A Study and Site Survey in Himalayan Region for Proper Utilization of Wireless Community Networks: An Assessment of Community Wireless Implementation in Heterogeneous Topography

Bishnu Prasad Gautam, Dambar Raj Paudel and Shree Krishna Shrestha

● **Abstract**

今日、世界中の多くの国で有線、無線、および衛星ベースの大規模なネットワーク通信が展開され、数多くのネットワークが存在するようになっている。これらのネットワークは低地地域からヒマラヤ山脈などの高地地域にまで広がっている。このような遠隔地のネットワークは、単に”情報交換するだけのものではなく、それらの地域に暮らすコミュニティの生活水準を高め、コミュニティ及び、ビジネス、大学、病院、学校などの組織を連帯するためにも使用されている。本論では、ネットワークサービスを提供するにあたって、ヒマラヤ地方などインフラ整備から取り残された地域での、無線技術を利用した安価なワイヤレス・ネットワークの構築手法を提示すると共に、このような地域に適したネットワークモデルを提案する。また、少数ノードのワイヤレス・ネットワークが、コミュニティの社会経済の発展にどう貢献できるかを、ケーススタディを基に提示する。

● **Key words**

Heterogeneous Topography
Sustainability
Wireless Community Network

1. Introduction

Community wireless networks have been implemented to spread network access to rural, underprivileged, and remote areas. Most of the previous researches were focused on uncomplicated connection of network and deal with optimizing network performance through intelligent routing and scheduling, borrowing solutions by interconnecting network node. However, there are very limited researches especially in the case of high land altitude such as Himalayan region of Nepal. Though this research was occurred in comparatively lowland hilly area ranging from 700 m to 1800 m of altitude, our experience can be incorporated to higher altitude of Himalaya.This paper analyzes sustainability of community networks, security measures, services and network management applying standard monitoring tools that can be applied in heterogeneous topography.

2. Problem Statement

Having geographical diversity from high altitude to low land terrain structure as well as the wide-spread community structure of Himalayan region, the implementation of network infrastructure and developing internet enabled services are regarded as challenging task. Such kind of geographical complexities are contributing to lag behind the society of such areas economically and technologically. We also realized that there is a lack of proper research of establishing community networks in this kind of heterogeneous topography. We found two major convincing factors that motivated us to render our research in these areas:

I. Lack of proper research of establishing wireless networks in Heterogeneous Topography.

We know that there are plenty of well established community networks; however we have seen very limited numbers of networks that are in operation especially in high altitude mountainous regions. We agree that it is difficult to set up wired networks in such areas due to its geographical barrier. Therefore, we decide to research whether wireless networking can be introduced in such areas as a better alternative.

II. Lack of research to establish affordable community wireless networks.

During our preliminary study, we also found that there is a lack of practical data or survey of such areas regarding the establishment of sustainable community networks. We do believe that our research will further contributeto the literature of community wireless thereby providing the model which brings down the operational costs and ensure affordability to the community of such areas without compromising the quality.

3. Objective of Research

The main objective of this research is to develop a model of community wireless networks that provides connectivity to the internet for deprived communities. This research was carried in order to meet the following objectives:

- To establish a model of an affordable community wireless network based on the research findings.
- To recommend and to propose best suited network tools for the management of thecommunity wireless networks at heterogeneous topography.
- To provide the sustainable management approach of community wireless networks.

4. Significance of the Research

Community wireless has emerged in rural areas in different countries. While a lot of deploying companies and initiators including government bodies have been working for establishing community wireless network itself, there are few researchers who are studying about the community wireless in the developing countries having heterogeneous topography.

Establishing a suitable community network after a proper study would certainly avail the local community with internet access and provide number of e-services such as community portal, e-mail, e-library, tele-medicines, e-learning etc. Furthermore, such community wireless networks will ensures local framers to find proper market for community products and save their livelihood through the proper usage of the community wireless [5].

5. Implementing Community Wireless Network

5.1 Site Survey

Before the installation and project implementation a detail site survey is required. This research has focused on developing a wireless community network in heterogeneous land in Kaski region of Nepal and thus completed the preliminary survey required for implementation of our research project.

