Nepal Wireless Networking Project

Final Report of

APT ICT J3 Project in Nepal

Submitted by:

E- Networking Research and Development, Nepal

http://www.enrd.org

Project Supported By:

Asia Pacific Telecommunity

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Preface

Dear Readers,

This is the detailed final report of Nepal Wireless Networking Project implemented with the financial support of Asia Pacific Telecommunity (http://www.apt.int). Therefore we have tried to provide detail information on how the network was built (with technical details), the kinds of services it provides, how it operates, and what impact it will have on the community.

The Nepal Wireless Networking Project was started with my dream in 1997 to connect Himanchal High School of Nangi, Nepal to the Internet. It was the time when no villager had absolutely any idea what an Internet was. That was no small task then because the school had no phone line, no electricity, and no computers. The only way to access the Internet for me was a full day's travel by walking five hours downhill and four hours bus ride to the nearest city - Pokhara. However, step-by-step I worked with the village and a team of volunteers to achieve that goal. We built a 2 KW hydropower generator in the village and built computers in wooden boxes from donated PC parts. By 2003, we had set up a limited Internet connection using wireless Ethernet (Wi-fi) technology. That was the beginning of Nepal Wireless. Today, we have connected over 50 villages in different parts of Nepal. We expanded our services to include telemedicine, distance education, communication service, and e-commerce services. We are also using the wireless network for weather and climate change monitoring purpose as well.

Many thanks go to Asia Pacific Telecommunity for the financial support to build the wireless network in Mustang areas. That was a challenging project to accomplish because of the high Himalayas that we needed to go through. However, with the hard work of our technical team and international volunteers, we became able to overcome the geographical challenges. We hope this report will help you to understand our project and see how it can lead to new forms of development in rural Nepal. We appreciate for your interest and welcome your involvement.

Mahabir Pun
Team Leader, Nepal Wireless

1. Introduction

Kagbeni Relay of Mustang

Nepal is a small country between India and China with majority of the highest peaks of the world located in it. Nepal is known more with the Mount Everest and the Himalayas around the world than any thing else. In global economic scenario the position of Nepal is not different from the economic condition of other underdeveloped countries. Nepal's GDP is US$ 5.5 billion; with annual average growth rate of 4.9%. The per capita income is US$ 250, which is among the lowest in the world. The country has a population of 25 million now with a growth rate of 2.24% *(NPC, 2001).* The majority of population is significantly residing in rural areas with the population density 686 per square kilometer *(World Bank, 2002)*. The population density is among the highest population densities in the world with respect to cultivable land *(MOPE, 2000*). The life expectancy at birth is 63.3 years, the lowest in South Asia. The infant mortality per 1,000 live births is 64.4, which is the highest in South Asia. The illiteracy rate among the population above the age of 15 is 62 percent *(World Bank, 1999, CBS 2006).* According to the Human Resource Development Index of 0.323, Nepal ranks 151 positions among 174 countries *(HRD, 2001).* This shows the fact that Nepal is one of the poorest countries in the world, with 82.5% of the population living below the international poverty line of $2 per day *(World Bank, 2003)*

The data mentioned above makes us to think that a developing country like Nepal needs to focus more on foods, health and education as the priority sectors. However, the fact is that without building a strong communication infrastructure based upon broadband information highway it will be difficult to make any development work run smoothly. Using communication technologies (ICT) as the tool, we believe that we can help people to increase their efficiency and enhance productivity and hence improve their economic status. Thus ICT can be of immense help for developing countries like Nepal to bring prosperity in the rural areas (BAAC, 2002).

However, many developing countries including Nepal have not been able to use the information technology in its full capacity and provide benefits to its citizens. There are several factors responsible for creating the barriers such as political instability, low education level, and less priorities given by the government for the advancement of the information and communication technology.

Over the past few years a great deal of attention has been placed on issues of ICT access and the "digital divide" by development organizations and governments. While various conferences, resolutions, and commitments have taken place it is difficult to determine if any tangible progress has been made. The Nepal Wireless Networking Project has taken a serious look at the same issues, but it approached the problem from a grassroots perspective. Since 2002, it has been working to bridge the digital divide in Nepal by extending ICT access to rural areas through wireless technology.

Trainees from the villages at the wireless networking training in Pokhara

2. Status of Telecommunication and ICT infrastructure in Nepal

Building Relay Station in Kagbeni

Nepal Government introduced information technology in 1971 to process the national population census data. National Computer Center (NCC) was established in 1974 with the objective of providing IT training within Nepal. NCC developed software for various government agencies, and processed examination results for Examination Control Board of Ministry of Education and Tribhuvan University. It also conducted regular training courses on computer literacy and software applications. NCC was dissolved in 1998 and currently there is no computer-training institution in the government sector.

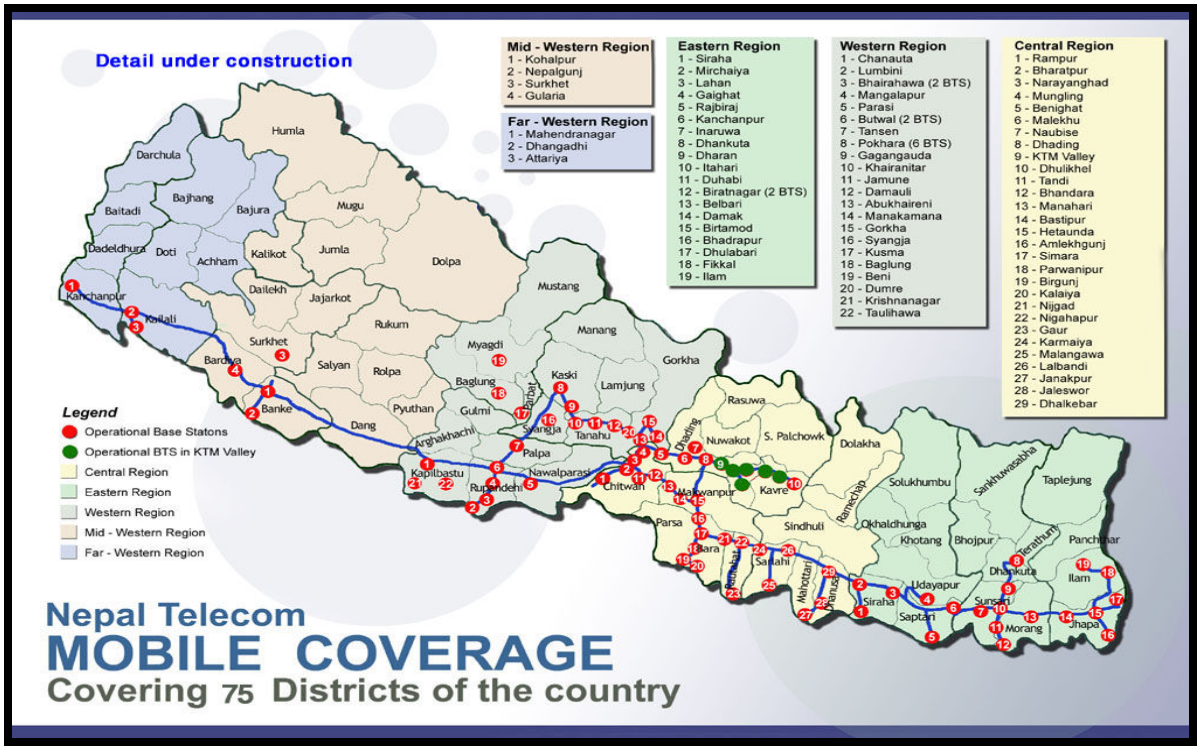
The introduction of IT and IT related services in Nepal was led by private sectors. The private sectors initiated training centers, created Nepali fonts, as well as did trading on both Macintosh and IBM compatible personal computers. Starting in early 1980s Apple computers were introduced in Nepal, followed by the introduction of IBM compatible PCs afterwards. One of the early initiatives in exporting software from Nepal was done by a company called DSI, founded by an American national. By mid-80s, there were many private trading houses in Kathmandu dealing in computers. During that time several private computer institutes were opened in the urban areas to provide basic computer training. However, the progress was limited till the democratic movement in 1990. It was after the movement of the 1990 and liberal environment that the growth of IT industry flourished in Nepal.

In 1992, Mercantile Communication Pvt. Ltd. started commercial e-mail through Internet and it was formally registered in 1995 as the first Internet Service Provider (ISP) in Nepal. Then several private ISPs were registered. The country now is enjoying the development of ICT from private sectors, NGOs, and associations. Under the Ministry of Science and Technology, High-level Commission for Information Technology has been formed, which develops ICT related policies and helps the government, and other ICT related organizations to develop ICT in the country. Every year Computer Association of Nepal organizes national exhibition in Kathmandu to help introduce new ICT developments from around the world to the Nepali people.

