OPAALS PROJECT

Contract n° IST-034824

WP11: Bridging Digital Ecosystems Research to Regional Development and Innovation in the Knowledge Economy

D11.16 - Report on Gasabo District wireless community network deployment experience exchange

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Short Description:

The Deliverable provides a comprehensive account of the progress made on the Gasabo District wireless community network deployment experience exchange project during the reporting period June 2009-August 2010. It also addresses issues and problems affecting the progress of the project or with other projects.

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Partners contributed: NUR

Made available to: the Public

Versioning

Version	Date	Name, organization
1	20/09/10	National University of Rwanda
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Dependencies:

Achievements*	Gasabo District wireless community network deployment project was planned to study and evaluate the use of ICT in some selected sectors of the District, evaluate the socio-economic impart on the inter and intra community usage and service delivery. To realise this goals, the project was organisedin three phases: Phase I 1. To carry out a survey and analyse the usage and needs of ICT in some selected sectors within - rural Gasabo District.

	2. Base on (1), to select and design appropriate ICT infrastructure and services to serve the selected sectors. Phase II 3. To implement and test the designed infrastructure and install the appropriate services for the selected sectors Phase III 4. To study and analyse the socio-economic impart of the proposed ICT services on the selected communities. Phase I was completely executed from June to December 2009. During this phase the following were done: Four districts out of eight were selected in collaboration with the Rwanda Development Board (RDB), the organisation, which expressed the desire to support the project and the communities were also selected based on the outcome of the survey that was carried out. A Campus Area Network (CAN) using WiMAX was designed. Local Area Networks (LAN) using ThinClient as well as the design of Wireless Local Area Networks (WLAN) to serve the communities were also completed. Based on unavailability of the national electricity, at one out of the four selected communities, we designed solar photovoltaic system to power the network. For all the LANs, we used the existing electrical network to develop power line communication network instead of the conventional networking using special cables eg CAT 6. To provide cheaper means of communication, VoIP was designed to be used all over the network. To sustain the digital ecosystems within the communities, we planned to train some selected communities to maintain and sustain the network and services. The National University of Rwanda (NUR) became a member of the OPAALS research group during the final phase. Unfortunately, there was no budget for purchase of equipment. The local organisation (RDB) could not financially support the project due to budgetary problems as a result the NUR group could not proceed to phase II. In this deliverable we present: how the district and the sectors were selected; the methodologies for the choice of technology and various proposed services; finally we presented the designed system. The report also discussed the problems in realising its final objectives but also gave some recommendations.

Work Packages	This deliverable may be beneficial to all partners belonging to WP10 ,WP11 and WP12
Partners	NUR
Domains	A combination of Social Science and Computer Science domains.
Targets	The main target of this deliverable are the SMEs, however just after completing the projedt the public administration will also interested.
Publications*	The following abstracts are being prepared for submission in international journal and conferences "A proposed Infrastructure for ICT service Delivery in the Gasabo Rural" "Ensuring a sustainable ICT Infrastructure and Service Centres in a Rural environment: The case of Rural Gasabo Network"
PhD Students*	There are no PhD students But the researchers who are working on the platform were the final year undergraduate students with background in the fields of Telecommunication Engineering and Computer Science. Their contributions are: Design of the WiMAX infrastructure network; Design of the WLAN, Design of LAN based on Thin Client all LANs are pallned to use Power Line Communication. Design of the Solar Photovoltaic power system, Design of the Voice and Video over IP (VoIP).
Outstanding features*	Presentation on the design network using WiMAX as a backbone, which will be used as a living laboratory for students' field practical work and testing drew a lot of attention from both local and foreign interest groups: We designed WiMAX network as alternatives to other communication infrastructure for cheap voice and data services, provide facilities for primary schools to be part of OneLaptopPerChild program. To support by training teachers and students of secondary school teachers in Science and Mathematics to give services in WLAN, LAN and trouble shooting in remote areas. Using VoIP technology to provide services to call centres and to hospitals instead of using expensive GSM MODEMs. The eHealth Department of Ministry of Health of Rwanda requests for support to use OPAALS' project network, if put

	in place, to test eHealth packages in the rural areas and advice the Ministry on usability of package. The Local Government find it difficult to introduce its eGovernment agenda due to poor ICT infrastructure in the rural parts of the districts. Our model will also planned to alert local government to use alternatives which could be less expensive. The Faculty of Medicine of the National University of Rwanda would like to work with the MSc in ICT Program on collaborative research in telemedicine. It is also acknowledged by the Groupo (GPI) of Trento, Italy as an innovative way of testing new developed untested packages. If we successfully used the OPAALS platform for our project and deploy some of the flypeers, the use of the results of the works done by the OPAALS research group will not only be limited to Europe but also the developing countries like Rwanda. Presently, the Ministry of Education would like to work with the MSc in ICT Program to design a WiMAX network to cover the entire Kigali. This will include the rural areas.
Disciplinary domains of authors*	Dr Felix K. Akorli, ICT

The information marked with an asterisk (*) is provided in order to address Recommendation n. 4 from the Year 2 review report

Table of Contents

1. Introduction

The vision of the Government of Rwanda is to build a knowledge base economic using ICT as its foundation. Many projects have been initiated in the past but efforts to get the rural areas to benefit from or take full advantage of these projects has been very slow. Some of the projects are: OneLaptopPerChild, eHealth, eGovernance, Cyber Cafes etc.

Over years, Cyber cafes have been spread all over the country unfortunately, most of those in the remote areas have been closed down. Some of the reasons are: lack of maintenance, expensive Internet connectivity cost, qualify staff to manage the cafes.

There are cases where diseases about animal are not communicated to appropriate authorities due to lack of improper communication infrastructure

The eGovernance is only being felt in the urban areas. The administrative sectors in the rural areas do not have connectivity. They depend on expensive services of mobile companies, which permit limited access among the executives. Information sharing from sector to district and vice versa is still based on paper works and physical delivery led to mismanagement of time, high cost of information delivery.

Health centres could not easily transfer referred cases to well equipped health centres because of lack of or high cost of communication cost and unavailability of good roads.

Primary schools in the rural areas are not benefiting from the OneLaptopPerChild project because of unavailability of connectivity and high cost of accessing internet through the MODEMs.

To solve some of the above mentioned problems, the Gasabo District wireless community network deployment project was to study the use of ICT by communities in some selected sectors of the District, evaluate the inter and intra community usage and service delivery and to come out with recommendation as to how to mitigate some of the problems. To realise this goals, the project was

planned in three phases:

Phase I

1. To study and analyse the usage and needs of ICT in some selected sectors within rural Gasabo District.
2. To select and design the appropriate ICT infrastructure and services to serve the selected sectors.