5.2 Goals of the Survey

The overall goal of this survey was to provide the information needed to design a fully integrated ICT enabled solution for community of selected areas in order to meet the overall objectives of the research. Furthermore, our goal of survey was to identify geographical structure of those locations including the basic needs of local communities and the services that we can deploy once the network is established. After the network is successfully deployed, ICT applications installed in the community networks will be capable to offer the following additional services to the local population.

- Free voice calling among connected node locations and center server location.
- Low-cost internet calling, using Skype or other services, to enable local customers to reach relatives living abroad or elsewhere in Nepal.
- Wider availability of network service in rural areas.
- Provision of internet access to areas currently without access,to allow local people to send and receive email messages and to use the web.

5.3 Survey Scope

The research survey was occurred in 2 locations: Kaskikot and Dhital respectively. These locations are situated nearby Pokhara, the second largest city of Nepal, which is the major source of internet connectivity.This location is being selected at which node for the internet firewall and voice traffic server for the entire network will be set up. In order to find the most feasible locations for the installations, selected line-of-sight (LOS) locations were also visited in order to collect the data.

5.4 Selection of Site

Using the above criteria, our analysis concluded that 2 sites, plus the Pokhara link, must be connected readily, creating a strong backbone for future expansion. Individual links were, therefore, simulated between the various radio nodes at these sites, and a list of appropriate access point radio and antenna combinations was created. We have acquired the following data through our survey as shown in Table 1 below by using Radio Mobile Version 9.9.5

Refer to Table 1 and Figure 1 for a list and map, respectively of the selected sites.

Table 1. Network node locations

Location	Type	Link distance to next node
Pokhara (Network Base Station)	Server/Internet Gateway	8.5 km
Kaskikot (Backhaul Repeater Station)	Main relay point	2.5km
Dhital (Service Relay Station)	Sub-relay point	*Link end*

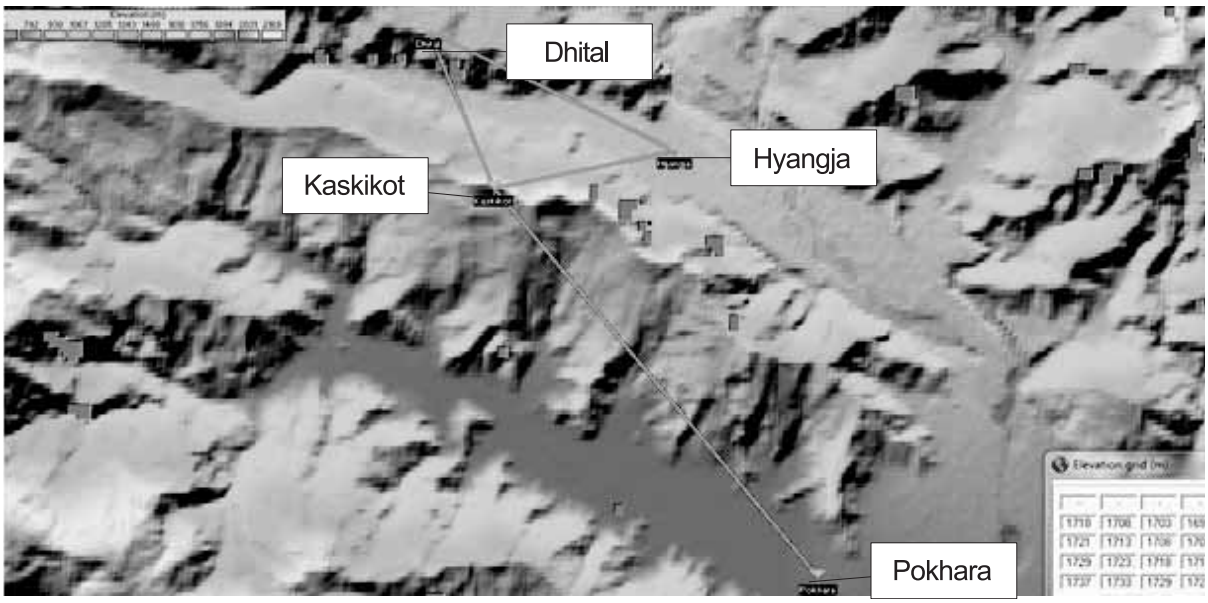

Figure 1. 2.4GHz wireless link Radio Mobile analysis map

This figure shows the wireless data network linking 2 network sites via relay stations. Only readily feasible site locations are indicated, as showing all the unfeasible sites would make the diagram quite difficult to read.