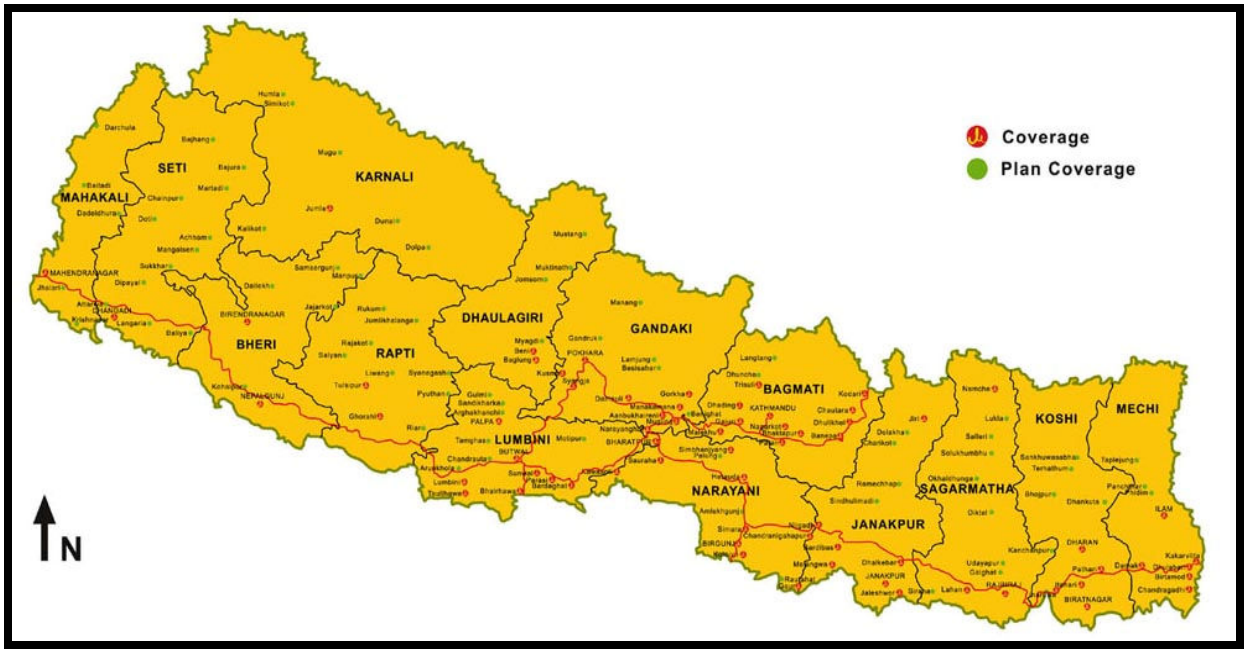
VSAT was liberalized in Nepal in 1997 as per the Telecommunication regulation 1997. As a result the number of ISPs increased and the price of Internet service kept decreasing. Moreover, Nepal government regulated and de-licensed the ISM Band wireless frequencies (2.4 GHz and 5.8 GHz) in 2007 that opened more opportunities for the extension of wireless network in the rural and urban areas. Nepal Government released the Science and Technology Policy - 2005 and Electronic Transaction Ordinance (Cyber law) - 2005. The Telecommunication Regulation - 1997 has opened more opportunities for telephone operators as well as ISPs. Now there are more then 38 ISPs, 3 fixed telephone service providers, 2 GSM cellular Mobile service providers, 94 VSAT users, 3 rural VSAT users, and 1 rural Internet service providers. *(MIS NTA-July 2009).*

After all these efforts, the telecommunication and internet penetration rate in Nepal is still very low. According to the Nepal Telecommunication Authority MIS July 2009 report, the total telephone subscribers including PSTN and mobile are 6,069,659 which give the penetration rate of 22.07%. If we see the data service parts then the numbers of subscribers to access data services are 176,024 and the numbers represent from major urban areas and district headquarters.

Different service providers are doing their efforts to extend their coverage areas. We can compare the coverage area of two major telecommunication service providers, Nepal Telecom and Spice Nepal P. Ltd. From the picture given below we can see that they are concentrating mostly to provide services in the urban and populated areas, and the district headquarters. Also it can be seen that they are focusing more in the eastern and southern parts of Nepal where the density of the population is much higher in comparison to the population density of northern and north-western part of the country.

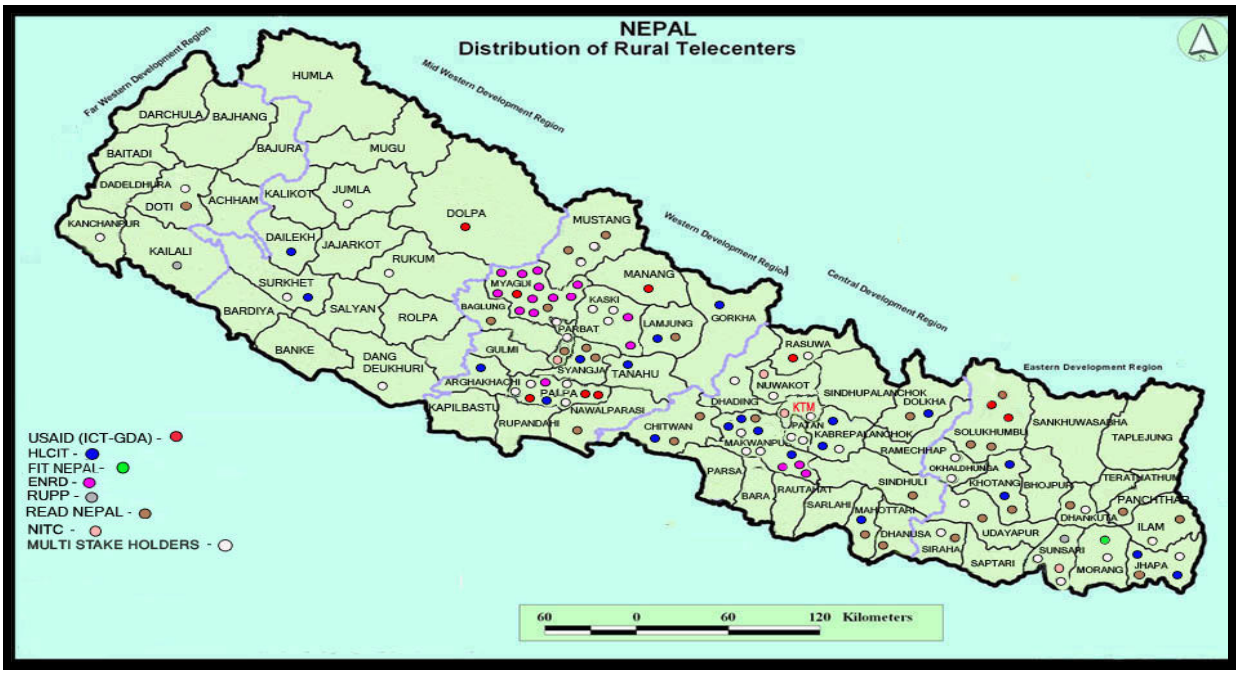


Mobile coverage of Nepal Telecom (Source: Nepal Telecom)



Mobile service coverage of Spice Nepal Pvt. Ltd. (Source: Spice Nepal Pvt. Ltd)

Thus, it can be clearly seen that the distribution of the telephone services is very much unbalanced and is more focused on the highly populated areas. There are total 3,915 local governments called Village Development Committees (VDCs) in Nepal. Out of them only 1,885 VDCs has rural PCOs and 436 VDCs has no connectivity at all. Majority of populations are not getting access of telephone services.



Distributions of rural tele-centers run by different organizations (Source: HLCIT)

In this scenario, the distribution of the internet services that are available in the rural areas of Nepal is even more frustrating. According to the tele-center mapping report from the High Level Commission for Information Technology, there are 91 tele-centers established by different organizations all over the country (*Source: telecenter.org.np*). Most of those tele-centers have connectivity through dial-up connection. However, the fact is that many of those tele-centers are not in operation because of the poor management.

In summary, we can say that there is no Internet, email and IP based telephony services available in majority of the Village Development Committees (VDCs) in rural Nepal with some exceptions. The VDCs that come in the exception category are those VDCs that are located near the big cities like Pokhara, Kathmandu, Biratnagar etc, or those VDCs that have initiated programs by themselves to bring Internet on local level using mostly VSAT technologies provided by STM or Mercantile Communications.

3. Nepal Wireless Networking Project

The first long range link testing (34 KM) was done in 2002 from Mohare to Pokhara putting a dish on the ground

Beginning of Nepal Wireless in 2002 with dish antenna and Wi-fi radio on the tree.

Over the past few years a great deal of attention has been placed on issues of ICT access and the "digital divide" by development organizations and governments. While various conferences, resolutions, and commitments have taken place it is difficult to determine if any tangible progress has been made. The Nepal Wireless Networking Project has taken a serious look at the same issues, but it approached the problem from a grassroots perspective. Since 2002, it has been working to bridge the digital divide in Nepal by extending ICT access to rural areas through wireless technology.

At a time when there was little interest of Nepal government and the private sectors to bring the information technology in the rural areas, Nepal Wireless Networking Project was born informally in 2002 under Himanchal Higher Secondary School. In its inception, the project did not have a goal to become a rural Internet Service Provider. It was solely started with a dream in pursuit of finding ways to bring Internet and telephone at Himanchal Higher Secondary School, Nangi village, Nepal and the dream unexpectedly turned into a project. Nangi is the village where Mahabir Pun, the team leader of Nepal Wireless Networking Project, was working as a volunteer teacher.

Now the project is being run formally by E-Networking Research and Development (ENRD), which is a NGO registered with Nepal Government. ENRD, as an NGO, can formally

help to build wireless network in the rural areas but it can't work as an Internet Service Provider (ISP) according to the law of Nepal Government. Therefore recently a not-for-profit making company by the name of Nepal Wireless has been registered. An application to become a rural ISP is now underway and Nepal Wireless will formally become a rural Internet Service Provider once the application is approved by Nepal Telecommunication Authority.

From 2002 to 2009, Nepal Wireless Networking Project has built small scale wireless infrastructures using Wi-fi and some proprietary equipment. It has expanded wireless network to provide Internet to some rural population of Myagdi, Kaski, Parbat, Baglung, Makawanpur, Dolakha, Gorakha and Mustang districts. In all its projects, it is using the ISM band of 2.4 GHz and 5.8 GHz, which are license free frequencies as per Nepal Government's directive.

3. 1. Goals and Objectives

The long-term goal of Nepal Wireless is to become one of the biggest rural Internet Service Providers in Nepal. The objective is not to bring only the Internet and computers in the rural areas but to maximize the benefits of wireless and information technology for the rural population in remote areas by introducing different useful applications. Using the wireless technology, we hope to make the life of rural people bit easier and more enjoyable. Specifically, the project aims to achieve the following goals, divided into six main goal areas:

- **Education:** To increase educational opportunities in the rural communities by creating tele-teaching and tele- training program and by making to e-learning materials accessible to students, teachers and villagers through e-libraries created by different organizations.

- **Health:** To connect the rural health clinics and health workers to the city hospitals in order to provide quality medical assistances through telemedicine program and make the availability of healthcare in the rural communities by virtually bringing medical doctors.

- **Communication:** To increase communication facilities in the rural areas by providing telephone services through Internet phone system (VoIP), to make Internet available for the use of email, and to help villagers to discuss by using Nepali language bulletin boards for community discussion.

- **Local e-commerce**: To help villagers to buy and sell their products in the local market through local intranet.

- **Job creation:** To generate jobs in the rural areas for younger generation through ICT related services such as communication centers, VoIP phone services, remittance services, and virtual ATM machine.

- **Weather and climate change monitoring:** To collect data for the researchers of climate change monitoring projects and provide real time weather information of the air route between Jomsom and Pokhara for airlines.

