PROJECT DETAILS:

Outline of pilot project

Introduction

The development of Gabagaba village wireless mesh project will make a big impact by transforming the community in adapting to using modern technology concepts as we now live in a modern era. This will also break the barrier in digital divide for rural communities using ICT and a first of it's kind to be implemented in a rural village within PNG as a pilot project.

A wireless mesh network consists of a number of routers each equipped with 802.11b/g/n/ac that form a robust, adaptive mesh allowing outdoor (AP) access points to relay data to any other possibly via multiple routing hops. APs are typically placed on rooftops and use a suitable high gain antenna to provide long distance routes (hundreds of meters or more) between access points. Attached to each access point is a Ethernet port as a bridge to a local area network which could be a wired Ethernet LAN or a separate 802.11 access point. Users connect to the network using an 802.11 enabled desktop, laptop PC or smart phone which associates with the nearest access point. The mesh backhaul APs' provide a wireless distribution network between the separate LANs.

The primary benefit of a wireless mesh solution is it's low cost compared to wired networks. A wireless mesh network is also more flexible in terms of deployment planning since it is easy to extend the capacity and coverage of the network by adding more access points and very little cabling is required. These mesh networks can be deployed in most rural areas where network cables cannot be used across rivers and mountains.

The first phase will require at most 1 router node and 6 access points with 4 extenders to provide connectivity to approximately 3,000 users. This smaller scale network will give us experience with the router hardware and software and assist in designing Phase II which will expand the network to the primary school with another 1 router and 3 access point nodes. In addition to the benefits, the Intranet will serve as an example for other nearby schools in Rigo district looking to rapidly and inexpensively deploy a mesh network. Moreover, this project will give us a unique opportunity to study the needs and usage patterns of a sizeable community of users relying solely on the mesh network for intranet connectivity. We expect many interesting technology lessons to emerge from this project related to traffic load, robustness of mesh routing and the design of networks for harsh and unstable environments in rural communities.

Wireless Network Design

Figure 1 shows the overall design of the proposed wireless mesh network. The network consists of a set of *mesh nodes* that form a backbone network via 802.11g//n/ac combined with multi hop routing *wireless access points* to provide connectivity to end users on each building rooftops and *network switches* to connect the interior desktop computers via network cables. We envision a single access point on the roof of each of the main buildings in (Phase I) and the rest at the school buildings in (Phase II). Users will access the network using their digital devices. Wireless antenna extenders are to virtually connect far distance buildings. There are no network connections from [Phase I] Base station to [Phase II] Base station as these are completely separate networks. The only links you see in the diagram on Base station 2 and Base station 1 are links via the wireless routers through these separate networks to connect to the Digicel tower for Internet access.

Overall Mesh Network Diagram:

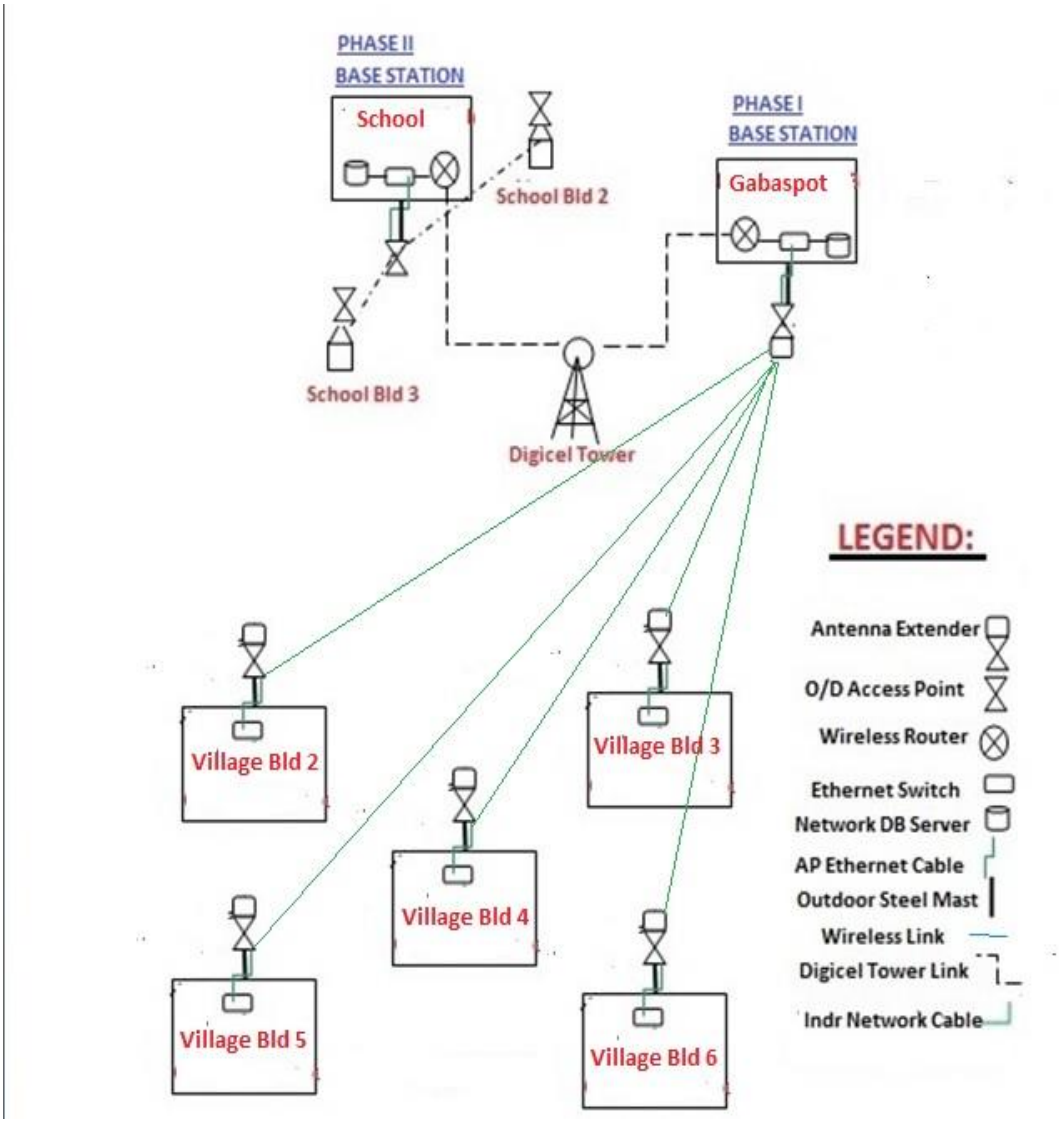


Figure 1: Overview of Gabagaba Village Wireless Mesh Network Diagram

Wireless Mesh Network

In a mesh network, the AP uses its own radio to provide a wireless backhaul to other APs on the network, eventually reaching an AP with a wired Ethernet connection to the wired backhaul infrastructure and the network. In this sense, a mesh network is a network of repeaters, though mesh is designed to operate automatically and more intelligent on a large scale. A mesh network creates a set of "dynamic WDS Bridge" links, using routine algorithms to automatically calculate the most optimal wireless path through the network back to a wired root or base node. This makes mesh networks relatively robust to the failure of an individual AP in a process referred to as "self healing "the routine algorithm will automatically calculate the next best path through the network if an AP in the path goes offline. Since the routing functions are done automatically within the mesh software, mesh networks are actually fairly straightforward to setup and therefore scalable to cover large geographical areas.

