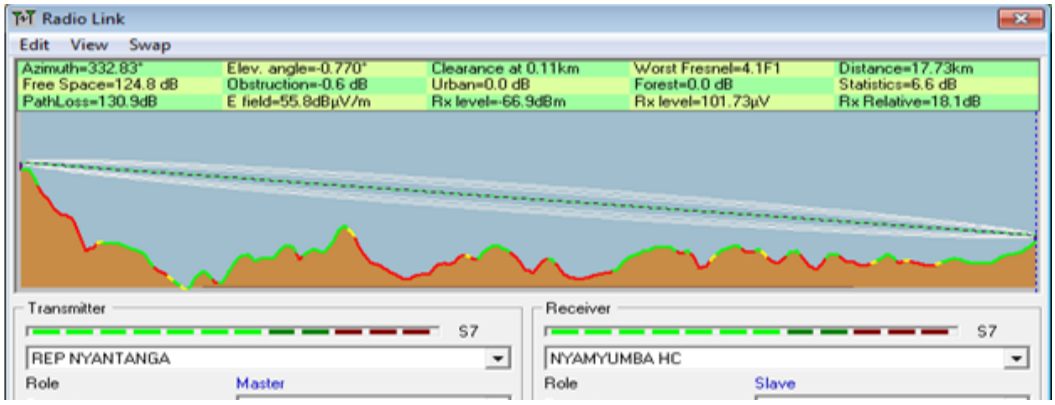


Fig 19: Repeater Nyantanga to Nyamyumba HC

The Fig 19 shows that distance between Repeater Nyantanga and Nyamyumba HC is 17.7 km and the terrain elevation variation is 360.8 m. The propagation mode is line-of-sight, minimum clearance 4.1F1 at 0.1km. Adding that the link Repeater Nyantanga to Cyahinda HC shows that distance between Nyantanga and Cyahinda HC is 2.8 km and the terrain elevation variation is 265.3 m. The propagation mode is line-of-sight, minimum clearance 5.0F1 at 0.2km.

The topology which covered wireless link of all health centers in software simulation is shown in Fig 20.

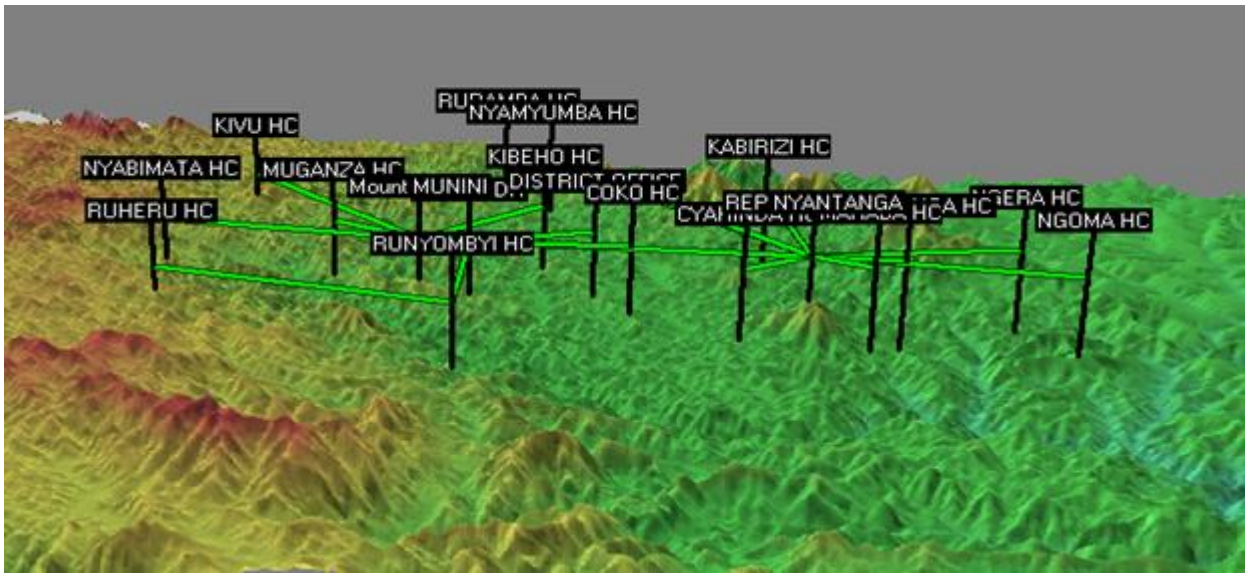


Fig 20: Topology networks in software simulation (Radio Mobile)

II. RESULTS DISCUSSION

In this research paper, for all wireless network links we set transmitter antenna height to 25 meters and for the most receiver antennas height to 10 except Coko Tower and Repeater Nyantanga also used tower height of 25 meters. Rocket dish antenna with 23dBi is used and the average frequency is 2350 MHz to each link and the loss is set to 1dBi for each radio link. Each link carries out a radiated power

(EIRP) of 42dBm and Rx sensitivity is -85dBm. Rocket dish antenna with 23dBi is used.