The project already has started to provide some benefits mentioned above to the villagers, such as communication, educational, and telemedicine facilities to the rural people even if it is on small scale as well as air route information to the airport.

Team members welcomed by the villagers with garlands and cup of local wine

4. Partners, Japanese Experts and Supporters

It is a true fact that Nepal Wireless does not have all the expertise to fulfill all the project goals by itself. Several partner organizations and institutions helped to implement the project and to provide services to the rural people. We are thankful for each of the partners and supporters mentioned below that provided support for the project.

Office of Mustang District Development Committee

1. Mustang District Development Committee provided support to run and maintain the network in Mustang sector and paid for the local cost incurred for the project.
2. Himanchal Higher Secondary School supports for monitoring and maintaining the relay stations and network in rural level in Myagdi sector of the network for smooth operation and maximum uplink. (http://www.himanchal.org)
3. Open Learning Exchange – Nepal developed contents in Nepali language for the students and implemented the contents in the schools of Mustang. It has also developed e-library contents for the students and villagers (http://olenepal.org)
4. Nepal Research and Education Network helped for research and development (R&D) and supports for technical issues like network designing, equipment testing, routing, and server building and maintenance. (http://nren.net.np)
5. Om Hospital, Pokhara, provides telemedicine support to rural health workers.
6. Kathmandu Model Hospital provides its facility and doctors to run telemedicine program and tele-training program for the rural health clinics and hospitals.
7. Nepal Medical College, provides telemedicine services for the rural clinics.
8. Thamel.com, Kathmandu helps for implementing credit card transaction services.

9. Gandaki College of Science and Engineering, Pokhara helped for developing applications of local e-commerce and phpBB and customizing them in Nepali.
10. Kaski Association of the Blinds is cooperating to introduce computers and Internet for the benefit of visually impaired people.
11. Japan International ICT Association (JIIA), Tokyo provided technical support for selecting the right equipment and by sending their experts to Nepal for guidance.
12. ITU Association of Japan (ITUA-J) helped to develop links with Japanese partners and supporters, and provided technical support and guidance.
13. KDDI Corporation, Japan is a supporter for the project and provided 85 laptop computers. KDDI sent technical expert, Mr. Fuke, to help in telemedicine program.

		
Mr. Yasuhiko Kawasumi	Mr. Naomi Fuke	Mr. Izumi Aizu

Photos of the Japanese Experts, who visited the project sites and gave their inputs

Before the decision to buy WiMax equivalent Alvarion product was made, Mr. Rajendra Poudel and Mr. Yasuhiko Kawasumi did extensive researches and had had several rounds of meetings and discussions with the members of different Japanese organizations such as WiMax Forum, Japan Radio Corporation, the communication specialists of the KDDI Japan, and Japan International ICT Association. The meeting with KDDI resulted also to the donation of 85 laptop computers to Nepal Wireless through ENRD. Mr. Kawasumi worked with Mr. Wisit Atipayacoon of ITU – Bangkok, who helped to ship the laptops to Kathmandu via air cargo. Moreover, Mr. Poudel, Mr. Kawasumi and Mr. Fuke did the selection and the final testing of the telemedicine equipment in Tokyo before they were bought and shipped.

Outcomes of the field visits of the Japanese experts and their recommendations:

ENRD invited Mr. Naoki Fuke (KDDI) and Mr. Yasuhiko Kawasumi (ITU Association of Japan), and Mr. Izumi Aizu (Institute for InfoSocionomics, Tama University) during the project implementation period as Japanese experts. Mr. Kawasumi and Mr. Fuke visited Nepal and project site from October 19 to 24 and Mr. Izumi Aizu from November 20 to 26 of 2009. Both teams were accompanied by accompanied by Mr. Mahabir Pun, where ENRD has set up telemedicine centers and community information centers by the financial support of Asia Pacific Telecommunity. Mr. Fuke and Mr. Kawasumi visited project sites, such as Pokhara, Jomsom, Kobang, Tukuche, Marpha , Chandrakot, Kathmandu. Mr. Izumi visited Pokhara, Muktinath, Jharkot, Lete, Kobang, Kalopani, Syang and Chandrakot. The main objectives of the mission team were as follows.

- To confirm the implementation of Nepal Nepal Wireless Networking Project
- To find out how the local people are starting to use the network
- To recommend the appropriate wireless technology and telemedicine equipment
- To share ideas from the past experiences, to explore further possibilities and suggest areas for improvements with new ideas

The mission team of Mr. Kawasumi and Mr Fuke accomplished the following objectives and provided suggestions and advices for the project.

- Through the exchange of views with medical doctors at the Jomsom District Hospital, and Kathmandu Model Hospital the expert team extended advice/suggestions and its extension plan relating to telemedicine application.
- The team made survey on the availability of refurbished PCs donated by KDDI.
- The team extended advice/suggestions for the Nepal Wireless Networking Project and its future extension plan launched by ENRD.
- Based on the survey visit to the project sites the expert team submitted the report with recommendations on telemedicine applications and community telecenter development plan including applicable devices for the project.

Considering the situation of the rural clinics, the team recommended that the targeted medical facility should be limited to the primary health center and a few medical posts as the result of the initial feasibility study. Depending on the functions required for the primary health center and the health post, the mission team of Mr. Kawasumi and Mr. Fuke recommended the following equipment to be installed in the rural clinics.

A**.** Recommended equipment for the primary heath center

- Electrocardiograph (ECG) equipment
- Digital stethoscope
- Oximeter (Blood oxygen level monitor)
- Ultrasonograph equipment
- Transparent image scanner for X-ray machine

B**.** Recommended equipment for the health post

- Electrocardiograph (ECG) equipment
- Digital stethoscope
- Oximeter (Blood oxygen level monitor)
- Blood pressure monitor with digital interface

Also the team recommended to installed large LCD monitors at Kathmandu Model Hospital and Pokhara hospital so that doctors can see the patient's face with a high resolution image through a video conference system.

The followings were some suggestions given by Mr. Izumi Aizu for the project.

1. **Use of Wiki – highly recommended**: It may be useful if Nepal Wireless Networking Project prepares a dedicated Blog or Wiki site, asking students to contribute their own material. For example, how about starting "A Week in the Life" event, asking participating students to write their own diary for a week and share them with others. It could be done linking all schools connected to the Internet in Nepal, or even with counterparts outside Nepal. For students, it will provide more incentives to get to know other people outside their own village. There were some schools in Japan who are linked nationwide, and shared their

observation of how potatoes grow, in different parts of the country. As some cities in Japan are located in the very south, and others in the center and some others in the north, the timing of blooming the flowers of the potatoes differ, a simple fact for us, but a new finding for the children.

It is also highly recommended to encourage children to communicate, not only just to teach how to use computers or software technically. To promote this, it is suggested to create a community of users, students, parents, village people, and friends even from overseas. The human communication encourages the users to use computers more regularly, obtain sense of "connectedness" and promote the use of networking in social context. This way, students can learn science in the filed, history and culture of the community in the modern society.

There are several application services to be used – Social networking such as Facebook, You Tube and Twitters, or shared Wiki for more dedicated purposes.

2. **Use Social Network Services (SNS) and "Cloud" services:** While real-time videoconferencing is a great tool, the other end, asynchronous mode of communication can be further explored, too. In addition to e-mail and bulletin board, so-called "Social Networking Services" are becoming increasingly popular and effective.

   If doctors, for example, use twitters, they may also be able to stay with colleagues in more real-time manner. If they share some "database" using Wiki or Blog like services, even closed, they are also able to share knowledge very effectively. Some of these services work quite well without consuming much bandwidth. Some are offered "online" with so-called "cloud" services, which do not require physical local servers that can save the cost of purchasing them and associated cost of maintenance and technical support. Of course, there are several perceived barriers to using SNS and cloud services. International connection may become bottleneck. Customizing the features require certain skills. But even so, it is worth to consider using these new waves of services.

3. **Some Suggestions for enhancing the educational effectiveness:** Based on the observation, the following ideas are suggested:
   - Prepare online "self-learning" course for technical training.
   - Find "bright students" in senior class who may also take care of the technical support.
   - Let teachers use the Internet more – i.e. use of e-mail is still less than desired level, offer practical cases where they need to use e-mail and Internet.

5. Project Implementation

Assembling Grid Antenna at Mohare Relay

Implementation of the APT supported pilot project started in January 2009. At the beginning, the project had planned to connect Lete, Kobang, Tukche, Marpha, Syang, and Jomsom of Mustang district through wireless technology. Kagbeni and Muktinath villages were added later. In the same way, the names of the villages that are connected to the wireless network in Myagdi sector are Bhuka, Sapet, Chimkhola, Jhin, Aulo and Kaphaldanda. Originally, Patalekhet and Paudwar villages were proposed, however, the power company could not bring power at Patalekhet on time and there was technical problem to connect Paudwar village directly from Mohare relay station. Thus a total of 14 villages are connected in the wireless network now that were built with the financial support of APT. Moreover, the project has set up a communication center for the blinds in Pokhara. With the completion of the project, a number of services are now being provided by the project through the schools, clinics and village communication centers, and relay stations as given in the following paragraphs:

5.1. Internet Access: Internet has been available in the villages that are connected to the villages. The schools of most of the villages except Muktinath and Aulo have been connected to the network. Each school has a computer lab with the number of computers from two to six. This is just the beginning and the schools will raise money from different sources to buy more computers.

E-Networking Research and Development (ENRD) will conduct computer training for the teachers in 2010. Moreover, some of the school teachers have already gotten some basic computer training by themselves. As for the schools and communication centers in Myagdi sector of the network, there are a couple of school teachers in Chimkhola, Aulo, Bhuka, Sapet and Kaphaldanda, who already have taken some computer courses in Pokhara. Therefore it has not been difficult to teach rural people and students on how to use Internet that is available to the villages. Some students, teachers and the villagers already have their own web-based email account such as yahoo, hotmail and gmail. Moreover, free accounts are available through nepalwireless.net if people are interested to have it. For the nepalwireless.net email account, we already have a mail server and we are going to upgrade the mail server in near future. Also the villagers are learning how to use Yahoo Messenger, Skype, and Gmail etc to make voice and video call. However, there is bandwidth constraint to make video calls using the Internet.