Senario of Wireless Mesh Network Infrastructure

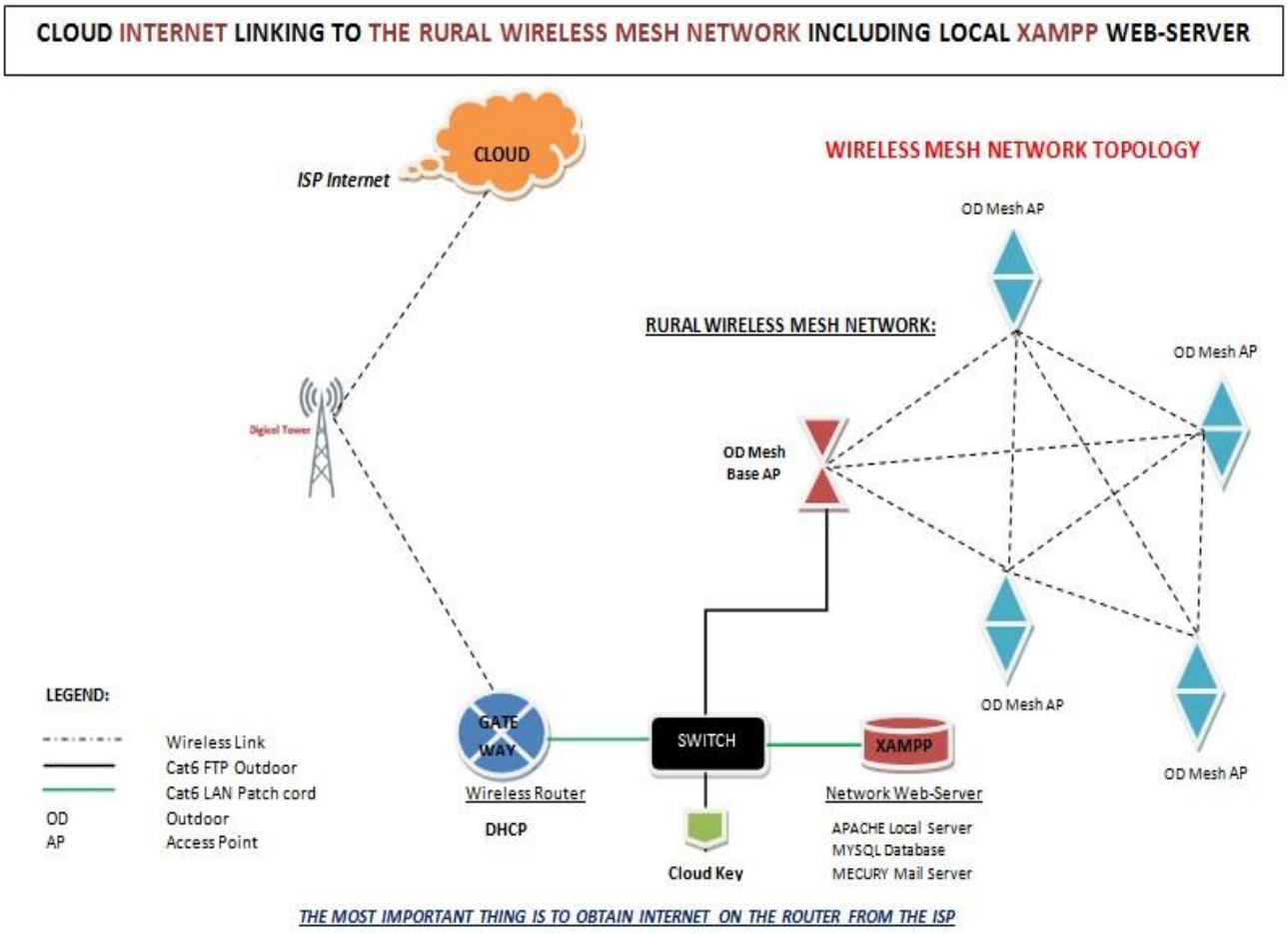


Figure 2: A mesh network scenario

Our goal is to keep cost to a minimum, so we must carefully weigh the cost and performance of the various solutions on the market. As described earlier, this design leads to a decentralized network architecture in which the failure of an individual router will only lead to loss of connectivity and reduced capacity, not the failure of the entire network. If each access point has multiple links to other access points, network partitions can often be avoided when failures occur. Likewise, localized packet loss due to interference or heavy load can be mitigated by dynamic route selection. For example, multiple flows traversing the network can be load balanced across separate paths. Finally, the mesh architecture makes it possible to expand the capacity and coverage of the network simply by adding additional APs. Little configuration is required since a router joining the network will automatically probe for new routes.

802.11 Access Points

The second tier of our proposed network is a series of 802.11b/g/n access points connected to each of the mesh routers via an Ethernet switch. The access points provide network connectivity to the end users which may be using smart phones, laptops, desktop PCs equipped with wireless interface cards. Wireless access points targeted for home use are inexpensive but are not intended to scale to more than a few users while commercial

access points with higher capacity are often used in office settings. We expect these latter type will be required to support the user population in Gabagaba village.

Owing to the small size of the buildings, we estimate that 2-4 access points per mesh router will be required to provide connectivity to at least the main and other common areas. This approach also limits the cost of the wired Ethernet LAN connecting access points to the mesh routers. The network can be readily extended by adding more access points with increased cost and complexity.

We plan to configure the backbone network to operate on a different 802.11 channel than the WAPs to minimize interference and maximize capacity.

Latest Wireless Technology

We will develop and implement the latest wireless mesh technology based on design, topology and protocols plus deployment using latest mesh networking devices such as wireless routers, access points, switches, cables, laptops and desktop server computers. We will also develop and implement the local intranet for hosting of local website, database and email server using the latest server applications and other required software applications for better system performance, control and monitoring..

Challenges

Implementing a wireless mesh network at Gabagaba carries with it some unique challenges that stress the capabilities of current mesh network strategies. A major goal of this project is to understand and overcome the challenges of implementing a mesh network in a harsh and dynamic environment. Several of the challenges we will need to address in this project include:

- The layout consists mostly of low buildings although there is clear line-of-site between the rooftops of the buildings. This is in contrast to rooftop mesh networks primarily placed on taller buildings.
- Temperatures reaching up to 120 F during the hot season. This has implications for the mesh routing node hardware and packaging.
- A large number of trees within the environment which raises challenges for interference and channel sharing. We expect some degree of congestion in the 2. 4 GHz frequency.

Proposed System Design

We intend to develop the Gabagaba wireless mesh network in two phases: Phase I will cover five (6) rooftop buildings in the village area while Phase II will cover (3) rooftop buildings for the village Primary school, Baptist school and the Foundation school.

We describe the system design in detail below.

Overview

1. Village area - house rooftop1
2. Village area - house rooftop2
3. Village area - house rooftop3
4. Village area - house rooftop4
5. Village area - house rooftop5
6. Village area - house rooftop6
7. Primary school area – building rooftop1
8. Baptist school area – building rooftop2
9. Foundation school area – building rooftop3

Phase I: Village House Rooftop Buildings

Phase I of our deployment involves a small-scale mesh network of 1 router and 6 access points covering all major zone areas within the village therefore from the west, north, south and east. The goal of this first phase is to demonstrate the use of the mesh network in a relatively confined area as well as to work out the technical details required for the full-scale deployment in Phase II.

Figure 3 shows a Google Earth satellite image of Gabagaba village with mappings of buildings that will be wirelessly linked with backhaul wireless mesh APs' access points uplinked to the base station at Gabaspot.