5.5 Sites

Each site would have a small to medium-sized room with additional room space for the power backup system. It is preferable to place the batteries in a box or closet space to protect them from inadvertent damage by users. Please see following pictures for views of various link locations.

Pokhara, Internet Gateway

Kaskikot, Community School.

Dhital, Radio Location

Dhital, Community Structure

Figure 2. Probable Locations for Wireless Installation

6. Proposed Network Design

The network gateway node is selected as Pokhara where a server with necessary hardware equippements and software for providing services and network operation are located. Server is connected with the high internet bandwidth. The high-speed backhaul radios at the relay stations operate on a dedicated core local-area network (LAN) that reaches from Pokhara to the Kaskikot hill. Also there will be Access Points (APs) for providing internet to distribute internet to end users in the villages. The nearby villages like Dhital, Hyangja are connected establishing repeaters to their APs respectively Conceptual and schematic diagrams of the network is below.

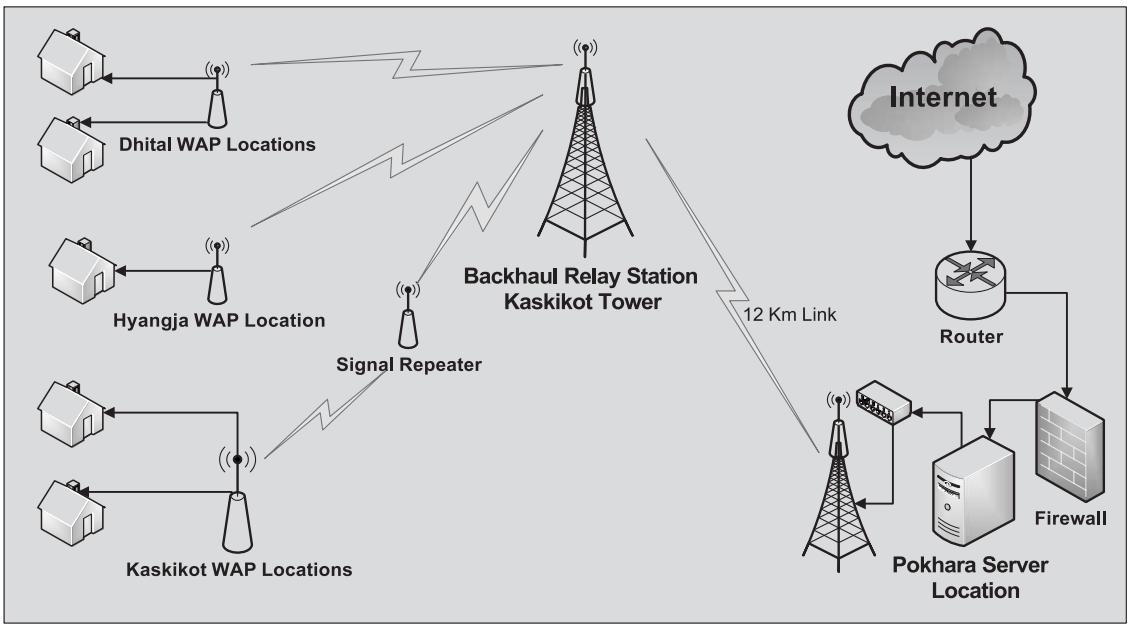

Figure 3. Proposed Network Design

6.1 Major Hardware Specifications

The hardware and cost in building a wireless community network in heterogeneous topography is largely dependent on project goals and how many locations are going to be connected and network bandwidth as well. From a general connectivity with limited budget to tens of thousands of budget using advanced ISP-class equippements can be invested but building a full fledge network with affordable cost is our research goal[1]. The major hardware required for building community wireless is as below:

Network Server, Firewall, Web Server and connectingmedias

Power-over-Ethernet adapters (required for outdoor antennas and wireless radios)

Directional antennas (for long distance links)

Omni-directional antennas (for hotspots)

Lighting protectors (for outdoors installations)

5.7 GHz radio with reflectors, 5 GHZ Access Points and Client radios

24dB Directional, 15 dB Panel and 14 dB Omni Directional Antennas [2]

Wireless routers, Routers and switches

Wi-Fi to PSTN Phone adaptors and IP phones

Solar Panels (is required for power grid is not connected)

Backup system (includes inverter and deep cycle battery that requires during power outage)

6.2 Recommended Network Appliances

A considerable numbers of network and peripherals are required for a complete community wireless network infrastructure. Some of the standard appliances are displayed below.

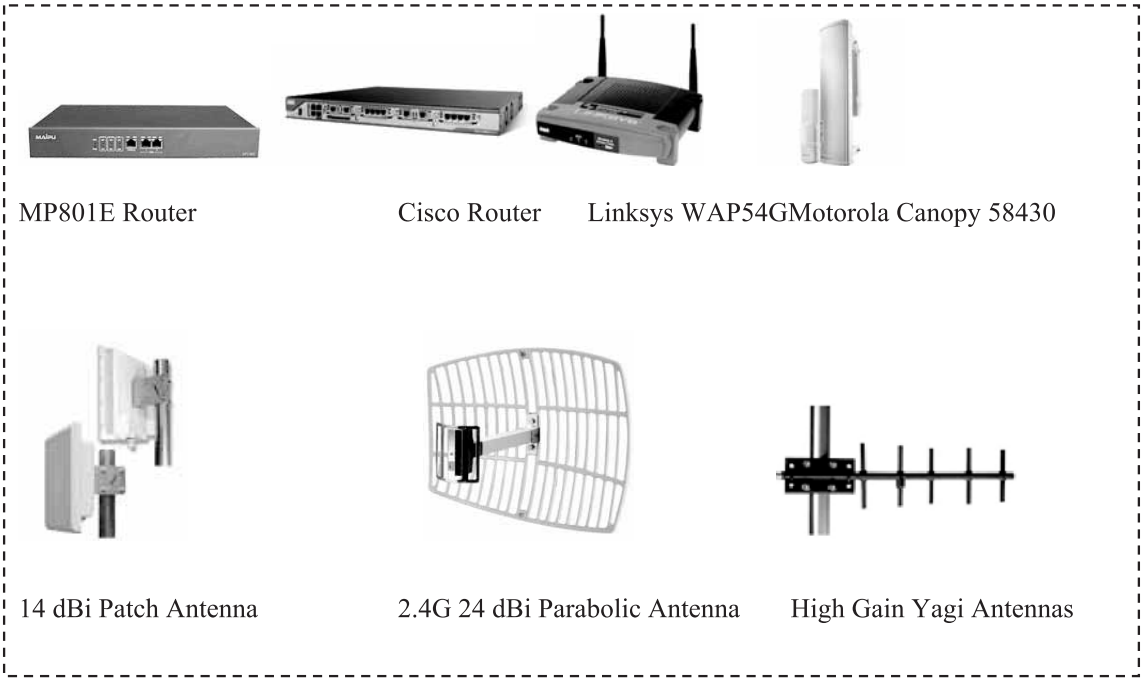

Figure 4. Network perepherals for establishing an idle Community Network

7. Budget Analysis

For establishing a community wireless network, a detail primary budget analysis was done. Cost estimation is completed with reference to manufacturer and selling agents provided cost of hardware and required peripherals. The projected cost is summarized in the following table:

Table 2. Capital Cost for establishing a community wireless Infrastructure

S.N.	Particulars	No.	Per unit cost	Total Cost
1	Pokhara (Base Station)			
1.1	Tower	1	10,000	10,000
1.2	Earthing	1	20,000	20,000
1.3	Backup + Inverter	1	32,000	32,000
1.4	Wireless Equipment (2.4 GHz)	1	55,000	55,000
	Server Cost	2	50,000	100,000
2	Kaskikot and Dhital (Relay Station)			
2.1	Tower	2	18,000	36,000
2.2	Earthing	2	25,000	50,000
2.3	Backup + Inverter	2	32,000	64,000
2.4	Wireless Equipment (2.4 GHz)	2	55,000	110,000
2.5	Antenna (Local Distribution)	2	13,000	26,000
4	Engineering Costs (2 Eng. 7 Days)	14	1,000	14,000
Total				517,000

Note: Mentioned cost is in NRs and the total cost is equivalent to USD 7,281

Table 3. Annual Running Cost

S.N.	Particulars	Qty	Total
1	Internet Bandwidth	1Gbps	80,000
2	Technical Support	1 person	120,000
3	Hardware Maintenance	Total network	60,000
4	Electricity and Backup System	Total network	70,000
Total			400,000

Note: Mentioned cost is in NRs and the total cost is equivalent to USD 4,583

8. Management and Security Measures of Wireless Community Networks

A community network in rural village has different network management needs and expectation because of the lack of technical expertise and network administrator [10]. They want tools that are low cost, easy to install and use, and with rich feature.

8.1 Network Monitoring Software for Community Wireless Network

Open Source offers many tools for various IT needs including network monitoring, bandwidth monitoring, network discovery etc. Most popular open source tools that we recommend for community wireless network management are described in details.

8.1.1 Nagios: The Open Source Network Monitoring Software

Nagios ® is a host and service monitoring tool designed to inform you of network problems before your clients, end-users or managers do. It has been designed to run under the Linux operating system, but works fine under most *NIX variants as well. The monitoring daemon runs intermittent checks on hosts and services you specify using external "plugins" which return status information to Nagios. When problems are encountered, the daemon can send notifications out to administrative contacts in a variety of different ways (email, instant message, SMS, etc.). Current status information, historical logs, and reports can all be accessed via a web browser [3].

8.1.2 Kismet: Wireless Monitoring Software

Kismet is the open source Wireless Discovery and Intrusion Prevention Software which is an 802.11 layer2 wireless network detector, sniffer, and intrusion detection system [3]. Kismet will work with any wireless card which supports raw monitoring (rfmon) mode, and can sniff 802.11b, 802.11a, 802.11g and 802.11n traffic. Kismet identifies networks by passively collecting packets and detecting standard named networks, detecting (and given time, de-cloaking) hidden networks, and inferring the presence of non-beaconing networks via data traffic [3]. A community wireless network can utilize and can get advantage from this software as it is free open source software. The following diagram ok Kismet displays its service clearly.

8.2 Security Measures

Change the System ID: Devices come with a default system ID called the SSID (Service Set Identifier) or ESSID (Extended Service Set Identifier). It is easy for a hacker to find out what the default identifier is for each manufacturer of wireless equipment so you need to change this to something else [9]. Use something unique- not your name or something easily guessed.

Disable Identifier Broadcasting: Announcing that you have a wireless connection to the world is an invitation for hackers. You already know you have one so you don't need to broadcast it. Check the manual for your hardware and figure out how to disable broadcasting.

Enable Encryption: WEP (Wired Equivalent Privacy) and WPA (Wi-Fi Protected Access) encrypt your data so that only the intended recipient is supposed to be able to read it. WEP has many holes and is easily cracked. 128-bit keys impact performance slightly without a significant increase in security so 40-bit (or 64-bit on some equipment) encryption is just as well. As with all security measures there are ways around it, but by using encryption you will keep the casual hackers out of your systems. If possible, you should use WPA encryption (older equipment can be upgraded to be WPA compatible). WPA fixes the security flaws in WEP but it is still subject to DOS (denial-of-service) attacks.

Restrict Unnecessary Traffic: Many wired and wireless routers have built-in firewalls. They are not the most

technically advanced firewalls, but they help create one more line of defense [9]. Read the manual for your hardware and learn how to configure your router to only allow incoming or outgoing traffic that you have approved.