Mr. Kawasumi and Mr. Fuke at the office of Kaski Association of the Blinds

Demonstration of JAWs software for blinds at the office of Kaski Association of the Blinds

In order to help the blind people to use computers, the project is working with "Kaski Association of the Blinds", which is a NGO that works for the education and rights of blind people. We have provided two desktops and two laptops to the association of the blinds. The goal is to find how blind people can get benefits from the use of information and communication technology. For the computer training the central office of the association is going to send trainers. They are using the computers with software called JAWS that facilitates the communication for the blind people by

reading the texts on the screen. That is how the blind people can receive and write emails, and browse the Internet to get vast amount of information they need using keyboard of computers. There are 117 members of the association and 70 of them are students going to college in Pokhara.

Also several government offices are getting Internet connections from the network in Jomsom because Jomsom is the districts headquarter of Mustang district. There are 6 hotels and 8 government offices that have subscribed Internet from the network until now. Tourists are also being able to use the Internet. Mustang is a famous destination for tourists and there are many tourist hotels in different villages.

5.2 Internet Telephone Service: Except Chimkhola, and Jhin, all the villages that are connected to the wireless network now have access to the mobile service provided by Nepal Telecom. Therefore the villagers can use mobile phones to communicate within Nepal. For the areas without mobile phone coverage, the project has set up Asterix PBX server, which is an open source telephone exchange based on the SIP protocol to interface network IP phones with the PSTN line of Nepal Telecom. Just to make calls within the network, users don't have to use their mobile phones. Instead villagers can place local calls to another village using extension number given by network administrator and IP phone. Moreover, villagers also can place ordinary landline phone calls through using the PBX server. The project is working on the PBX server to allow users to place local calls from outside the network using the extension number provided by Nepal Wireless. The system will allow both incoming and outgoing phone calls.

The most benefit the villagers are getting is from the Internet phone service to make international phone calls, which is expensive to do using mobile phones. There are several companies in the cities that provide Internet Phone services. The project has introduced the Internet phone service through the village communication center. People are using the phone to make calls to their relatives working abroad such as Malaysia, Gulf countries, Japan, the UK, the US etc. The Internet phone and the Internet have been also very helpful for the tourists traveling in Mustang district because they have been able to communicate cheaply with their friends and families.

5.3 Teleteaching and tele-training: The project is testing tele-teaching and tele-training program by using video conferencing cameras. Point to point Video conferencing works very well, however, there are still technical issues to be solved. We need to find cheaper way for making multi-conferencing system work. National Center for Educational Development (NCED) and Department of Education of Nepal Government has shown interest to run teacher training program to the remote districts as a pilot from a central location through video conferencing. To make that happen, they already have set up a video conferencing facility in their building in Kathmandu. They are also interested to connect school resource centers run by the District Education Office in order to provide educational resources to the resource persons.

The network built by APT project in Mustang helped Open Learning Exchange Nepal (OLE-Nepal) and the Ministry of Education of Nepal Government to run their e-education pilot project by connecting the schools in the wireless network. They have provided basic computer training to the teachers of seven schools of Mustang district to implement e-education program through "One Laptop Per Child" (OLPC) program.

OLPC Laptops in Mustang

Students using computer

The school servers of OLPC program is connected to the Mustang Wireless Network to get Internet connection. Moreover, the head office of OLE-Nepal and Department of Education in Kathmandu is directly connected to Mustang Wireless Network through Intranet as well. The network administrator of OLE-Nepal now can upload new contents they produce through the Intranet to the school servers at much

faster speed than they could have done with the Internet. That has saved their time and money to visit the schools and upgrade the contents because it takes two full days by bus to go to Mustang from Kathmandu to do what they are doing now from their office in Kathmandu.

Moreover, the educational materials developed by OLE-Nepal are also being provided to the schools, where the OLPC laptops were not introduced. It is because the educational contents were developed by using Flash and it can also run in normal desktop computers as well. Other educational materials developed by OLE Nepal are available online at http://www.pustakalaya.org/, which is an online library with varieties of educational materials useful for students and villagers.

5.4 Telemedicine: With the support from APT, we have connected three clinics and upgraded the video conferencing system at Kathmandu Model Hospital by putting Polycom video conferencing system and a bigger LCD monitor. Before that, Nepal Wireless, with the equipment support from International Telecommunication Union (ITU) and AMD, had been helping to run telemedicine program from Kathmandu Model Hospital to five rural hospitals and clinics through the wireless network. The new system can do video conferencing and consulting to six sites at the same time.

Primary Health Center Lete, Mustang

Jomsom District Hospital, Mustang

D

Jomsom District Hospital and Lete Primary Health Care Center of Mustang district and Aulo Sub-health Post of Myagdi are connected to the wireless network now for telemedicine. We have put Polycom video conferencing system at the hospital and

clinics. The doctors of those hospitals have already started consultation using the audio video conferencing system.

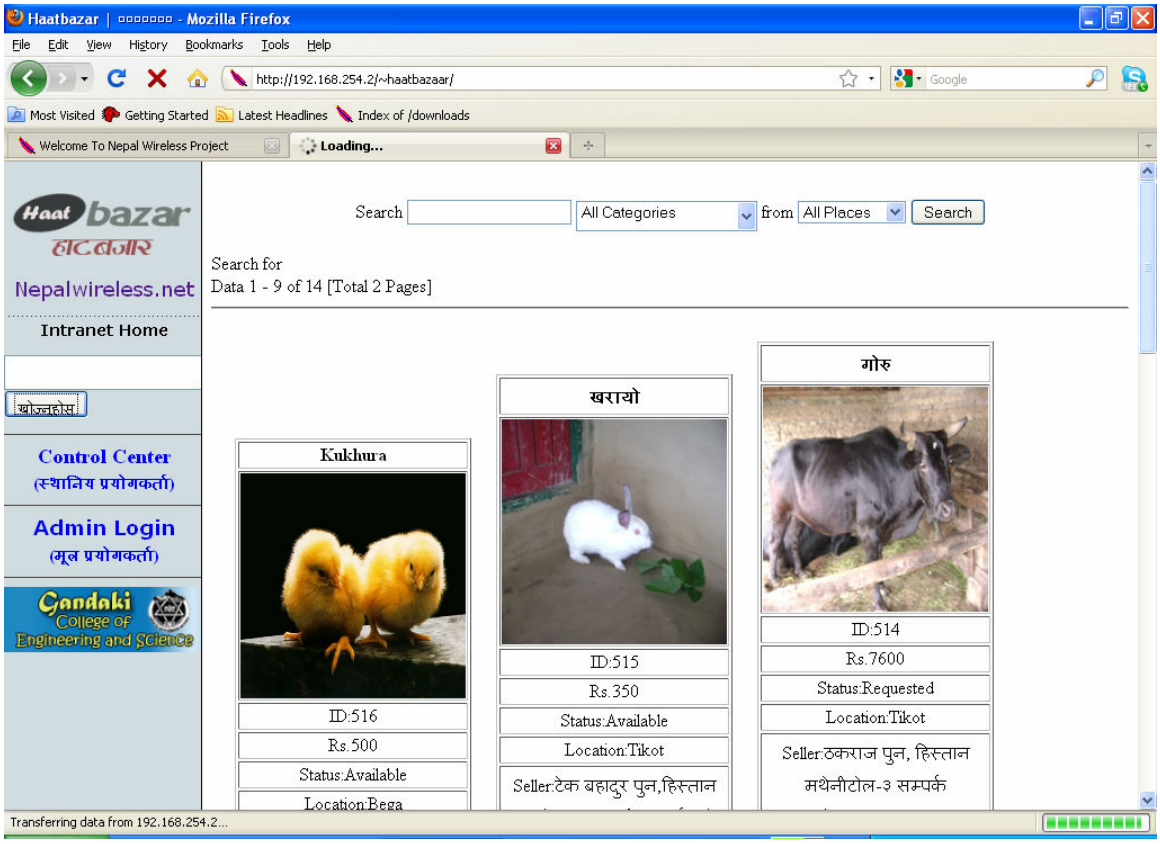
Dr. Saroj Dhital looking at the ultrasound image transmitted live from Mustang

Dr. Dhital looking at the electrocardiogram image transmitted from Mustang

With the technical support from the Japanese experts, Mr. Yashuhiko Kawasumi and Mr. Naoki Fuke, the project recently bought an Ultrasound Imaging Device, two Electrocardiogram devices and three digital stethoscopes for telemedicine in Japan. We have tested the equipment successfully from Jomsom District Hospital.to Kathmandu Model Hospital. With the help of those telemedicine equipment, the patients will be able to get better medical advices from the doctors in Kathmandu.

Now Nepal Medical College and Teaching Hospital of Kathmandu is also connected to the wireless network and they have given their commitment to support for telemedicine program from Kathmandu to the rural hospitals and clinics of Nepal

5.5 Community Discussion and Local ecommerce site: From the server in Pokhara, the project is providing local e-commerce site and an online discussion forum called phpBB or php Bulletin Board. Using the phpBB, users are able to engage in community discussions and post the products they want to sell in Nepali. The bulletin board is open to all the people in the wireless network and the users don't have to sign up to use it.



Local E-commerce site, where villagers post their products

The users can post their personal messages, urgent messages, local news, stories and poems in the bulletin board. Some people are typing their messages in the bulletin board in Nepali using Unicode; however, most of the people have not learned how to type in Unicode. Therefore they are using Romanized Nepali to post their messages. People can also use the bulletin board to advertise their products or services.

5.6 Website of the Mustang DDC for E-governance: Nepal Wireless Networking Project is helping to develop website of Mustang District Development Committee (http://www.mustangddc.gov.np) for e-governance program. Mustang DDC is planning to train the secretaries of six local government offices in order to implement e-governance program from this year. For that, six laptops donated by KDDI Japan have been given to six local governments. The local governments of Mustang DDC for now will be able to download the materials developed by different ministries for e-governance purposes.

Dr. Kiyoshi Honda and his team with the Weather Station at Khopra

5.7 Weather and Air Traffic Route Monitoring: This is the new idea Nepal Wireless decided to implement for monitoring the weather status of the air route between Pokhara and Jomsom. The idea came after a discussion with the airport authority of Jomsom. The plan is to provide weather information of Khopra relay station and the real time visibility status of the sky between Mohare and Larke hill. This is a narrow valley between Dhaulagiri (8,167m) and Nilgiri (7,061m) through which the planes have to fly. At some points the valley is less than 2 KM wide only. Therefore the pilots of the planes have to really see the path in order to fly through the valley. They need to know the visibility status of the narrow valley before they decide to take off from the airport in Pokhara. The airport authorities can get the information through the Internet.