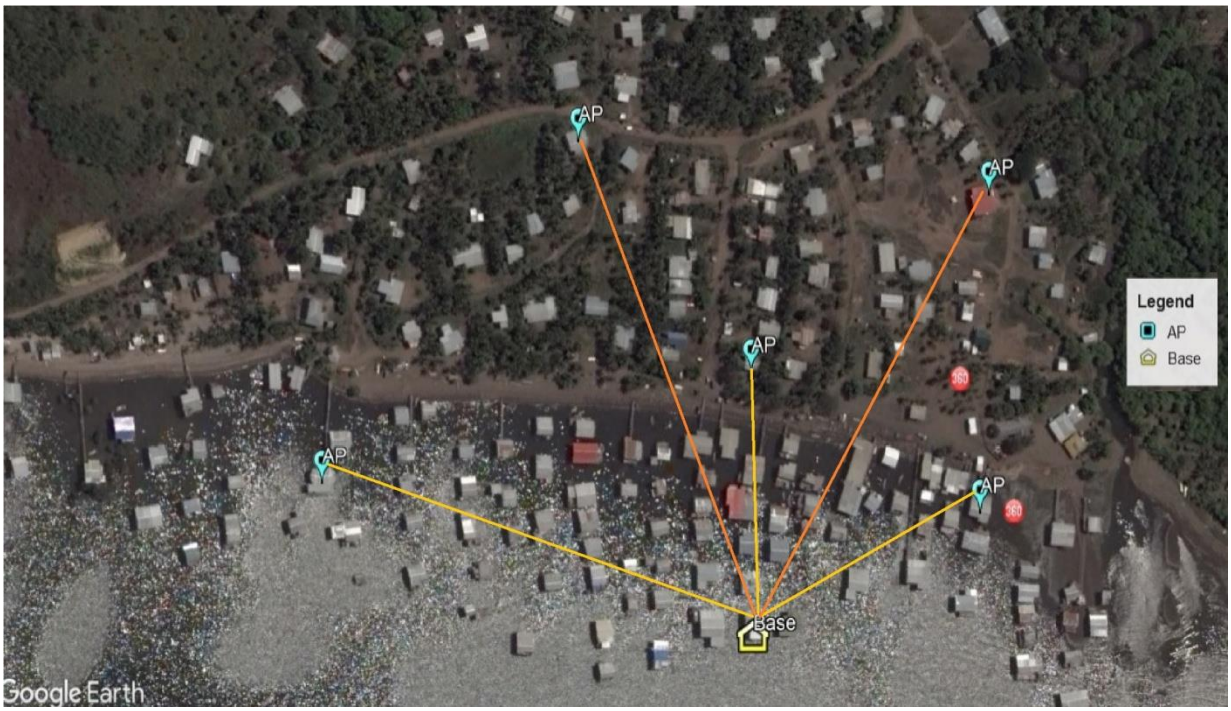


Figure 3: Overview of the Village Wireless Mesh Network

We estimate each building will require one access point as backhaul on rooftops with dual band Omni antennas running on 2.4 and 5.8 GHz to provide adequate coverage in a radius of 180 meters. Ethernet LAN port on APs' will be connected to switches inside the buildings to provide access to wired desktops and printers.

A wireless router will be setup at the village base station as (gateway) default DHCP server.

Each building sites will be given respective SSID or site names to distinguish network zone sites. An entry level web-server computer will be setup and deployed at village base station as host to provide local intranet services such as emails, websites and database.

Additional APs' will be deployed to extend coverage to other black spots where there is a demand.

All security measures will be put in place like virus applications and firewalls to safeguard the network from illegal access, unwanted third party applications and user authentication.

Table descriptions of devices to be deployed for phase 1 and phase 2:

Stage	Building Site Names	#mesh router nodes	# access points	# network extenders	# network switch	# server computer
Phase 1	GabaSPOT Base 1	**1**	**1**	**2**	**1**	**1**
	GabaSPOT House 2	0	**1**			0
	GabaSPOT House 3	0	**1**			0
	GabaSPOT House 4	0	**1**			0
	GabaSPOT House 5	0	**1**			0
	GabaSPOT House 5	0	**1**			
Phase 2	School Base Station1	**1**	**1**	**2**	**1**	**1**
	School Building 2	0	**1**		0	0
	School Building 3	0	**1**		0	0
Total Count	**9**	**2**	**9**	**4**	**2**	**2**

Phase II: School Wireless Network

The second phase of the project will be the setup of the school wireless mesh network and local Intranet. This will require one access point as base at the admin office building and another 2 backhaul access points on two other school buildings to extend mesh coverage within the entire school parameters.

One wireless router will be setup as (gateway) default DHCP server and one network switch to connect hardwired desktop computers and a printer inside at the school administrative office building. One computer will be setup as web server to host the local intranet services for email, website and database.

Duration: 5 months

Phase 1 will take 3 months to complete for the village mesh network.

Phase 2 will take 2 months to complete for the village school mesh network.

Both phases will require the purchase of equipments to support the 9 buildings in the village.

Budget

The project budget components for Phase I and Phase II are put together as shown on table below.