Phase II

3. To implement and test the designed infrastructure and install the appropriate services for the selected sectors

Phase III

4. To study and analyse the socio-economic impact of the proposed ICT services on the selected communities.

Phase I was completed in December 2009. The district was selected in collaboration with the Rwanda Development Board (RDB), the organisation, which expressed great interest to support the project.

Phase II was to be completed in February 2010 and the third phase was to begin in March, 2010.

The National University of Rwanda (NUR) could not start phase II became we became a member of the OPAALS research group during the last Phase of the project. No budget was allocated for purchase of equipment. The RDB, that expressed great to support the project was unble to financially support the project with purchase of equipment sets for phase II. As a result the project could not start phase II.

In this deliverable we present what was done in phase I: how the district and the sectors were selected; the methodologies for the choice of technology and various proposed services; finally, the designed infrastructure and system to deliver the services. The report also discussed the problems faced during the implementation of phase I.

2. The Gasabo District Experience

This district was selected because the Rwanda Development Board planned to open cyber Cafes in the remote rural areas within the district in order to give access to Internet facilities and create IT training centre to help the rural communities to be trained in the use of IT tools. To RDB, this project was to help suggest possible solutions to extending ICT facilities to the remote areas.

2.1 The Gasabo District

This district covers approximately 429 km², with a population of 410, 485 inhabitants, it is the largest of the three districts of the Kigali city. It is divided into 15 sectors, figure 1, seven of these are urban and the rest, 8 are rural. In total there are 104 schools; 15 first level, 57 primary schools and 32 secondary schools; It also has 4 hospitals and 12 clinics and health centres.

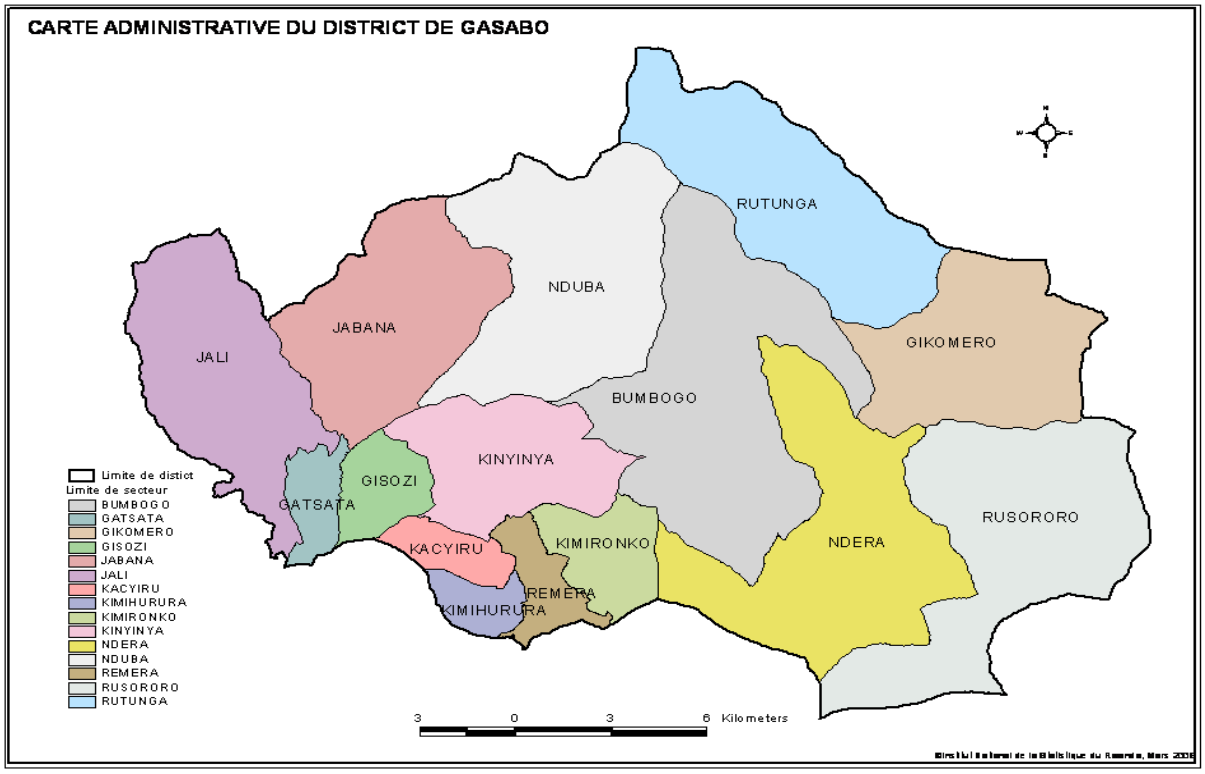

Figure 1: Gasabo District and its Sectors

2.2 Criteria for selection of the sectors

The criteria, agreed upon by the project team and RDB-IT staff, for selecting the four sectors were based on the following:

- having a primary school located on the same campus with or not far from a secondary or technical school;
- There should be a clinic or health centre or a hospital;
- The communities must be interested in and ready to use IT facilities for improving upon their respective socio-economic status.

All the eight districts were visited and based on the above set criteria, the team selected the following four sectors:

1. Jali
2. Ndera
3. Rusororo
4. Gikomero

These sectors are at least 15 kilometres away from one another and are situated within the mountains.

2.3 Methodology for Selection of the Communities and Services for Design and Implementation

In order to select the various communities (group of organised people) that would be used for the the project, the following research methods were used:

- structured questionnaires for the executive secretary and staff of the sector office;

This was to identify the obstacles that impede effective running of the sector and to discuss how the introduction of ICT facilities could help the office improve upon effectiveness and efficiency of operation and service delivery:

- structured questionnaires for the heads and staff of the primary and secondary schools

To find out the weakness of running the schools to achieve good academic

results and to explore possibilities of how they can become better when ICT facilities are provided:

- Interview with some pupils and students of the primary and secondary school

To identify what some of the students felt are the advantages of studying in the schools in the city and what facilities they would love to have in the school in order to improve upon the results and to explain how ICT could help them realise their dreams:

- focus group discussions was organised for groups such as: crop and vegetable farmers, dairy farmers, local finance and banking operators;

To find out in what ways what are their experiences during harvest period and to explain how ICT could help improve upon their sells. We also tried to identify how they get financial help and also discuss how the use of ICT could improve upon their financial transactions:

- identify features and positions which could be used to support wireless infrastructure.

This to find how the features around the selected communities could support ICT infrastructure and service delivery. Discussions with senior staff of health centres witin the selected sectors to find out how they cope up with their duties and how the use of ICT could improve upon health delivery.

2.4 Outcome of the Survey

The analysis of the data collected revealed the following:
The executives of the district and the sector offices are very much aware of the importance of ICT to running efficiently the day to day affairs of administration and that they have already undergone many training and participated in workshops on eGovernance. The only impediment was unavailability of ICT infrastructure.