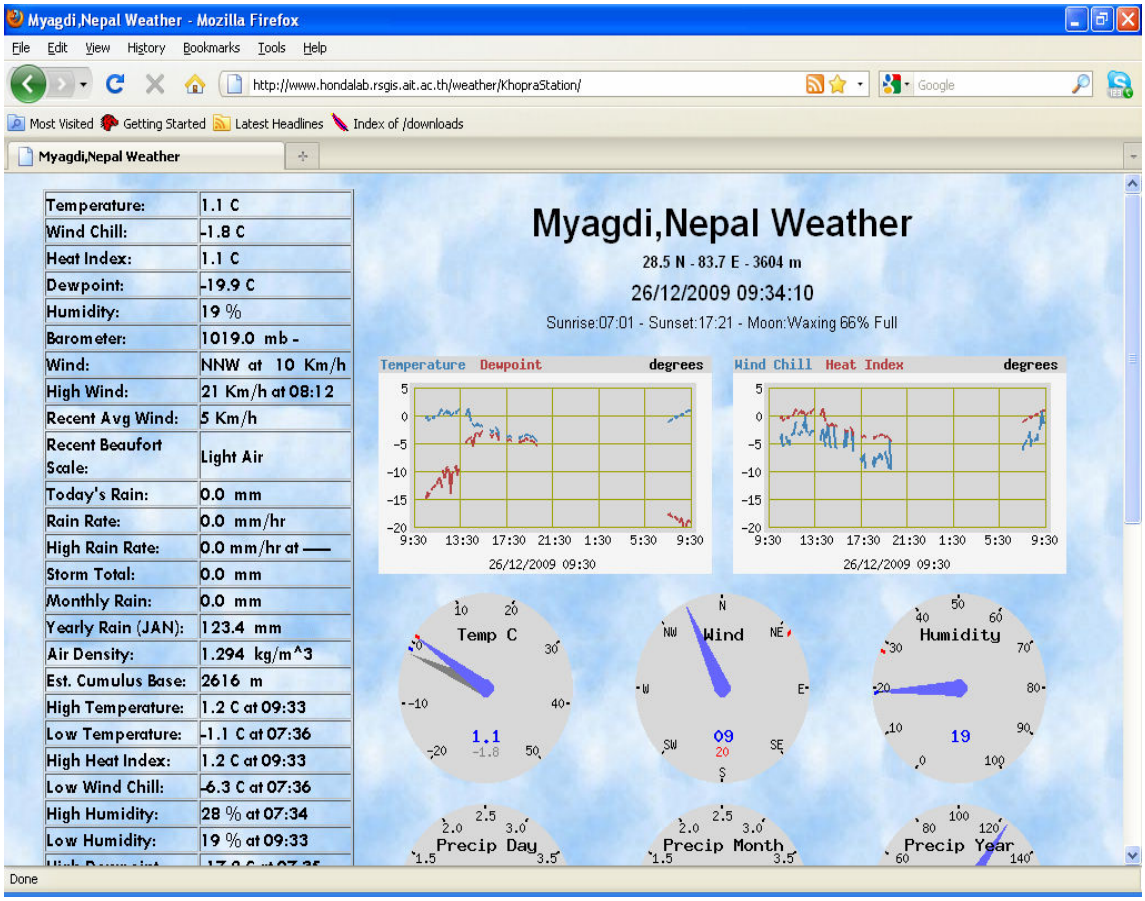
The goal is to provide the real time information through weather station and a network camera. For that a Vaisala weather station has been setup along with an IP Camera. The IP camera can rotate 360 degrees for visual monitoring. The weather station has sensors that measures parameters like temperature, air pressure, wind speed and direction, precipitation, and relative humidity.

Photos taken by the movable IP camera for the air traffic controllers

The Nepal Wireless network is being used to collect the data from weather station and the camera in every 5 minutes onto Linux Boxes deployed in Pokhara base station. The Linux Boxes are low power PCs without fan with data and operating system stored on Compact Flash cards. These Linux Boxes run a service called SOS Station, based on an open standard Sensor Observation Service, which provides APIs for obtaining data from sensors and also controlling them.

The collected data are in turn being sent to a server called Sensor Service Grid (SSG), currently located in Thailand. The SSG server has been deployed by Dr. Kiyoshi Honda and his staff from the Asian Institute of Technology on which real-time sensor data from several locations in the Asia-Pacific are currently being synced. The SSG servers provide services for data visualization using real-time maps and graphs, as well as remotely controlling the sensor configuration and meta-data.

Dr. Kiyoshi Honda bought the weather station equipment including the network camera. He traveled with his staff to Khopra Relay in October 2009 and put the system. The link to the site to get the information is http://ssg.sensor-asia.net/Login.jsp (Customer code: NepalAirRoute, User name: guest, and Password: guest), which gives the recent photos of the surroundings and recent monitor graph of temperature, humidity, air pressure, wind speed and wind direction, precipitation etc. Another site to see the information is http://www.hondalab.rsgis.ait.ac.th/weather/KhopraStation/ that also gives the weather information of Khopra area as shown below.



Real time weather information collected by Vaisala weather station installed at Khopra

Another weather station of that kind will be put in Larke Relay in February 2010, which will help to give more clear view of the air route of the narrow valley through which the planes fly. National Trust for Nature Conservation, Nepal (http://www.ntnc.org.np) is going to provide support for the new weather system that will be put at Larke Relay station.

5.8 Basic wireless networking training for the rural network operators

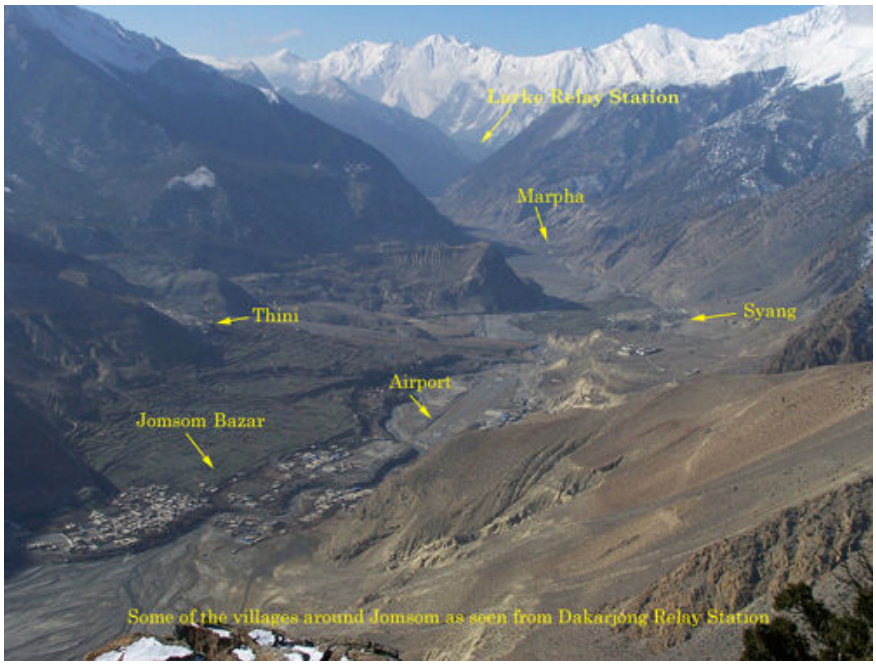
Trainees from different villages

Sebastian Buttrich, the trainer from Denmark

With the support from Internet Society, WirelessU.org, and nren.net.np, Nepal Wireless Networking Project hosted a basic wireless networking training program from October 14 to 24 for its network operators. A total of 18 participants from different villages attended the workshop. Sebastian Büttrich (*http://wire.less.dk/*) was the chief instructor for the training along with Indiver Badal, and Gaurab Upadhaya. Sebastian, who is from Germany, has physics background that includes fields like RF and microwave spectroscopy, photovoltaic systems, and advanced mathematics. He has been supporting remotely to the Nepal Wireless Networking Project for several years. The topics covered in the training were as follows.

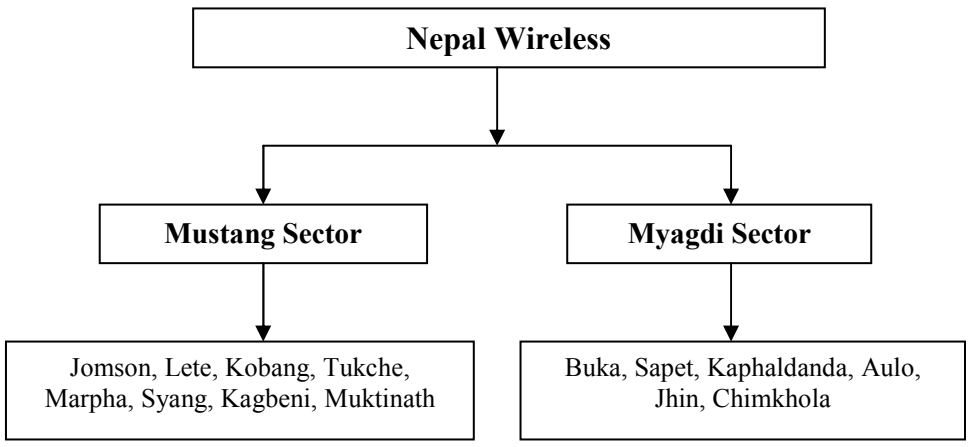
- Introduction to working with wiki - demo and exercise with workshop servers' mediawiki
- Wireless devices - basic configuration of the Access Points and client radios
- Introduction to radio physics, link budget and dB math
- Link Budgets calculation and introduction on some of the long links in South America
- Structured Troubleshooting - theory and exercise
- Internet Protocols - IP planning - subnetting, routing
- Antenna Basics, Planning Radio_Mobile software, field techniques (GPS, compass, etc) Power over Ethernet, grounding, and lightning protection
- Outdoor installation - General weather protection, lightning protection and grounding Wireless device configuration for actual deployment
- Dimensioning of solar power systems, GNU/Linux basics, installing and running Ubuntu

6. Network Service Area



Jomsom and Kali Valley as seen from Dhakarjung Relay station

For making it simple to understand for those readers who have vague knowledge about the geographical situation of the project site, we would like to divide the project site in two sectors. The first is Mustang sector where we have connected eight villages. The second is Myagdi sector where we have connected six villages even if some of the villages are actually not in Myagdi district. One communication center established for the blind people is located in Pokhara city. Thus, with the financial support from APT, the Nepal Wireless connected those fifteen rural communities and now offers ICT facilities.