Budget costing:

Description	Price	Qty	Total
Totolink 300RH Wireless Router 11dbi	K108	2	K216
Ubiquiti Unifi Network Switch 8 – 150watts	K650	2	K1,300
Ubiquiti UAP AC Mesh Node	K300	9	K2.700
Ubiquiti UAP AC Mesh PRO	K540	2	K1,080
Ubiquiti Outdoor tough cables 305m	K450	1	K450
Ubiquiti Cloud Key Controller	K255	2	K510
Ubiquiti ETH-SP Ethernet Surge Protector	K53	9	K477
Directional Dual-Band Antenna for UAP-AC-M Model UMA-D	K323	4	K1,292
Extra link LAN Patch cord Cat.6 FTP 3M 1GBIT	K11	4	K44
Network Server Computer	K5,000	2	K10,000
UPS 650 Watts	K250	9	K2,250
Outdoor Iron Mast 10 meters	K600	3	K1,800
Website Development plus database	K30,000	1	K30,000
Training of users and administrators	K6,000	1	K6,000
Network Engineer to do site installations	K2,000	1	K2,000
Technical Support Personnel	K1.000	2	K2,000
Transport hire to deliver equipments	K550	2	K1,100
TNT Airfreight Charges	K800	1	K800
Labor charges for all device configurations + site survey	K3,000	1	K3,000
Service Maintenance Contract (1 Year)	K50,000	1	33,000
	SUB-TOTAL		K99,039
	10% VAT		K9,903.9
	TOTAL COST		**K108,942.90**

Deployment of Wireless Mesh Network Devices

Wireless Routers

2 x wireless routers will be configured as default DHCP servers for automated assignment of network IP addresses to all digital devices connecting to the mesh network including firewall for security reasons. One will be setup at the village base station and the other at the school base station.

Outdoor Access Points with wireless Range Extenders

9 x outdoor mesh access points with Omni antennas will be configured and erected on 9 buildings to broadcast and extend wireless network coverage within a radius of 300 meters in diameter at the village and school boundaries. Four other outdoor directional extended antennas will be use as long range links (LOS) line of sight to connect distance buildings from the village base station building rooftop to other building rooftops. These links will require 4 high mast or iron post at about 10 meters.

Web-Server Computers

2 x desktop server computers will be installed and configured with Windows 10 Professional operating system and XAMPP web-server software applications to host the local office Intranet (websites) and MySQL for web database storages. Anti-virus software will also be installed to safeguard the server from virus infections. Mercury email server will be activated under XAMPP to enabling users to send and receive emails locally using their desktop computers, laptops and Wi-Fi smart mobile phones as well.

User accounts will be created with respective user password for authentication. Client email applications such as MS outlook will be configures for laptops and computers. Mobile wireless devices will be configured with mobile email applications to authenticate to the email server. This is a local email server hosted locally and will and not to be used as a Global Internet email server.

Network Control Rooms

There will be 2 network control rooms, one will be at the village base station office and another at the school base station to be setup and configured with all essential network components such as network cables, modems, routers, switches, POE injectors, firewalls, power cable adaptors, UPS, backup NAS and initial two (2) computers as central local Intranet web servers. These control rooms will be known as base stations for control and monitoring of the wireless mesh networks as shown on Figure 4.