All the executive secretaries and one other officer in the sector office were

provided with mobile phone. This was due to lack of enough fund. This mobile phone is part of a user group facility in order to facilitate intra and inter sector communication and also to communicate with the district office. It is the same phone, which is used as MODEM for transmission of documents to the district office. Documents more than 15 pages have to be taken to the district office by hand.

The Gikomero is the only sector that is not served by the national power grid, therefore has its own stand alone photovoltaic power system with battery backup. Any communication between the sector with any organs, societies or offices of the communities within the sector have to be done through physical contact if urgent or through physical handing of letters through a courier. The officer agreed that a good communication network within the sector and linking to the district office would not only reduce cost on and the number of trips made daily to outside the office but also improve efficiency of time delivery and meeting datelines.

It was at the district offices that requested setting up IT training centre and call centres at the sector office for the communities to enable them communicate with families and make direct contact with business communities in the city.

2.5 Primary and Secondary schools.

The primary schools indicated that they would like to participate in the OneLaptop PerChild project but for unavailability of Internet facilities, and being far from the Kigali City they have been excluded from the project. They would like use the facilities that would be provided by the project to become computer literates as well as getting their pupils as well as the teachers to know how to use the laptops. The teachers are aware that with the help of Internet they could get additional teaching materials for their pupils and also know what goes on in the world.

All the headmasters of the secondary schools lamented that their levels excluded the from the OneLaptopPerChild project, because it was meant for only primary schools. They also observed that their students have been finding university

programmes very difficult because their students did not have knowledge in the use of ICT equipment before entering universities.

The secondary school at Rosororo, has a department of Computer Science. The school has not got facilities (computer laboratory) to enable the teachers teach effectively. The teachers could only deliver the theory and could not demonstrate any practical outputs. The results for years have been very poor. They believe in the introduction of ICT infrastructure, LAN and WLAN and having Internet facility the school will be in position to deliver good practical oriented subjects and also raise the standard of rating of the school.

The schools believed that having ICT facility in their premises would bring life in the schools and that the schools would aldo attract good students. They also noted that due to the facilities available in various schools in the cities the bright students prevailed on their parents to send them to other schools in Kigali or Butare. They believe that trend might change if the project would be executed.

Of the 30 students who randomly interviewed in each of the schools, they indicated that their colleagues in the cities would definitely do better because of exposure to new ways of teaching and learning and also possibilities to get additional learning materials.

The interviewers also explained to the staff and students of the secondary schools, how in the project would organise study groups or clubs in local and wireless networking would help them learn about IT. They also confirmed that with the Internet and ICT facilities the result of the final years might be better than before.

2.6 Focused Groups Discussion

The focused groups that were interviewed were the communities that cultivate perishable crops such as tomatoes, paper, others were those who sells milk. Interviews were also granted to bee keepers.

Tomatoes farmers complained that, a lot of the tomatoes get spoiled when not purchased on time. The was because they have to inform the district office to

look for potential buyers and if they did not arrive on time to buy them in bulk ost of the harvest would get rotten. Due to this they have been sell ing the tomatoes cheap. They noted that due to indirect communication with potential buyers they would always be at the loosing end. They were really relieved when we discussed with the groups the opportunities that they would have if ICT facilities are introduced.

There are also local financing and banking communities. Savings are made by the farmers and when supports are needed they raise loans to purchase items for personal use or for their works. However, due to unavailability of modern communication facilities linking the various sectors, anytime they needed financial support, it become necessary to return to their community bank in order to raise the financial help. Those who are in charge of these facilities insisted that in order to avoid fraud and that due to unavailability of communication among the group, it would be difficult to help their client if they do not see them physically.

The interviewers explained how inter-networking with the groups using ICT facilities would help improve transaction and increase efficiency in delivery of service and also will get more people to join the system. This explanation was accepted and were ready to collaborate to have the ICT network set up to link some of the banking and financing offices.

The district office has no direct communication link with the eight rural sectors, however the *User Group Service,* a service which being provided by a service provider ,MTN, for companies where a reduced fixed monthly charge per user is paid by the district office. The charges per person per month are usually lower than a post-paid charges. The Gasabo District office paid for 45 staff in the entire district, specifically those who are heads of various sectors and services in the district. In addition, these staff also receive RFW 23000 (approximately US$45), per month for making calls from fixed wireless booths. The interviewees complained that the amount covers only a quarter of the expenses made on telephone calls.

The Secondary and Primary Schools are given monthly per school communication allawance of FRW 80000 (approximately US$ 140) monthly and

prepaid mobile telephone call card of RFW 55000 (approximately US$ 100) monthly. This amount is share among three top heads of of the respective schools.

The health centres are given FRW 60000 (approximately US110) per month to call ambulances when necessary and for other activities

It can be deduced that the most important service needed by the District office and sectors as well as the entire communities is a system for a cheaper communication services.

It was realised from the analysis of the answers to the questionnaires that, the most important and urgent need of the communities is facility to communicate within the communities and also to have direct contact with the Kigali City. This is to help improve service delivery as well as have opportunities to promote their produce. This would also help reduce expenses on travels from one place to another within Gasabo district or elsewhere. They also want facilities that can help send or transfer documents from sector offices to district and other part of Rwanda or elsewhere. Schools are interested to communicate with peers in other schools and the world and also access information in order to expand their knowledge.

3. Selection and Design of Systems

In order to serve the sectors and give reliable and sustained digital ecosystem to the Gasabo communities, WiMAX technology was selected to provide the backbone for the ICT infrastructure. The selection of WiMAX was based on the features of the system, wide coverage area, capability for voice, data, video and multimedia transmission, opportunity for expansion of service delivery.

3.1 Proposed Services

After the analysis of data through the survey different communities are selected from four different sectors and various services, table 1, are designed to meet their needs within the digital ecosystem. Some of the services are the same for some communities. This is to help compare the acceptability and readiness of the communities to new technologies.