In order to connect fifteen villages, it has created eight relay stations to forward the signal over mountain passes across the Himalayas. The air distance from one relay station to another varies from 10 KM to 34 KM. The relay stations are located at Dip, Mohare, Khopra, Chandrakot, Todke, Larke, Dhakarjong and Kagbeni. The project has also set up a base station and server facility in Pokhara, and a connection to Om Hospital in Pokhara, Kathmandu Model Hospital and Nepal Medical College in Kathmandu for telemedicine. Photos of some of the villages are given below.

Kagbeni Village

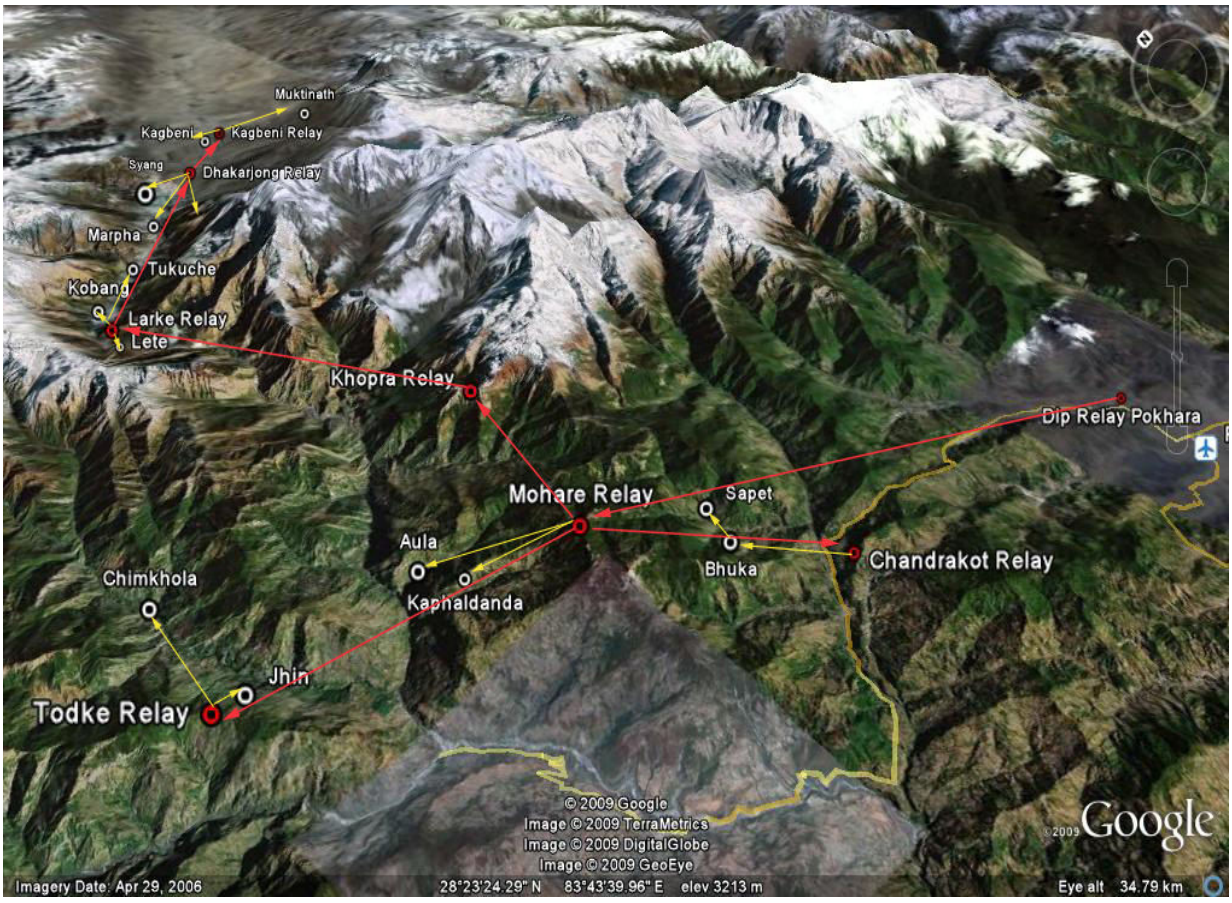
Tukuche Village

Larjung Village

Jomsom Village

There are seven villages serviced by the network in Myagdi sector of the network. The population of those villages varies in size from 500 to 1800 people. Complete details of the village location are given below in Table 1. Furthermore, eight villages of Mustang district have been connected to the network. Altogether 12 schools are connected. Among the twelve schools,

2 of them are middle schools, 9 of them are K-10 high schools and one is K-12 high school. The number of students in those schools ranges from 80 to 300 students. Among the 12 schools, four schools serve as the communication center for the village.



Google Earth map of the network looking towards Jomsom from Pokhara area

All the villages of Mustang district that are serviced by the wireless network are situated mostly along narrow valley of the Kali Gandaki River that originates near the Tibetan border. There is a dirt road that goes to Mustang from Beni. Therefore all the villages of Mustang sector that are connected to the wireless network are reachable by jeep or local buses.

In Myagdi sector of the network, Kaphaldanda Chimkhola, Jhin, Aula, Sapet and Bhuka villages have no motorable road and are accessible only by foot. Just to give a rough idea as how one can visit the networked villages of Mustang and Myagdi sector, the approximate walking distance in hours from Pokhara, Beni and Jomsom to reach each of the villages by walk and jeep have been given in Table 2.

Node Name	Latitude	Longitude	Elevation (Meter)	Population	Computers	Services [1]
Nadipur	N28° 14.037'	E83° 59.335'	925	x	1	Base station
Dip	N28° 14.765'	E83° 59.435'	980	x	1	Relay
Mohare	N28° 22.285'	E83° 40.758'	3,320	x	1	Relay
Khopra	N28° 28.336'	E83° 42.487'	3,650	x	2	Relay
Chandrakot	N28° 18.328'	E83° 47.153'	1,525	780	6	Relay
Larke	N28°39'45.20"	E 83°36'19.28"	2,823	x	x	Relay
Dhakarjung	N 28°48'6.61"	E 83°44'44.16"	3,340	x	x	Relay
Kagbeni Hill	N 28°50'1.72"	E 83°47'35.60"	3,034	x	x	Relay
Todke	N28°24'25.06"	E 83°30'22.42"	2,350	x	x	Relay
Bhuka	N28°19'34.07"	E 83°43'57.44"	1,832	1,250	2	I V
Tikhe dunga	N28° 25.836'	E83° 37.232'	2,250	845	4	I V
Kaphaldanda	N28°23'23.72"	E 83°37'29.04"	2,215	945	3	I V
Aulo	N28°24'40.80"	E 83°36'57.54"	1,450	1135	4	IMV
Jhin	N28°24'31.95"	E 83°31'20.05"	1798	1,425	4	I V
Chimkhola	N28°28'35.38"	E 83°31'4.65"	1,605	1,254	6	I V
Lete	N28°38'30.15"	E 83°35'56.80"	2,430	735	3	I MV
Kobang	N28°41'11.56"	E 83°36'33.97"	2,693	600	4	I V
Tukche	N28°42'38.55"	E 83°38'49.13"	2,590	785	6	I V
Marpha	N28°44'59.42"	E 83°41'5.25"	2,730	750	8	I V
Syang	N28°46'46.51"	E 83°42'15.92"	2,984	688	3	I V
Jomsom	N28°46'59.43"	E 83°43'49.48"	2,760	2,234	6	I MVC
Kagbeni	N28°50'11.90"	E 83°46'58.99"	2,860	595	3	I V
Muktinath	N28°48'54.30"	E 83°51'39.76"	3,689	550	2	I V

Table 1: Complete list of Network Nodes

From	To	Distance	Means of travel
Pokhara Station	Beni	3 hours	By bus
Pokhara	Jomson	22 minute	By flight
Pokhara	Chandrakot	2 hours	By taxi (1 hour and walk)
Pokhara	Bhuka	6 hours	By taxi and walk (5 hours uphill)
Pokhara	Sapet	5 hours	By taxi and walk (4 hours uphill)
Pokhara	Mohare Relay	2 days	By Jeep and walk (7 hours uphill)
Pokhara	Khopra	2 days	By Jeep and walk (9 hours uphill)
Beni	Jomsom	8 hours	By Jeep or bus
Beni	Kaphaldanda	4 hours	By jeep (3 hours) and walk
Beni	Todke Relay	5 hours	By walk (Up hill)
Beni	Jhin	4 hours	By walk (Up hill and straight)
Beni	Chimkhola	8 hours	By walk (Up hill and straight)
Beni	Aula	4 hours	By Jeep and walk (3 hours up hill)
Jomsom	Larke	5 hours	By Jeep and walk (3 hours)
Jomsom	Kobang	1 hours	By Jeep
Jomsom	Dhakarjung Relay	3 hous	By walk (up hill)
Jomsom	Muktinath	2 hours	By Jeep

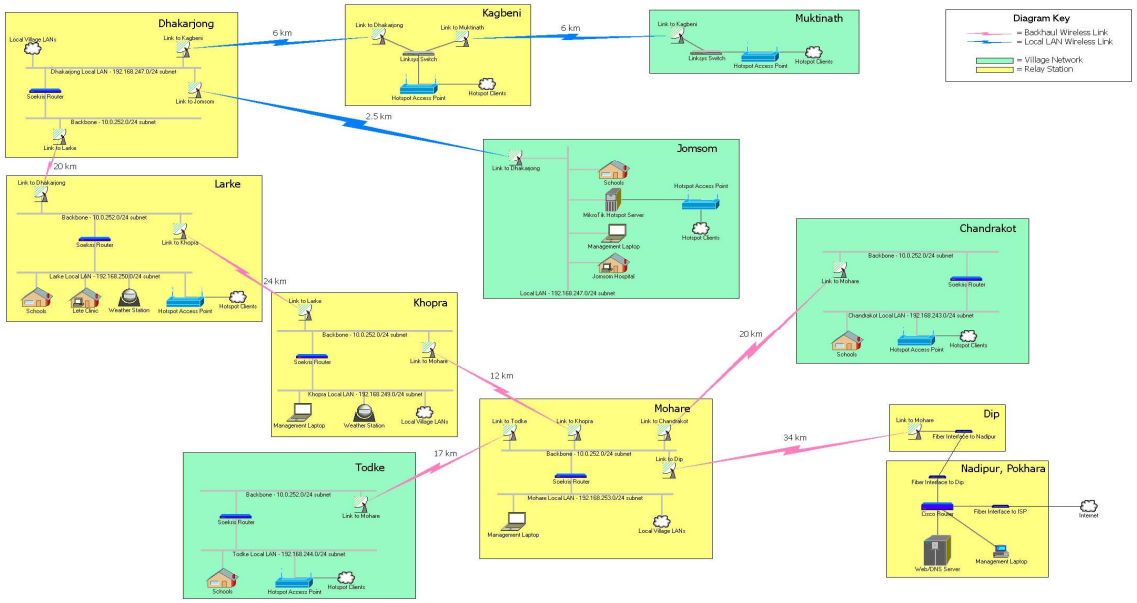
Table 2: Walking distance in hours and days from the nearest highway