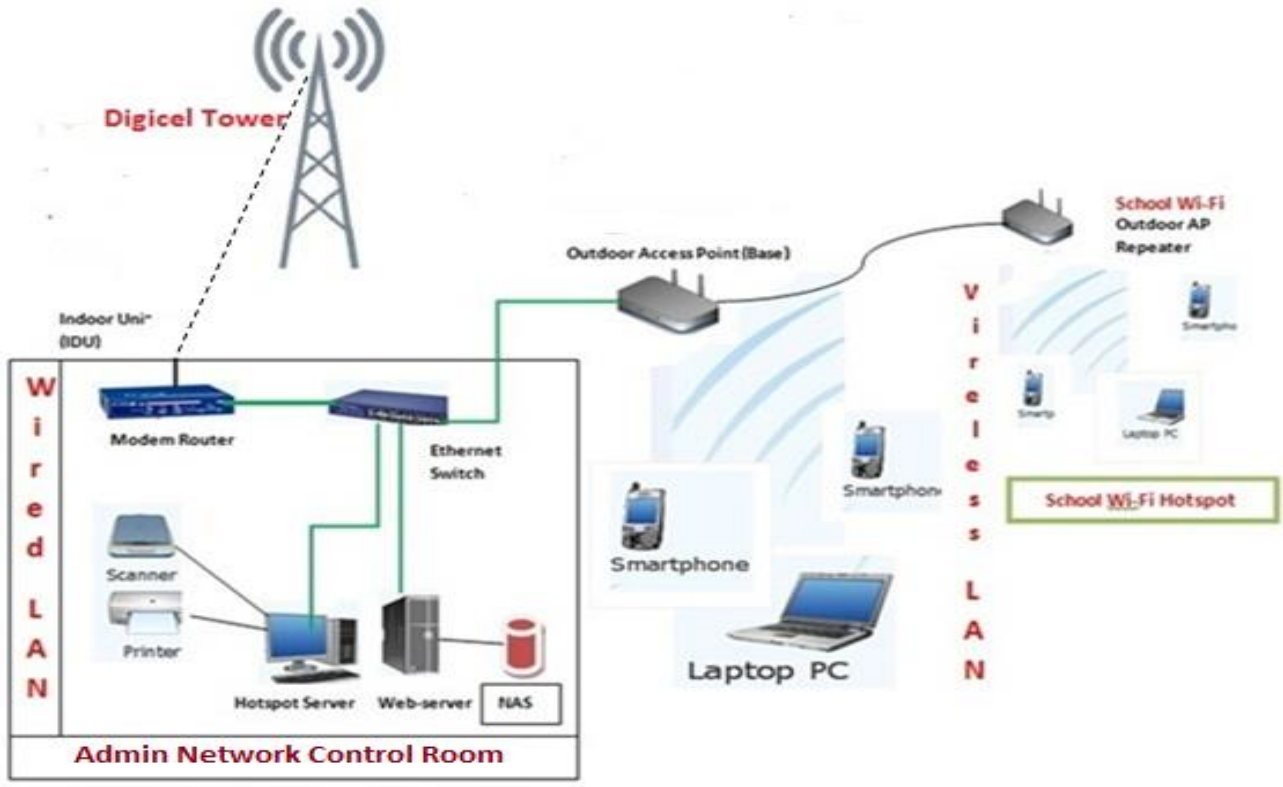


Figure 4: Scenario of Network Control Room + Outdoor (APs') Access Points broadcasting radio wave as coverage received by digital wireless devices.

Appropriateness of the project

The community can establish and maintain a wireless mesh network and have access to a range of modern information and communication services. These services include telephony (Voice over Internet Protocol), instant messaging, electronic mail, web access, multimedia services and service delivery (e.g. telehealth and e-learning).

We now live in a modern era and implementation of this wireless mess network infrastructure project will transform and play a major role in impacting and boosting the livelihood of the Gabagaba community by sharing resources wirelessly and to express themselves via this medium in such a way that was never experienced in a rural village environment before using ICT.

The network will be established to associate and link stakeholders in the community in various sectors such as the councilor, village court, police, aid post, church, school, youths, disabilities, sports plus the community as a whole to share resources as shown in Figure 3.

Almost 80% of the people living in the village have digital devices like mobile smart phones, pads, tablets, laptops, desktop computers and these can be fully utilized via the village mesh network. The network will also be best utilized to share resources such as printers, overhead projectors, files, folders, video Phones, multi-media and locally developed websites via wireless routers, switches, outdoor access points, modems and network web-servers.

"For the first time, we can provide a number of sectors the critical ability to easily set up portable mesh networks for local Intranet and bridge with a distant existing network and gain access to the cloud or Internet"

Diagram of WLAN Office up-linking various sectors within the community

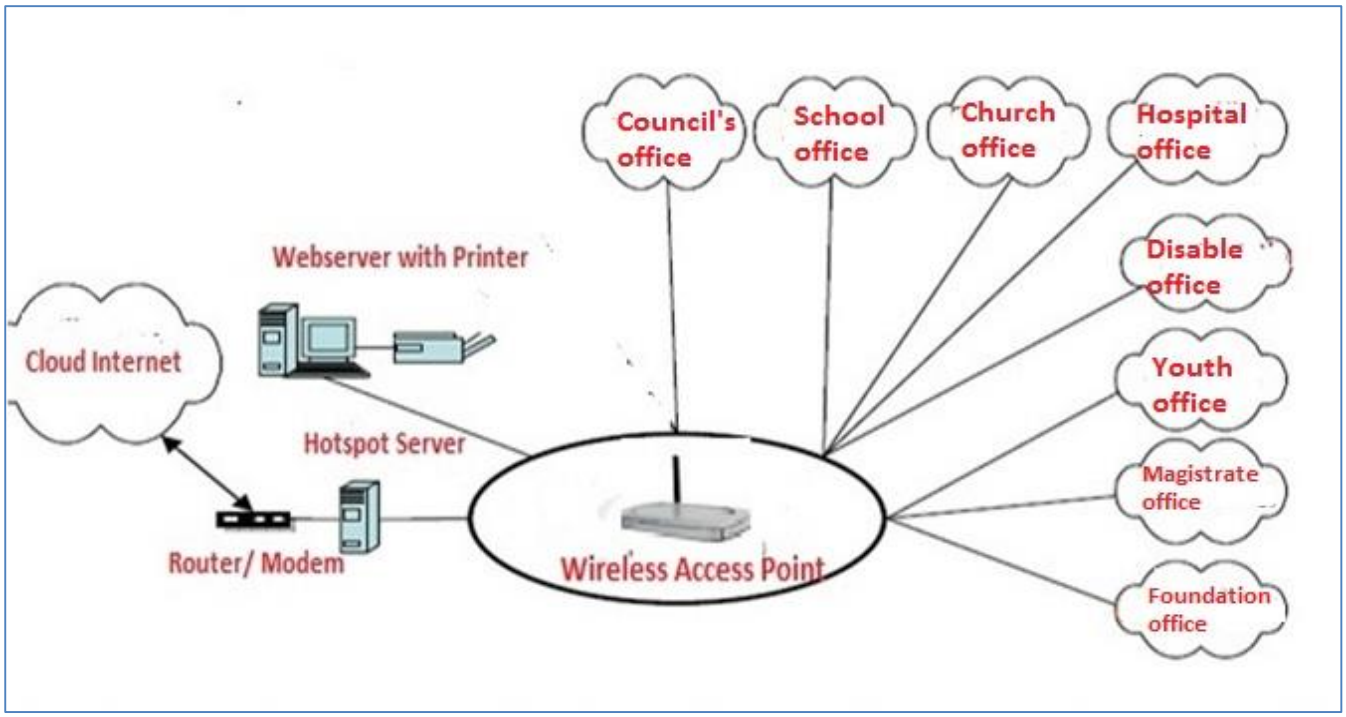


Figure 5: Village sectors to link via the mesh network to communicate and share activities.