Table 1: Recommended ICT Systems and Services

Selected Sector	Selected Community	Needs of the Communities	Designed Services for the Communities
Ndera	District Office	Communication (data and voice) to improve delivery, efficiency and reduced	WiMAX network linking the selected sectors and communities Link WiMAX network to existing District network which has fibre connectivity VVoIP for the whole network Call centre
	Farming	Use of basic IT (Spreadsheet for basic bookeeping, Word for simple report writing etc,)	Thin Client network VVoIP Call centre
Gikomero	Sector Office	Comminication (voice and data) with district office and improve information delivery and reduce cost to be more effiecient,	Connectivity to WiMAX backbone with CPE and integrate with WiFi Call centre
	Primary School	Network to benefit from OLPC project to get teachers and students use modern technology To improve IT know-how of staff and teachers To improve communication with outside works through linkage and twinning.	PV system to power LAN and WLAN Connectivity to WiMAX backbone with CPE and integrate with WiFi to create WLAN LAN with Thin Client for internet access Call centre

	Secondary School	To improve teaching Computer Science, To improve knowledge in LAN and WLAN networks To understand trouble shooting of networking; physical and wireless	Call centre PV system to power LAN and WLAN Connectivity to WiMAX backbone with CPE and integrate with WiFi to create WLAN LAN with Thin Client for internet access Form interest study Club to teach students and teachers on LAN and WLAN and trouble shooting and repairs
	Local financing and banking (LFB)	To have good communication link with the National Bank and other banks in Kigali. To link LFB offices within the sector to improve service delivery, payment and become efficient.	Call centre Link only 3 offices of LFB which are at least 20 kilometers apart. Provide simple accounting software on nodes Provide internet access through WiMAX
	Heath Center / Clinic	Improve Communication between HC, Clinic and other clinics and hospitals	Call centre Link the HC and Clinic to internet. Adopt and train health information system
	Farming	IT training	Thin Client Ntwork located at Sector Office. To use PV system to power thin client
Jali	Sector Office	Comminication (voice and data) with district office and improve information delivery and reduce cost to be more effiecient,	VoIP Create call centre
	Clinic	Improve Communication between HC, Clinic and other clinics and hospitals	Call centre Clinic connectedto internet. Adopt and train health information system
Rusororo	Primary School	Network to benefit from OLPC project to get teachers and students use modern technology To improve IT know-how of staff and teachers To improve communication with outside works through linkage and twinning.	PV system to power LAN and WLAN Connectivity to WiMAX backbone with CPE and integrate with WiFi to create WLAN LAN with Thin Client for internet access Call centre
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			internet access Form interest study Club to teach students and teachers on LAN and WLAN and trouble shooting and repairs

3.2 Design of the Network Architecture

Three final year undergraduate students from the Department of Telecommunication Engineering, who also conducted the interview, designed the various system and services: the ICT infrastructure; the Voice and Video over IP; the Local Area Network (LAN) based on Thin Clients technology. and Wireless Local Area Network (WLAN). The group, together, designed the photovoltaic power system for Gikomero and the power line communication system for those places where there already exist the national electricity grid.

3.2.1 The design of the backbone

The terrain of the rural Gasabo district covers the mountainous areas of the Kigali City as shown in figure 1. The design of the WiMAX network take into consideration the obstacles, which could create shadows zones thus affecting Line of Sight (LoS) radio propagation.

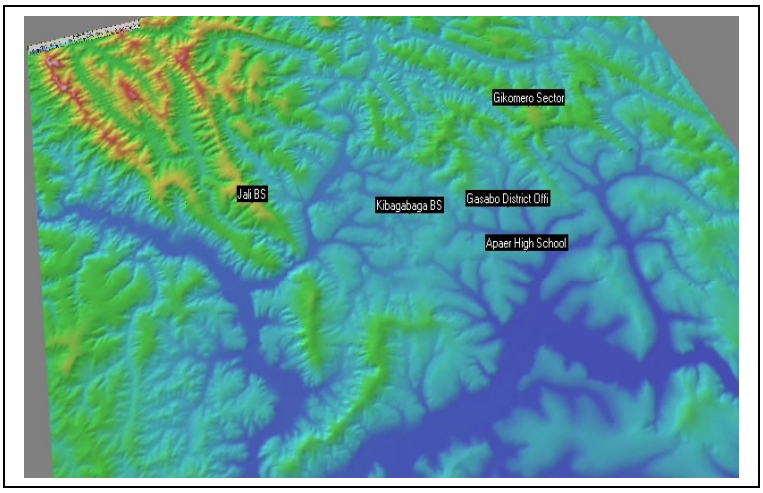

Figure 2: The Terrain of Gasabo District and Point of Placement of Service Points

The backbone of the network is WiMAX comprising: micro base station, outdoor unit, antenna, indoor unit and customer premises equipment. In order to have a good LoS within the Gasabo District, Mount Jali was selected. The other advantage of selecting Mount Jali was that there is a 24 hour power supply. With an 120^0 sector antenna of gain 25dbi, the network could illuminate about eighty percents of the rural Gasabo district and have good Line of Sight (LoS) reception, strong enough to give services to the selected sectors and communities from Mount Jali. The design also considered the future expansion of the project. In Table 2, we show the GPS points, where the Customer Premises Equipment, (CPE), the receiver sets, are to be located. Mount Jali has facilities to support 24 hours power supply. The backhaul of the network located on top of the Gasabo district office, where the main router and servers are to be installed. The Kibagabaga point is also selected for placement of a second micro base station in the near future to give back up to the station on Mount Jali and also to link all the Health centres in the District since it is a referral hospital.

Table 2: GPS Coordinates of Communities and Service Points

Sector	Places	Latitude	Longitude	Altitude (m)
Ndera	Gasabo District Office	$1^0$56'49.458-S	$30^0$10'24.36-E	1455
Gikomero	Gilkomero Sector Office	$1^0$52'39.690-S	$30^0$13'08.160-E	1857
	Gikomero Health Centre	$1^0$53'14.616-S	$30^0$13'07.446-E	1874
Jali	JALI Sector office	1^0*53' 15.0"S*	*30 ^{0}00' 20.6"E:*	*2010*
	JALI HEALTH CENTER	1^0*53' 23.0"S*	*30 ^{0}01' 08.6"E*	*1998*
Kimironko	KIBAGABAGA Hospital	1^0*55' 510"S*	*30 ^{0}06' 45.3"E*	*1470*
Rusororo	APAER (Primary and Secondary School)	1^0*58' 34.2"S*	*30 ^{0}10' 57.5"E*	*1388*

3.2.2 The Line of Sight Path Calculation

The LoS path was calculated by using an Open Source package – Radiomobile. It helps estimation of Fresne Zone and path clearance. The path profile are all clear off obstacles thus giving good Point to Multipoint path profile. This package is also used to calculate the coverage areas of the WLAN.

The Jali – Gikomero sector

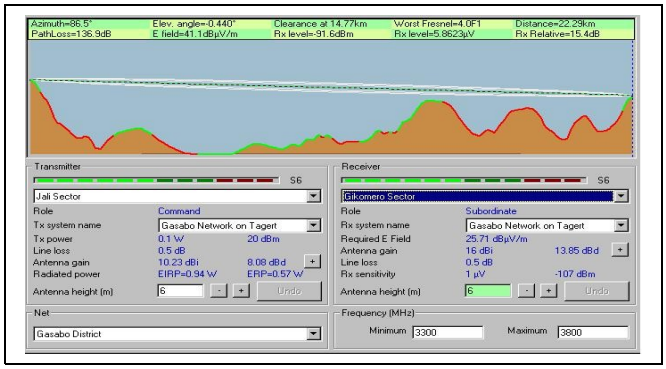

Figure 3.1: Path profile Jali Micro-Base Station – Gikomero sector

The simulation work done, using Radio Mobile simulation tool, gave the following principal results for Jali BS – Gikomero path profile:

- RSSI value of -52.5 dBm for the Downlink (Figure 3.1).
- Distance between Jali Micro-Base Station and Gikomero sector is 22.29 km.
- Propagation mode is line-of-sight (LOS).