[1] I = Internet, C = Credit card transaction, M = telemedicine, V = VoIP network phone

7. Network Design and Technologies Used

Putting Alvarion radio at Kobang School

7.1. Network Description:

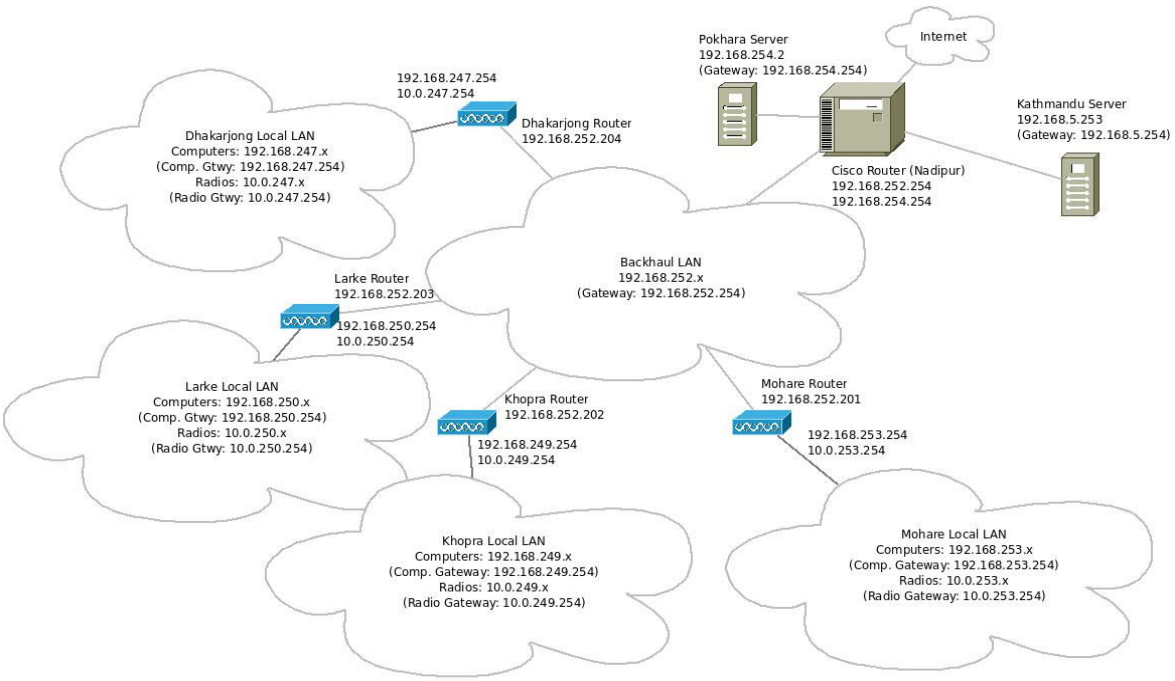


Schematic Diagram of the Nepal Wireless Network

Connecting the districts of Myagdi, Mustang, Kaski, and Parbat

Supported by Asia-Pacific Telecommunity and Mustang District Development Committee

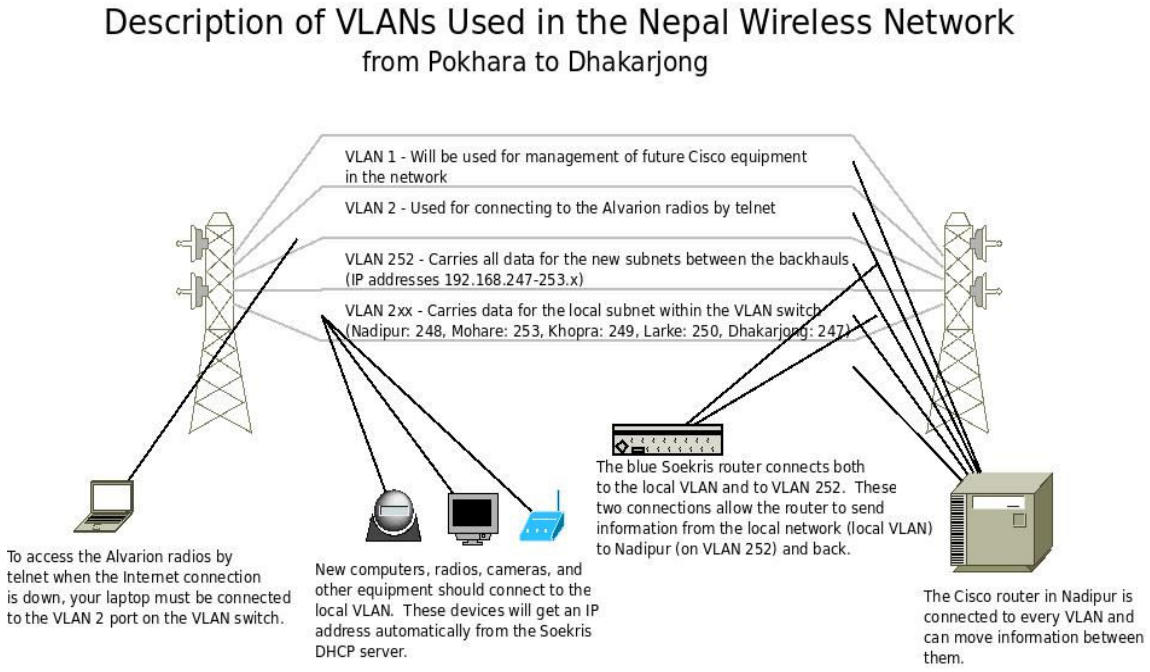
Mustang and Myagdi districts get the Internet via a server in the city of Pokhara, Nepal. The server is connected to an Internet Service Provider through a fiber connection. From Pokhara, a series of eight mountaintop stations relay the signal up into the mountains. Also there are Access Points at the relay stations to distribute Internet to end users in villages. Conceptual and schematic diagrams of the network are given below.



Conceptual Diagram of the Nepal Wireless Network

Connecting the districts of Kaski, Parbat, Myagdi, and Mustang

The high-speed backhaul radios at the relay stations operate on a dedicated core local-area network (LAN) that reaches from Pokhara to Jomsom. Villages in each of the network's coverage areas from the relay stations such as Todke, Mohare, Khopra, Larke, Dhakarjong, Chandrakot operate on separate local LANs through VLAN switches.



Routers at each of the relay stations provide DHCP services to the end users and interface between the backbone LAN and the local distribution LANs. Villages connect to the relay stations using point-to-point wireless links or by connecting to a wireless access point that serves many villages at once.

7.2 Access Technology

Access to the services is provided through desktop computers and laptops. However, the addition of Internet telephony equipment has increased the phone services to make international phone calls. Also the high-resolution Polycom network cameras have facilitated teleteaching and telemedicine, respectively. Because of the presence of the wireless network in Mustang, Open Learning Exchange Nepal has introduced 390 laptops in 7 schools. Moreover, 85 laptops donated by KDDI Corporation Japan have also been introduced in the schools, local government offices and rural clinics.

With the addition of an Internet telephony system, the project has added a number of network telephones in all the villages. We have set up 10 Polycom IP phones and 4 Linksys phone adapters that provide VoIP functionality. Client software (a "soft phone") can also be used where the hard phone is not available.

Tele health training run by Kathmandu Model Hospital in Kathmandu to the rural health workers

Tele-conferencing between doctors at Kathmandu Model Hospital and a remote village health worker

For teleteaching and telemedicine programs, we have obtained high quality network cameras. The cameras are Polycom 500, Polycom VSX 7000 and Logitech Quickcam®Orbit AF

in the network. The cameras offer a high video quality that far surpasses ordinary webcams. It has been made possible through the relatively high speed of data transfer within the network. The network cameras are actually a camera and computer combined in one intelligent unit. Therefore they connect directly to the LAN without requiring a computer. Moreover, the zoom, pan, and tilt functions on the cameras can be controlled remotely.

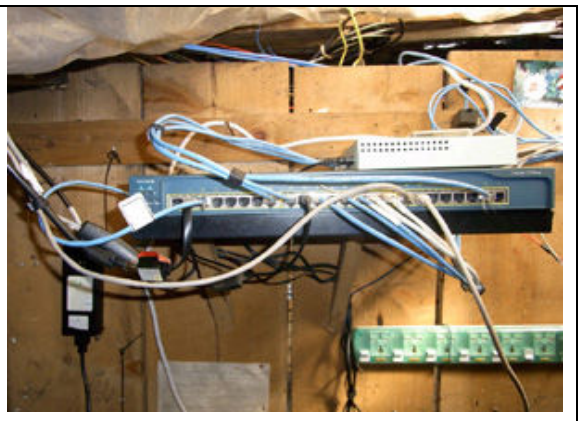
7.3. Transport Technology

A considerable amount of resources is dedicated to the network infrastructure and management. This includes wireless devices, a network server and associated software, and power generation at the relay stations. The summary of the transport devices used is as follows.