The findings showed that the average received power is Rx= - 51.7545 dBm which is secure enough to permit the data at the receiver end. The average Maximum Channel Noise (MCN) is -76.7545 dBm which cannot affect our networks. The average link margin (33.07198 dB) is enough to allow the existence of the Radio link. Therefore, with above MCN and Rx, we may calculate the capacity of a system to reproduce loud sounds without distortion = Rx - MCN which is equal to 25dB. The results of this research found that average link margin seems to be enough to provide data rate up to 54Mbps. The link budget is calculated by using MATLAB calculations and use M-file to configure what we wanted to display Rx and so forth and here are the codes used:

d= str2num(get(handles. edit1,'string'));

f= str2num(get(handles.edit2 ,'string'));

L=32.4+20log10(d)+20*log10(f);

c= num2str(L);

set(handles.text1,'string',c);

where d is the distance in km and L=FSL, f is frequency in MHz

The Table 2 shows the observation to the wireless network link after calculations in MATLAB and the findings showed that the wireless network linking is possible to link these health centres in Nyaruguru District

Links	FSL [dB]	Distances [Km]	LM [dB]	MCN [dBm	Rx [dBm]	Observation to the link
Munini DH-Mount Munini	103.9038	1.6	45.0962	-64.9038	-39.9038	OK
Mount Munini rep-Muganza HC	111.6426	3.4	37.3574	-72.6426	-47.6426	OK
Mount Munini rep-Kivu HC	121.7596	12.5	27.2404	-82.7596	-57.7596	OK
Mount Munini rep-Nyabimata HC	118.711	8.8	30.289	-79.711	-54.711	OK
Munini HC-District Office	112.2863	4.2	36.7137	-73.2863	-48.2863	OK
Munini HC-Coko HC	113.8008	5	35.1992	-74.8008	-49.8008	OK
Mount Munini-Kibeho HC	116.0796	6.5	32.9204	-77.0796	-52.0796	OK
Munini HC- Runyombyi HC	117.206	7.4	31.794	-78.206	-53.206	OK
Runyombyi HC (rep)-Ruheru HC	119.5568	9.7	29.4432	-80.5568	-55.5568	OK
Munini HC-Rep Nyantanga	120.162	10.4	28.838	-81.162	-56.162	OK
Rep Nyantanga-Ruramba HC	126.2243	20.9	22.7757	-87.2243	-62.2243	OK
Rep Nyantanga-Kabirizi HC	119.2839	9.4	29.7161	-80.2839	-55.2839	OK
Rep Nyantanga-Nyantanga HC	108.7645	2.8	40.2355	-69.7645	-44.7645	OK
Rep Nyantanga-Ngoma HC	117.7739	7.9	31.2261	-78.7739	-53.7739	OK
Rep Nyantanga-Ngera HC	116.2122	6.6	32.7878	-77.2122	-52.2122	OK
Rep Nyantanga-Maraba HC	106.6698	2.2	42.3302	-67.6698	-42.6698	OK
Rep Nyantanga-Cyahinda HC	108.7645	2.8	40.2355	-69.7645	-44.7645	OK
Rep Nyantanga-Nyamyumba HC	124.7808	17.7	24.2192	-85.7808	-60.7808	OK
Total	2083.5375	139.8	595.4364	-1381.5824	-931.5824	OK
Average	115.752083	7.76	33.0798	-76.7545	-51.7545	OK

Table 2: Radio Link Analysis by calculations

CONCLUSION AND RECOMMENDATION

i. CONCLUSION

In this paper, our objective was to investigate and study the field of Nyaruguru District and check whether the wireless networks linking is possible so that the rural Health centers could connect to main District Hospital of Nyaruguru District.

We chose Nyaruguru District as the area which has many high mountains similarity to other many regions in the country, which means the results can be also applicable in many regions of the country which could have the same problems. The possibility of this design could help the health centers to provide good services to the patients as they have to share knowledge easily with far doctors in the country.

In this research survey paper, we use software simulation Radio Mobile as it has the capability in wireless link and provide addition details to analyse the wireless links. We analysed whether there are no obstacles that could be the barriers for Wireless implementation towers and the propagation mode is line-of-sight with enough clearance which is meant wireless network link is possible and hence the Implementations towers would be possible without propagation obstacle to connect the health centers and others customers that would need wireless internet.

For the successful wireless links towers, smart antenna category of Rocket Dish RD-2G23, with Frequency range: 2.3-2.7 GHz, Gain: 23dBi, Polarization: Dual Linear were used.

ii. RECOMMENDATIONS

However, as the technology moves so fast it happened that Since WiMAX is used almost for decades and it is a part of Wireless 4G generation and it is easier to be updated for modern technology like LTE and even 5G Network technology but the current towers would be used (Bizimana et al.,2022). The policy makers and the ISPs have to intervene in this regards of upgrading WiMAX technology or LTE to new technology as when it is operated in the unlicensed nature interferences between towers might occur and it is for this reason it needs to be upgraded to resolve this issue. Because of the benefits of connecting Nyaruguru District's Hospital to its health centers, we recommend Ministry of Health (MOH) to provide the needs to support Nyaruguru District in this project to succeed. We also recommend To Rwanda Energy Regulation (REG) to resolve Electricity issue in Nyaruguru District because at time of Field survey, some health centers lacked electricity and mainly use of solar energy.

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