There is an acceptable mean value for the RSSI/DL of -62.18 dBm with a standard deviation of 1.25 dB. The SNR/DL found in the survey for this position in average is 34 dB corresponding to 12.71Mbps bit rates.

Jali Micro-Base Station – Gasabo District Office

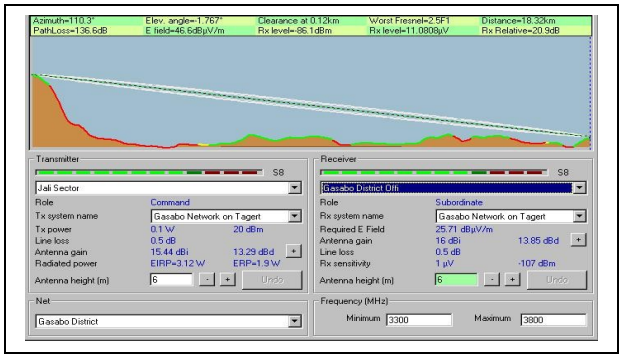

Figure 3.2: Path profile Jali Micro-Base Station to Gasabo District office

The simulation work done, using Radio Mobile simulation tool, gave the following principal results for Jali BS – Gasabo path profile:

- RSSI value of -52.5 dBm for the Downlink (Figure 3.2).
- Distance between Jali Micro-Base Station and Gasabo district office is 18.32 km.
- Propagation mode is line-of-sight (LOS).

The mean value for the RSSI/DL of -62.18 dBm with a standard deviation of 1.25 dB. The SNR/DL found in the survey for this position in average is 34 dB corresponding to 12.71Mbps bit rates.

Jali Micro-Base Station – APAER

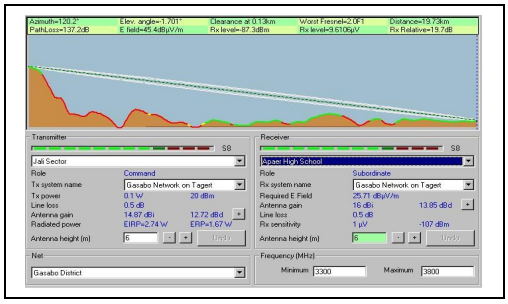

Figure 3.3: Path profile Jali Micro-Base Station – APAER Link

The simulation work done, using Radio Mobile simulation tool, gave the following principal results:

- RSSI value of -52.5 dBm for the Downlink (Figure 3.3).
- Distance between Jali BS and APAER is 19.73 km
- Propagation mode is line-of-sight (LOS).

From the site survey we have got a mean value for the RSSI/DL of -62.18 dBm with a standard deviation of 1.25 dB. The SNR/DL found in the survey for this position in average is 34 dB corresponding to 12.71Mbps bit rates.

3.3 Networks

The network diagram per sector and a linkage diagram of the Gasabo district network at the selected places are established. The network diagrams of NDERA, RUSORORO, JALI and GIKOMERO sectors are established.

The network at Gasabo district site is to be the centre of all the selected units in the district that have to report to the district office, so the main servers are to be installed at the centre. The following networking equipment set would be deployed:1 Main Router , 5 Main Servers for central functions, 3 switches, 2 thin clients drive server and other end user devices figure 4.1.

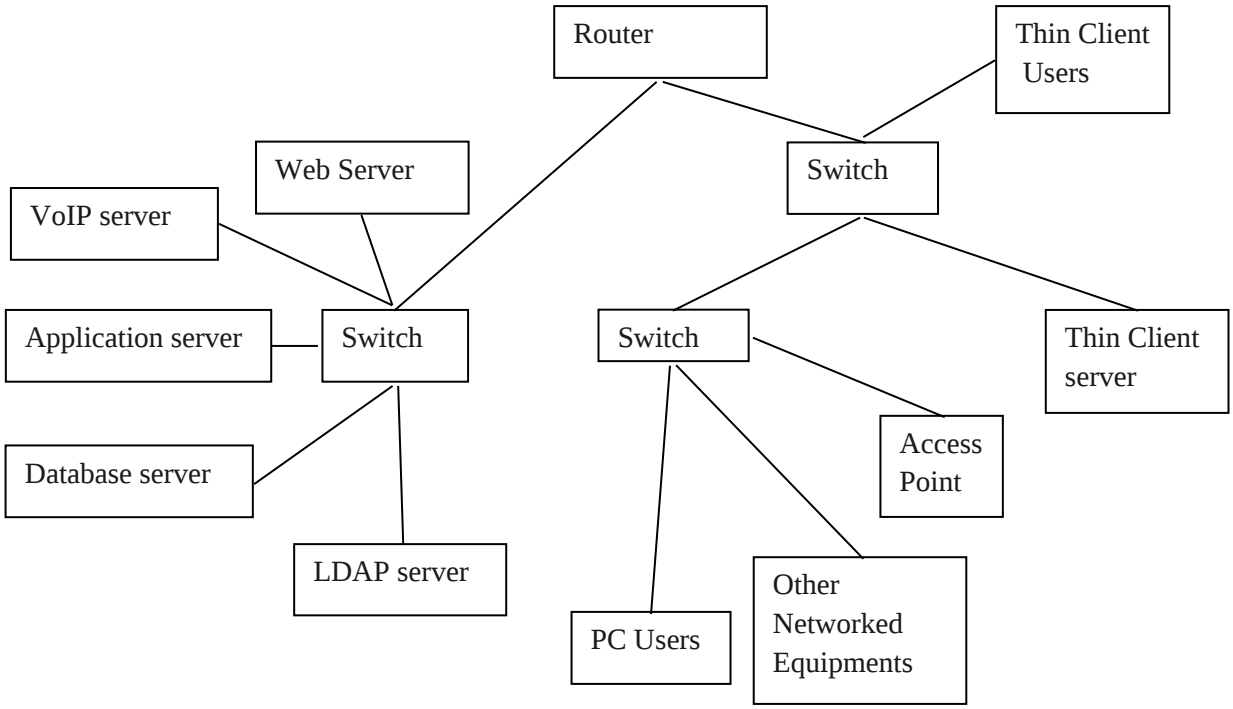

Figure 4.1: Gasabo network diagram

In Jali sector design diagram, equipments figuring out in the diagram below have been selected and this also included health center figure 4.2. The main networking equipments in the design at Jali sector office are 1 Wireless router, 2 switches of 24 ports and 1 thin clients drive server; at Jali Health center, 1 D-LINK router, 2 switches of 24 ports and 1 thin clients drive server.