Change the Default Administrator Password: This is just good practice for all hardware and software. The default passwords are easily obtained and because so many people don't bother to take the simple step of changing them they are usually what hackers try first [9]. Make sure you change the default password on your wireless router / access point to something that is not easily guessed like your last name.

Patch and Protect Your PC's: As a last line of defense you should have personal firewall software such as Zone Alarm Pro and anti-virus software installed on your computer. As important as installing the anti-virus software, you must keep it up to date. New viruses are discovered daily and anti-virus software vendors generally release updates at least once a week. You also must keep up to date with patches for known security vulnerabilities. For Microsoft operating systems you can use Windows Update to try and help keep you current with patches.

Disable remote administration: Most WLAN routers have the ability to be remotely administered via the Internet. Ideally, you should use this feature only if it lets you define a specific IP address or limited range of addresses that will be able to access the router. Otherwise, almost anyone anywhere could potentially find and access your router. As a rule, unless you absolutely need this capability, it's best to keep remote administration turned off. (It's usually turned off by default, but it's always a good idea to check) [9].

Use MAC filtering for access control: Unlike IP addresses, MAC addresses are unique to specific network adapters, so by turning on MAC filtering you can limit network access to only your systems (or those you know about). In order to use MAC filtering you need to find (and enter into the router or AP) the 12-character MAC address of every system that will connect to the network, so it can be inconvenient to set up, especially if you have a lot of wireless clients or if your clients change a lot. MAC addresses can be "spoofed" (imitated) by a knowledgeable person, so while it's not a guarantee of security, it does add another hurdle for potential intruders to jump.

9. Recommended Services that can be offered in Community Wireless Networks

The objectives of community wireless networks should be maximizing the benefit of wireless and information technology for the rural population in remote area by introducing different useful ICT applications. Rural people will be given access to e-commerce, e-education, e-medicine, news and limitless information offered by the web. Logistical planning will be made infinitely easier by the use of email and VoIP technology, allowing for more efficiency with business and the transportation of produce. We witnessed that Internet services are enabling each and every sector of the communities and the effects of it are inter related. The slight modification in any community component has its direct impact on other sector of the community. Considering this fact we had studied how to benefit each sector of the community by our community networks. The ICT applications integrated with the community services will benefit following sectors and the short description of each are provided below:

9.1 In Education Sectors

One of the development indexes of the community is education. We observed that getting education in our research area i.e rural area is seemed to be hard due to lack of the colleges and universities. Students of these regions need to go the larger cities for higher education. We have proposed a solution for these situations by implementing distance learning methodologies. With the collaboration of the colleges and universities of the city center, online lecture programs can be started on those areas which will benefit the youth to get the education. It preserves the youth strength remain on those places, which can be utilized on job creating tasks in the village. Moreover the youth will also be facilitated by the program of distance learning of different universities from all round the world.

9.1.1 Learning

To narrow the digital divide in education, standard system can be developed as e-learning system in community wireless network. The use of web-based teaching materials, multi-media CD-ROMs, e-mail, educational animation etc. have all been used and being used extensively in developed countries for the learning purpose [7]. However, e-learning is getting popular as a tool to bridge the gap between the education level of urban people and that of people living in rural areas. Wireless Community networks will be capable of providing e-learning service from which various people of the community will be benefited.

9.1.2 E-library

The goal of e-library is to provide literacy and awareness about the use of computer and information communication technology. Online delivery provides currency, diversity of content, and variety of access methods - all in engaging environment provides powerful, compelling resources for extending and reinforcing community students and people learning and achievement.

Every computer of this network will get free excess to the E-library server computer even in absence of Internet. The centralized server of the network provides some space for every student to make their personal web site.

9.2 Tele-Medicine

Providing quality tele-healthcare in both rural and urban settings introduces many challenges. From live videoconferencing to store-and-forward audio and image capture, to the collection of patient information that can be merged into a database or printed for storage in the patient's medical record, telemedicine is now able to provide both the patient, on one end, and the physician, at the other, a new level of service [6]. These days, there are advance video conferencing tool which provide qualitative video/audio service from which the doctor at distant can see the image of different parts of patient body if it necessary. Proper use of tele-medicine system and co-ordination, rural people can save lives from critical health problem and accidents without traveling to long way hospitals.