Intranet

A intranet or a local website will be centralized at the base station for access locally by all village stakeholders and enable them to post articles according to various categories or activities, view all member profiles, compose messages and send to each others with attachments, search for any posted articles or activities, participate in village forums by posting any topics or issues concerning the village, upload and share files, documents and folders with passwords plus other features like posting videos, photos, audio and community notice boards..

Create local web sites for the farming communities which will provide information about farming practices, weather patterns, fishing practices and advice about which crops to plant or animals to farm and at the same time promote or encourage these web sites locally. This will include information on local news, special events or activities, awareness, advertisement plus any education information.

Database

A village database will be developed to convert manual village record books kept by the councilor to digital format including vital raw data from other sectors. These data will be updated daily and will serve as a source of information when required by outside sources and relevant Government organizations' for statistical purposes.

Email System

A local email system will be setup to enable members to have email accounts created to send and receive emails with attachments locally via the village wireless mess network.

Wireless LAN Messenger

All mobile digital devices including laptops and desktop computers will be installed with instant messenger applications so users can freely chat, upload photo and share files instantly via the mesh network.

Other Network services include:

Wireless Network Training

Network training will be conducted for network administrators and users to familiarize themselves in the use of the wireless network features and Intranet.

Setup of Walk in Internet café & Support office

This will provide access to school leavers, unemployed youths plus others to do research via the Internet. Typing, printing, scanning, photocopying and binding services will also be provided including technical support on software and hardware repair on any digital devices like mobile phones, laptops and computers in the village as there is a high demand. The community will be happier as these services are just within footsteps saving travel cost to town and back.

Internet Hotspot via VSAT Dish

The Wi-Fi Hotspot will provide opportunities to allow the community for communication and entertainment through the medium of the Internet as this is the answer to an increasing demand. The public wants (1) access to methods of communication and volumes of information on any subject matter now available on the Internet and (2) at a cost they can afford and in such a way that they aren't socially, economically or politically isolated.

We are so privilege to partner with a VSAT satellite ISP provider EMSTRET WIFI offering global connectivity at cheaper and affordable data plan rates.

Figure 6: Google mapping showing EMSTRET VSAT location our project partner.

One of the major objectives of this project is to setup a small foundation to allocate certain percentage of earnings quarterly to particular stakeholders like the disabilities, hospital and youth community projects. The revenue for the foundation for allocations will be generated from the Wi-Fi Hotspot billings. This will also help eliminate stakeholders and individuals from seeking assistance and to stop the mentality of free handouts from the Government coffers as the country is now facing economic crisis.

Number of persons benefiting from the project

The wireless mesh project will have a huge impact in the community as evident when a trial run was demonstrated using a laptop as webserver, a home wireless router and a outdoor access point as repeater to extend coverage.

There is an increasing demand by the village working class, retired public servants, retires private employees, school students, teachers, disabilities and the young generation of regular mobile users in the village.

Participants will be identified and engaged directly or indirectly as volunteers to support the project as we have retired qualified IT professionals plus those currently employed but at the same time train school leavers and unemployed youths.