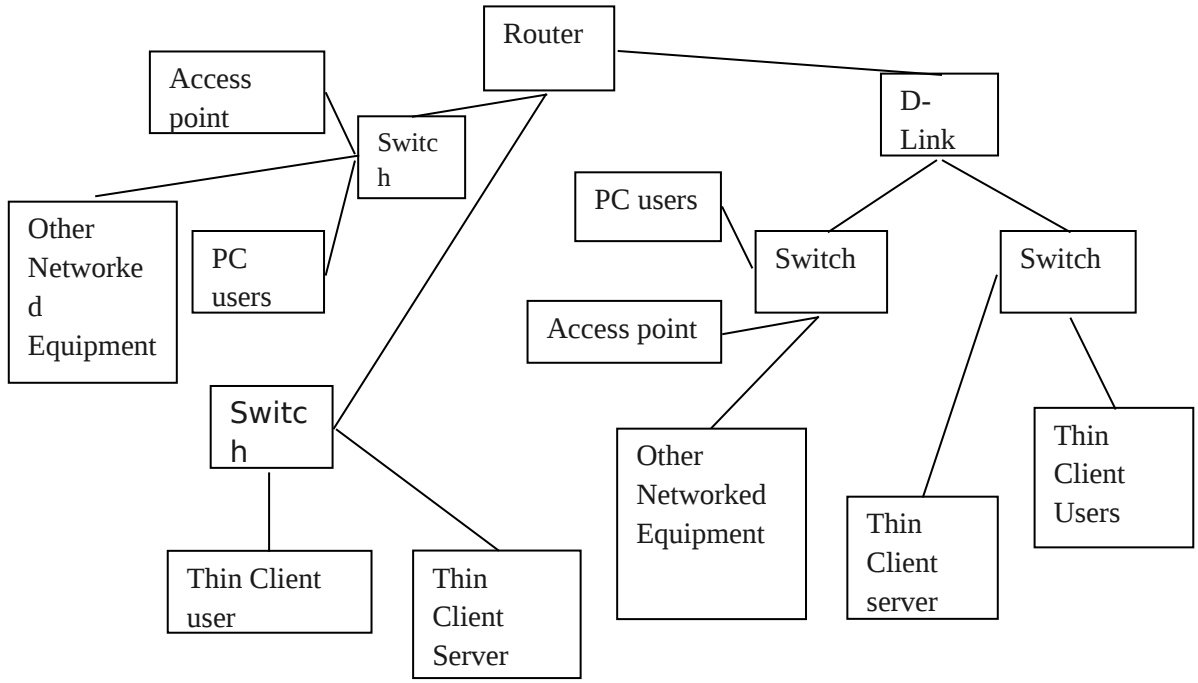

Figure 4.2: Jali Network Diagram

In this sector, APAER high school is the only selected site to have the wired LAN and WLAN figure 4.3 in this project. Hence the idea of the network design at the place is shown in the diagram below.

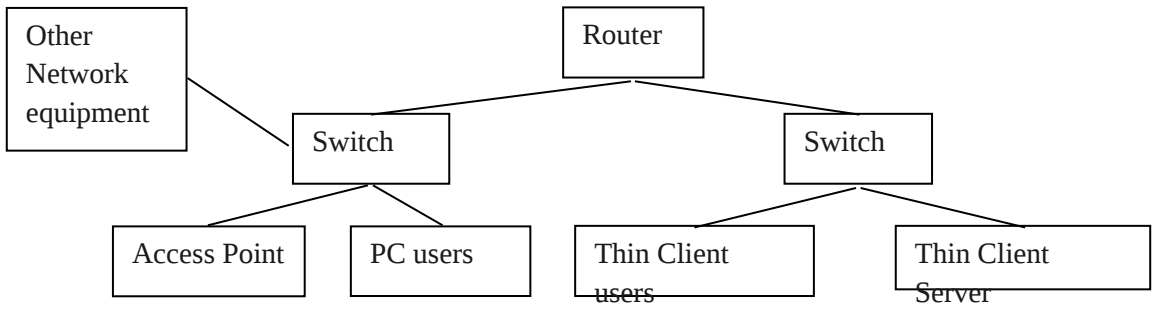

Figure 4.3 : APAER High School diagram

At GIKOMERO sector we have the GIKOMERO sector offices and the GIKOMERO health center are also considered in the design, there will be different equipment sets as shown in figure 4.4, to form the network.

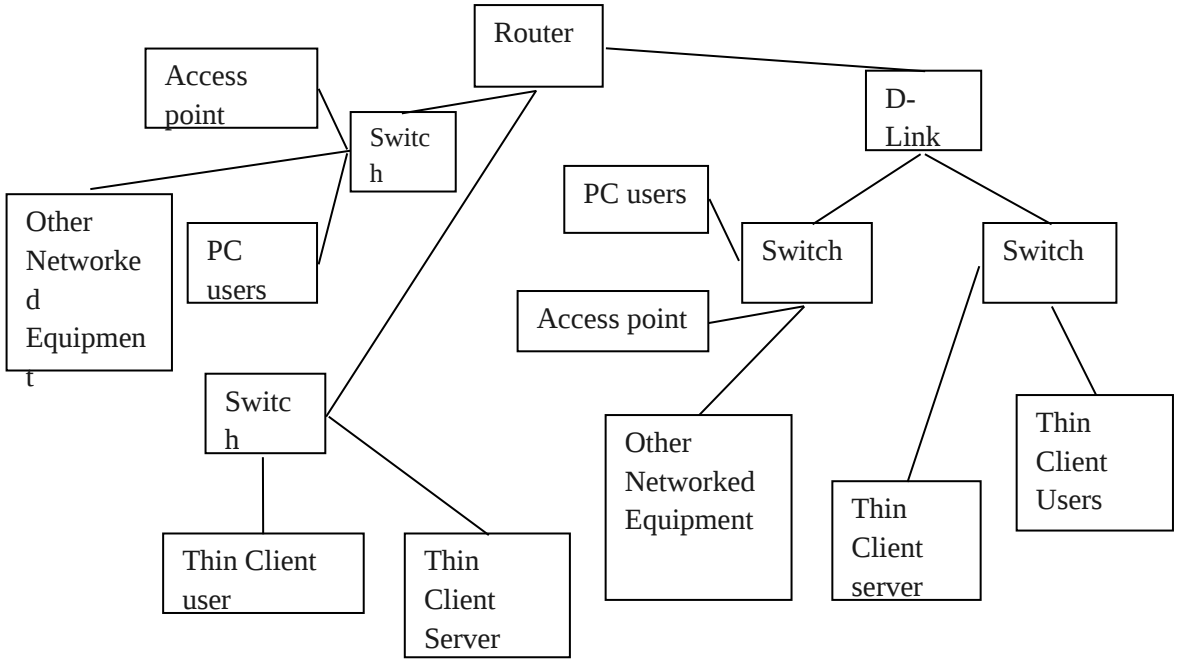

Figure 4.4 : Gikomero network diagram

3.4 Gasabo Campus Area Network

The project was to provide wireless network linking Gasabo district head office with all the selected sectors within the district and to provide VoIP facilities for communication among the selected sectors and the communities. This would form the telecommunication infrastructure upon which the local services would be built.