9.3 Email/ Internet/ VoIP

These are the common things to use by people after the availability of the Internet service. It is one of the trends that community people from underdeveloped country like Nepal go overseas in search of job and higher study. Their parent who resides in those villages can use international call that is cheap in comparison to other way of communication. Furthermore, Internet can be used in information searching from global database so that community people can benefit in numerous fields if it is utilized properly.

9.4 Community Portal

Community Web portals serve as portals for the information needs of particular communities on the Web. Web-Portal is dedicated to helping local people take advantage of and benefit from the new information and communication technologies and services associated with the Internet and media convergence [6].

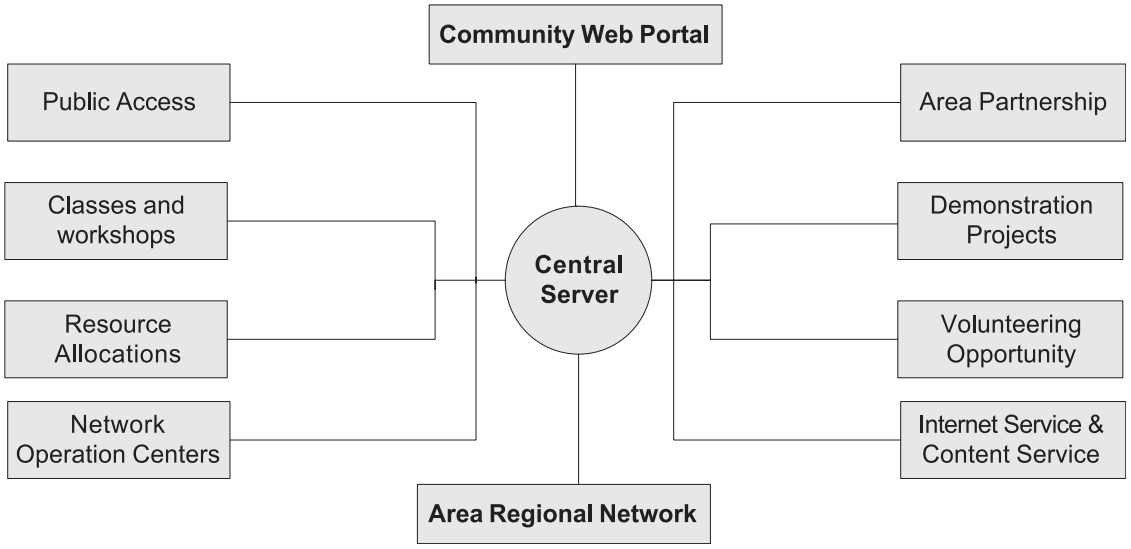

Figure 5. Community Web-Portal partners and projects in a nutshell

10. Socio-Economics of the community

Economics is one of the main sectors of community being benefited with our community wireless. Our community network will serve as the marketing places for the products of those areas. A design of a portal every people of the community will post something about their new product will be beneficiary to the economy of their community. We have seen a clear design of making our research area a completely tourist areas as our community network will be the access point for the tourists all over the world to visit the places. The sharing of the beautiful and adventurous places of community, our community network will guide the tourists to our community helping the economics of our community.

11. Considerations for Sustainable Management

Running and managing the network in a long run would be the most difficult goal when operating wireless networks in isolated topographical locations and remote village. The prohibitive cost of Internet connectivity in

many rural sectors of developing countries imposes a substantial operating expense that makes these models sensitive to economic fluctuations and necessitates innovation to attain viability [2]. Substantial progress in the use of wireless networks for rural communications has been accomplished over the past few years, due in large part to technological breakthroughs.

11.1 First Step to Sustainability

It is important to research all of the start-up costs in advance, and make realistic estimations on recurring expenses. It is always better to over-budget for expenses than to under-budget. With every wireless project, there are always unforeseen costs, especially during the first year of operations as you learn how to better manage your network.