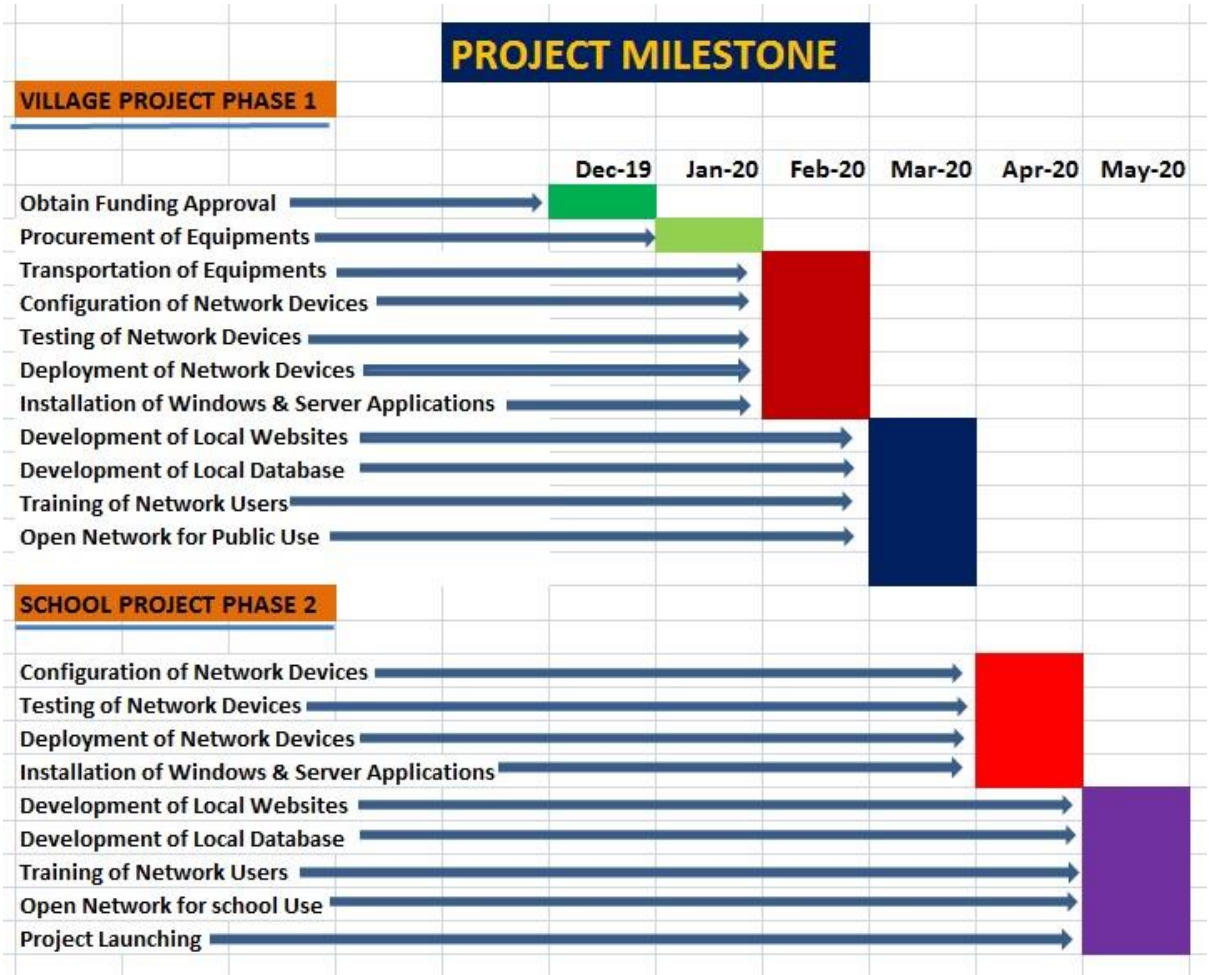
About 6oo students will have access to offline line electronic libraries containing only school educational information in web format.

An anticipated population of 3,000 in all cross sections from children to adults will have access to local developed social websites plus other downloaded sites from Internet relevant to their needs.

Project benefit

Creating a vibrant and knowledgeable community through (ICT) information communication technology and putting into real practice the full features of persona digital devices at home. Empower and create economic opportunities in generating income to support and sustain small scale community projects. This project will be used as a pilot project and when completed will be handed over to DDA and Central Provincial Government. This is to ensure there is budget for its upkeep and maintenance.

Milestone (significant phases of the project)



Expected output

Intranet is a cheaper way of communication within organizations and groups of people with potential online information via the internet relayed to the people via Gabaspot. It will be very affordable as opposed to internet. This service can be adopted for rollout to all villages and schools in the provinces and districts nationwide. A minimal monthly fee will be charged to meet the cost of maintenance where budget falls from government come. This is fall back security and the service sustained in the long run. User pay services are more for continued long sustainability and maintenance.

Reporting Procedure

We will ensure technical faults are promptly attended to and reported to DDA and Provincial Government. The project is collaborative effort between government, DDA and us in line with Government Public Private Partnership Policy which will fund and support for its sustainability in the long run.

Linkage to existing Government development policies

How will the project contribute to development of Papua New Guinea?

Referring to:

The Medium-Term Development Plan III (2018-2022) on ICT (Section 3.2)

1. By providing an effective and affordable ICT infrastructure in a rural setting using appropriate technology to suit individuals in achieving level of developments as expected in the Medium Term Development
2. NICTA Strategic Planning Report (2018-2022 (*Could not find in NICTA website so no comments*)
3. National Broadband Plan 2014 *(Could not find in NICTA website so no comments)*

Found policy on National ICT - APRIL 2008 Department of Communications & Information Technology

Refer to Act 2008 ICT Policy:

Access to telecommunications services on (***Strategies- community service obligations and competition***) stating Telecentres are a useful delivery mechanism for ICT services to rural and regional areas. A Telecentre is more than an Internet cafe. It is a place for voice, fax, email, web and any other service that can be delivered by a telecommunications link. On the contrary, they should be entrepreneurially run with a view to making profits from providing e-access to a community.

The above policy paragraph clearly explains the link to this project and is self explanatory with all details as outlined in the proposal and is in-line with the Government's ICT policy.

Financial support

This is a village community project and will be supported fully by Rigo MP with funding under DSIP with support of Provincial Government. The project will be promoted within the district through an awareness to be carried out so that provincial government is aware to allow their support from day one.

Sustainability of project

When project ends, sustainability will be through the following services incorporated in the project:

a) Collection of monthly subscription charged fees for using the local wireless mesh network.
b) Wi-Fi Hotspot via VSAT billing system
c) Walk in Internet Café cash sales
d) Technical support services
e) Typing and printing services
f) Community fundraising activities plus others