In other to help to meet all the needs of the main project, the study was divided into different parts and what is supposed to be done is to design wired LANs and WLANs for all the selected places and linking them altogether thus forming a Campus Area Network (CAN) figure 5.

With the above different considerations and with the merging of the ideas from diagrams at all places we come to a network design that links all selected places and support VoIP.

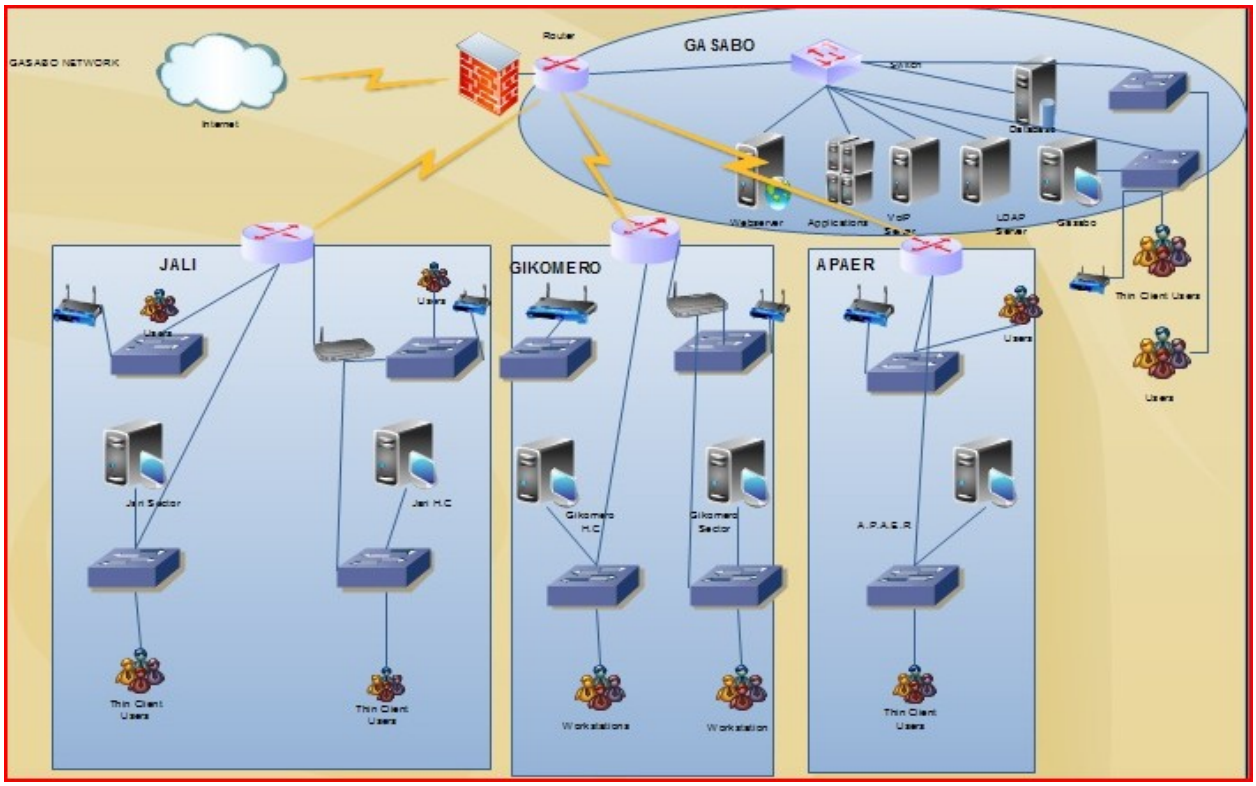

Figure 5: Gasabo Rural Campus Area Network

In the laboratory we simulated the Gasabo CAN using Packet Tracer and was to be well planned and ready for implementation.

3.5 Voice over Internet Protocol (VoIP)

The designed VoIP system is to provide a cheaper means of intra and inter sector communication and also to give opportunities to the communities to be connected to other part of the country or the world and to support Health Centres to communicate with other well equiped centre for service delivery in time of emergency. To suport call centres for cheap communication to bost bussiness in the communities.

3.5.1 Elastix VoIP Server

In order to realise a good VoIP system we used Elastix VoIP server. This is a collection of Open Source products and tools compiled together to become an integrated IP PBX. It is based on CentOS Redhat Linux. It is able to integrate with other products to make the system even more powerful. It integrates Fax, Openfire instant messenger, a billing system with pre and postpaid capability,

A2Billing calling card platform and billing application for Asterisk, a mail server.

Elastix has a powerful LAAMP (Linux Apache, Asterisk, mySQL and PHP/Pearl/Python) GUI for asterisk configuration; which is a web interface that allows one to access various server programs, so that, in general, it looks like one complete product. Elastix have also written certain software such as reporting programs, Hardware detection, Network configuration, and software update module, Backup Restore module, User Management and many more modules themselves. LAAMP is a stack of open source applications that are most used in modern web applications, because of its features. LAAMP supports ranges of existing and future open technologies and also able to adapt to or integrate close technologies. Any layer of the stack may be replaced with another one that performs better than previous one without compromising the performance of the system.

Conferencing control application, webmail interface and a Customer Relationship Manager(CRM) are also enabled. Calls are also possible to be routed to GSM Mobile systems by setting up GSM Gateways. Windows and Linux users are also able to use features such as Video and audio telephone, Openfire IM, Fax, E-mail and Conferencing.
For realising PBX features of the Elastix we used the Asterisk's PBX architecture as shown in figure 6.1.