To improve the chances of sustainability, it is generally best to maintain the lowest cost structure for the network. In other words, keep your expenses as low as possible. Take time to thoroughly research all of your suppliers, particularly the ISPs, and shop around for the best deals on quality service [8]. The following table shows the categories of cost involved in wireless system from installation to normal operation.

11.2 Local Partnership

The network service can be provided taking minimum of running cost in the local community making them as service partners. To make partners it necessary to identify the individuals, groups and organizations in the community that have a need of network and information services [1]. There may be of different potentials users of wide variety of individuals and local organization. The local partners can be made to following partners who always exist in the community.

- Local village committee
- Farmers' associations and cooperatives
- Private, public schools, colleges and library
- Businesses and local entrepreneurs
- Restaurants and hotels
- Health clinics and local hospitals
- Religious groups
- International and local non-governmental organizations (I/NGOs)
- Organizations in the tourist industry
- Other firms and organizations
- Individuals

After the partnership between service provider and above local partners, demanded service should only be provided so that they can use service for their socio-economic development. Assistance from key partners may also be necessary to secure sustainability for wireless network. During this stage, potential partners should be connected for mutually beneficial collaborations.

11.3 Awareness of Local Government

There is always a grand role of local government for developing and providing local services to their community. Always local government has yearly plan for collection of fund and invest [1]. If local government plays as a protector role and plans some percentage of its budget annually taking as it is one of the needful infrastructures for its village the program will sustain easily.

11.4 Information Centric Services

The service provided in the community should be information centric rather than on computers and internet alone to build local organization more fully woven into the fabric of the communication with a large base of income generation. They can systematically assess community information need and the communication need of other local organizations, and be creative and entrepreneurial in dealing with this need [4]. In this way the border approach of information society create road of self-sufficiency.

12. Conclusion and Future Enhancement of Research

During our site visit, we have met few Community Wireless Network operators and its users. We were reported that they feel benefited and enjoy the pleasures of public sociability with co-present patrons, while, at the same time, they are able to be connected to their friends, coworkers and family via the Internet. Both face-to-face interaction and online interaction seem to provide a positive effect to the community of Wi-Fi users. We are fully convinced that the local needs the network connectivity provided with various network services while at the same time it should be affordable in order to operate it economically sustainable.

Within the context of the assumptions based on our research, a community based network would definitely be sustainable, should it be supported by local government and the community. As our research suggest that community networks should be encouraged to generate some income through IP-telephony and other services and should expand more income generating services, reinvest back the income into the area, with a capital cost of about US$7,000 annual costs of about US$4,500, and income of over US$5,000, it can be run sustainable.

Due to lack of fund, we were unable to execute the project by the end of 2010, however, we have completed our site survey, literature review and other needful research required to implement the project. In order to execute the sustainable model of community wireless project, we are focused to gather the fund required for implementing the project. We conclude that this research has contributed to the literature of community wireless field and is able to propose the model for establishing community wireless project in heterogeneous topography.

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●英文タイトル

A STUDY AND SITE SURVEY IN HIMALAYAN REGION FOR PROPER UTILIZATION OF WIRELESS COMMUNITY NETWORKS: AN ASSESSMENT OF COMMUNITY WIRELESS IMPLEMENTATION IN HETEROGENEOUS TOPOGRAPHY

●要約

Today, there are numbers of large-scale networks that include wireless, wired, and satellite-based communications which are deployed in many countries around the globe. These networks are established in verities of location which diverges from low altitude areas to highland areas such as Himalaya. Among to those, wirelesses networking in remote areas are being used to connect other community networks, neighborhoods, businesses, colleges, hospitals, companies, schools, private and public community sectors in order to enhance not only to exchange information but also to provide varieties of network services between the communities which ultimately assist the livelihood of the community. This paper describes a network that effectively utilizes wireless technology and also proposes a network model that describes how an affordable wireless network can be deployed in rural and infrastructure bereft areas such as Himalayan region. This paper also presents a set of case studies that propose how the services in remote areas' wireless networks with limited number of nodes can contribute to uplift the socio-economy of the community.

● Keywords

Heterogeneous Topography
Sustainability
Wireless Community Network