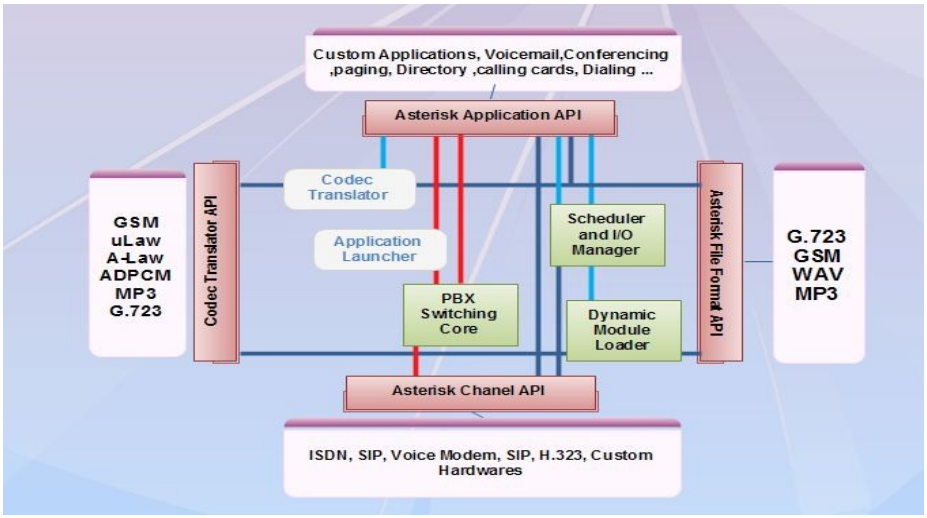

Figure 6.1: ASTERISK PBX architecture

The network set up for testing of the VoIP system is shown in figure 6.2. We combined LAN as well as WLAN.

Figure 6.2: Connecting the server to WLAN Setup to test VoIP with its softphone

The hardware setup of the test included the following coponents:

-Catalyst 2950 Series Switch
-Cisco 1800 Series Router
-Dell Optiplex GX280 Desktop
- HP Compaq 6710b Laptop
-Webcams
-Headsets
-1 Channel GSM gateway
-Planet Wireless Access Point

A control centre, figure 6.3, designed to monitoring calls will enable the operator to prepare call statistics and daily or weekly account.

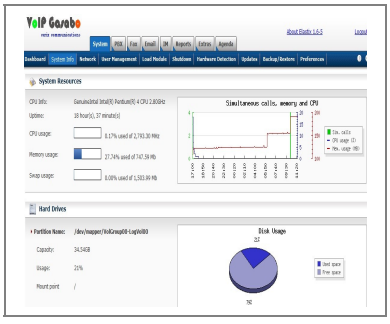

Figure 6.3: The control center showing the system information and monitoring

The list below shows the software sets used for the development of the VoIP system.

Elastix 1.6 Server: based on CentOS Version 5.3 with Kernel 2.6. 18-92.1.22.e15 on a i686

- Asterisk Version 1.5
- Webmin-1.400-1.noarch
- SSHSecureShellClient-3.2.9
- Spark Version 2.5.8 Messenger
- MP3 Audio Editor 7.8.5
- MS Excel 2007
- E-Drawer Max 4.6
- Wireless Monitor
- Various IAX2 and SIP Soft phones

4. Sustainability of the Digital Ecosystems

According to the Rwanda Development Board - IT, many of the installed Cyber cafes have not been functioning because staff who managed the cafes abandoned them; the VSAT unit have broken down as a result the Cafes could no longer offer services.

Many of the laptops provided for the OneLaptopPerChild to the primary schools, have broken down due to maintenance and mishandling. Maintenance of the computers became difficult due to computer virus attack. It is also reported that some schools never allowed the pupils to touch the laptops for fear of damaging them. Or the teachers are not confident to instruct the pupils on the use of the laptops.

In order to mitigate these problems, the project planned to train the teachers and students of the Departments of Science and Mathematics of the respective Secondary schools in the sectors to maintain and upgrade the systems.

4.1 Strategy to Sustain the Digital Ecosystems

The students of the MSc in ICT Program proposed a formation of the following study group clubs:

- Study Group in Linux Operating Systems specialising in Ubuntu.
- Study Group in Local Area Network
- Study Group in Wireless Local Area Network

The first club is planned to be formed at the APAER Secondary School. After successful implementation of this model within a year, other groups shall be formed in the other secondary schools.
Membership into the study groups shall be based, strictly, on interest as extracurricular activities but based in the school. However, selection would be based on passing interview. Any teachers who would be interested could become members. Membership of the first group will be maximum 5. A teacher from the secondary school will be responsible for each group. A one month extensive

internship training would be given to the members of the selected group at ICT laboratories of the National University of Rwanda. These laboratories are:

- Research in Open Source Software and Systems Initiative (ROSSSI);
- Mobile and Wireless Simulation Laboratory;
- Network and Network Security Laboratory;

After the completion of the internship, the members would join the students of the MSc in ICT Program and Department Electrical and Electronics Engineering to install and test the CAN for the Gasabo district. This is to motivate the members of the groups to own the network within their respective sectors.
The staff and students of NUR would continue visit the group once a month for two continuous years. During the vacation period of the secondary schools, which is normally tri-semester, a one week workshop would be organized within the laboratories of NUR for the group.

The members of the club will take over the expansion of the network in the respective sectors. The clubs will be made owned by the Ministry of Education but would be encouraged to charge for services offered to the communities in order to sustain the activities of the club.

The Clubs will maintain the network within the various communities. Expand the network when needed; Maintain the cyber cafes.

The Gasabo District Network, which is set up by the project, shall be used by NUR as a Living Laboratory for testing of packages developed by the students and staff of the Masters Program in ICT.

It is projected that with a successful implementation of the project will open consultancy opportunities for NUR and other research avenues for the MSc in ICT Program.

However, successful implementation and training of will encourage institutions such as RDB, the Ministry of Education the Ministry of Local government may support NUR to develop the ICT infrastructure and also software sets to support the Rwanda Vision 2020.

4.2 Possible Issues and Difficulties

NUR was accepted to th join the OPAALS group during the final phase of the project. Even when it was finally elevated, all the groups have already learnt a lot and have adjusted to the tempo of pace of working. This has taken sometime for the NUR group to cope with.

Phase I of the project was started on time as expected, but had to be individually financed without the support from NUR. Since funding was delayed, it was difficult for other staff to join the NUR group for fear that work would be done with no remuneration. Therefore when the second NUR staff who was working on the project it was difficult to replace her.

The budget for the project could not support procurement of equipment set. I believe in order to have positive impart on the society, a physical realisation is important. This will help demonstrate the results of the research efforts of the OPAALS in the Rwanda. It will also motivate colleagues to work in the implementation, testing and evaluation some of the performance of these systems.. This will help students and staff at NUR to start to contribute effectively to projects involving groups from Europe and developing countries.

5. Conclusion

The NUR OPAALS group completed Phase I of its project. A survey was conducted and four out of eight sectors were selected. Through the analysis of the data, a Campus Area Network was designed using a fixed Point to Multi-Point WiMAX tecnology and Local Area Network using thin clients systems. In order to reduce cost on Internet cables, a Power Line ommunication network was adopted. The project designed Voice over IP as the cheapest way of supporting voice communication in the Rural areas. The entire CAN was simulated in the laboratories at Nur and was found functioning and could be deplored. However, due to unavailability of funds to purchase equipment set to continue the project, phases II and III could not be completed.

If phases I and II were to be completed the result would have shown and demonstrated a successful knowledge and technology transfer, through a healthy North – South, inter-regional, multi-disciplinary research collaboration.