S.N.	Equiment	Number
1	Alvarion radios of different capacity	28
2	5.7 GHz Motorola radio with reflectors	6
3	5 GHZ MikroTik APs and Client radios	18
4	2.4 GHZ EnGenius , and Deliberant	10
5	24dB Directional Antennas	4
6	15 dB Panel Antennas	13
7	14 dB Omni Directional Antennas	3
8	Cisco routers and switches	4
9	Soekris Routers	4
10	Linksys wireless routers	12
11	Linksys Wi-fi to PSTN Phone adaptors	5
12	Polycom IP phones	5

Table 3: List of the main transport equipment used

Router at Mohare Relay Station



Router at Khopra Relay Station

7.3.1 Wireless Devices

The network has used variety of wireless devices to maintain connectivity between the nodes. Conceptually, we have divided this into a network backbone, which connects the Pokhara Base Station to the eight major relay stations, and client connections, which connect villages to the relay stations. In one case, a connected village has also acted as a relay station.

The network backbone is connected with Alvarion radios, and Motorola Canopy radios at 5.8 GHz whereas connections to the end users use wireless Ethernet (IEEE 802.11b/g standard) radios at 2.4GHz from three manufacturers – Deliberant, EnGenius, and MikroTik. For the routers the project is using Linksys wireless routers and switches.

Radios and Antenna at Khopra Relay

Radios and Antenna at Dhakajung Relay

Installing Client radio at Tukuche School

Tower at Mohare Relay

The Alvarion and Motorola devices were used for the backbone connection due to their high reliability, robustness, and to avoid signal interference. However, 802.11b/g radios were used for village connections due to their lower cost and the compatibility between manufacturers.

The new Alvarion backhaul link that we have built with the APT grant is empowered by the WiMAX equivalent broadband wireless technology. It can provide almost all e-applications available over Mustang and Myagdi area wireless network infrastructure of the Himalayas

7.3.2 Network Server

The network server in Pokhara facilitates network monitoring and management as well as provides a number of important services to community. The server computer is a large Pentium IV system with dual hard disks. The system runs a Fedora Linux distribution with additional third party software. It is configured for maximum redundancy to guard against failure.

Philip working in the server

Routers at the server room in Pokhara

Each of the disks is an identical copy of the other, and they are updated synchronously, referred to as a RAID0 (Redundant Array of Identical Disks) configuration. Linux was chosen for a multitude of reasons, primarily due to the large abundance of high quality Open Source software included with the standard distributions and available online. Linux is well tested and proven in production environments and thus made a perfect choice for the server. This choice of operating system does present a bit of a maintenance problem, as many computer technicians in Nepal are only trained on Microsoft products. However, through the use of graphical user interfaces and the custom development of maintenance and management software, the system

has proven to be maintainable by the local volunteers, when remote expertise has not been available. Currently, the server provides the following services:

- Phone system, both voice over IP as well as hopping to the local phone network
- Supports the Intranet: Community (Nepali) message board and locally hosted home pages for the villages
- File sharing: The server provides a central point of coordination for sharing teaching materials and network maintenance software for the network
- Database: Many additional projects on the network, like the Haat Bazaar trading forum, make use of a central database, which is hosted on this system
- Network name and route monitoring: The system can resolve IP addresses to names and also maintains a table of availability for each host on the network

Another server has also been set up in Kathmandu. The Kathmandu server is a mirror of the server in Pokhara. Its function is to provide similar services to the districts surrounding Kathmandu and to lighten the load of the server in Pokhara. As the network expands, functionality needs to be distributed in order to provide robust services and to protect against a single point of failure. The server in Kathmandu provides every service that the Pokhara service does with the exception of hopping off VoIP phone calls to the PSTN lines. It does however, route VoIP calls between VoIP endpoints in the network, providing seamless connectivity throughout the network. This server was built using the 'cloning' method we have set up at Sastra Network solutions, where we can quickly build a new server and upload configuration to it.

Asterisk PBX: This is open source telephone exchange software based on the SIP protocol to interface network phones with the Nepal Telecom PSTN. The system allows both incoming and outgoing phone calls. The server allow users to place calls from within or outside the network using the Polycom network telephones, Linksys phone adapters, or XtenLite phone software. A person, who has an extension number, can call to the villages or get call from the villages from any location anywhere in the world. In this sense the system works just like the Skype system

does. The PBX performs complete call logging to the database on the server, which can then be displayed through a web interface. Currently a 4 port Digium card is the gateway used to interface the VoIP lines to the normal telephone network (PSTN)

Message posted at phpBB Bulletin Board in Nepali Language

phpBB - The Bulletin Board in Nepali Language: This bulletin board software provides an online discussion forum. Using a localized Nepali version of the software, users can post and read announcement, local news, stories, songs, poems and urgent messages in the Devanagari script. However, many of the villagers have not yet learned how to type in Devanagari script. Therefore they are posting their messages in Romanized Nepali.

Apache and the Intranet Server: This popular open source HTTP server provides web pages customized for internal access. This includes links to network administration resources and a directory. Internal clients are provided with immediate to the intranet portal. This contains links to various other services provided by the server as well as

useful external links. Currently, the server hosts a minimal page visible to the outside world. This is largely due to the limited bandwidth of the server to the outside world as external traffic would compete with that generated by the villagers browsing the Internet. A current version of the front page of the Intranet can be seen in the following figure.

Front page of Nepal Wireless internal home page with the links to different applications

DNScache - The Domain Name Caching Daemon: This network service caches domain name requests, which can significantly reduce Internet access speed during peak usage. The software stores IP addresses for domain names (e.g. “google.com” or “yahoo.com” or “hotmail.com”) that have been accessed by users. These names can then be resolved within the network, reducing the amount of traffic that uses the limited 512 Kbps Internet connections. By configuring all the network clients to use the server as their primary DNS server, request/response traffic to the ISP is reduced by an order of magnitude, resulting in faster page loading times. It should be noted that the server only caches addresses, not data.

Samba - The Windows File Server and Master Browser: This cross-platform file server allows users to simply share files on the network. Samba allows both open and password protected shares and acts as a "workgroup master" by collecting the names and addresses of other computers on the network. The file server also makes the configuration of new computers very simple, as all the software necessary to image a new machine is stored there. It provides the means to backup data from the server to other computers on the network to guard against data loss and hardware failure

MySQL: This open source database provides support for a number of other software packages, including Asterisk PBX and phpBB. It can be administered with a web browser using phpMyAdmin.

WebMin: This web based administration system allows one to perform virtually every task required to keep the server in operation, including security, account management and network configuration.

SSH: The Secure Shell Daemon allows administrators secure access to the server from anywhere in the world. From this interface, all aspects of the system can be analyzed, diagnosed, modified or upgraded.

SmokePing: This service tracks availability and response times of all known hosts on the network. If a host is added to the local DNS table, SmokePing will automatically pick it up and generate trend graphs for the above parameters.

It should be noted that the server also contains two dozen or so custom scripts to tie all the functionality together in a usable interface. Administering such complex functionality, even from a GUI interface like WedMin, is too difficult for the average users. Thus we have implemented custom scripts written in Perl and PHP to provide a user friendly server management system.

8. Power Generation

Solar panels at Mohare Relay Station

When Nepal Wireless was started in 2001, the only source of power we had for Nangi village was from a 2KW micro hydro generator built by the school. With that power, we started computer classes. Then we tried to bring Internet in the village, however, we did not have telephone. That was why we had decided to use wireless technology. Thus the establishment of the 2KW micro hydro generator was the beginning of Nepal Wireless Networking Project.

Powering the wireless equipment at relay is the most challenging tasks for the wireless network operators. It is more challenging during the monsoon time for three months in Nepal because there is very little or almost no sunshine for several days. Putting solar power system to run the equipment for 24 hours is the most expensive part of building wireless network in the remote villages of Himalayan region. That is why it is recommended to use equipment including computers that uses as little power as possible.

As mentioned above, the network includes eight relay stations on mountain tops that transmit the signal over mountain passes to form the backbone and connect villages. Most of the high mountains where we built relay stations don't have power to run the equipment. Moreover, many of the villages are not connected to the main grid line to run computers. Therefore the project has used different sources of power such as solar, wind, micro hydro generator, and power from main grid line to run the equipment. Because power from main grid line is not available at the stations except Chandrakot and Dip Relay, solar and wind generators are being used to generate the electricity necessary to run those stations. The summary of the power system that we have put in the relay stations are given below in (Table 4).

Power Generation and Backup Systems Used in the Relay Stations		
S.N.	**Item**	**Quantity**
1	50 W Solar Panels	6
2	80 W Solar Panels	24
3	120W Solar Panels	8
4	30 Amp rated Solar Charge Controllers	7
5	40 Amp rated Solar Charge Controllers	4
6	400W Air-403 Wind Generators	1
7	100 amp-hour rated Deep Cycle Batteries	30
8	12 VDC to 110VAC Inverter (250W)	14
9	600 VA Kerosene Generator	1

Table 4: Power generation equipment used at the relay stations

A kerosene generator has been put for backup at Khopra Relay because it is at the elevation of 3,700 m and power back up is not enough during the monsoon time because of the heavy cloud.

Three villages, Chimkhola, Bhuka, and Sapet at the network, have power from local micro hydro system built and owned by the communities. Chimkhola has 10KW micro hydro generator. Bhuka and Sapet village each have 50KW micro hydro generators. Other villages have power from main grid line.

At Larke and Dhakarjug Relay Station, Nepal Telecom has given permission to use their solar panels (14), which were lying there idle for several years. Nepal Telecom had put the solar power system several years ago there to bring telephone in Jomsom, however, the project failed and they abandoned the facilities. We are thankful to Nepal Telecom for letting to use their facilities and the solar panels. Some of the photos of the power sources being used at relays are given below.

Wind Generator at Khopra

Solar panels at Mohare Relay

Solar Panels at Kagbeni Relay

Backup batteries at Mohare Relay

Powering the equipment at the relay stations is complicated by the fact that several devices run off AC power. Each relay station has 12 VDC to 220VAC power inverters because some of the equipment uses AC power to run. The equipment that we have put at each of the relay stations are wireless devices, an Ethernet switch, and a router. Mohare and Khopra Relay have an IP phone and a laptop computer because there are two persons living to take care of the equipment at the relay stations.

As for storing solar and wind power, maintenance-free backup batteries such as Trajon and Volta are being used at the relay stations. We have also put Exide tubular batteries that are especially built for storing solar powers. One thing that is needed to be taken care of at higher elevation such as Khopra (3,650), Dhakarjung (3,300) and Muktinath (3,689 m) is keeping the batteries warm. The temperatures get well below freezing point at that elevation and it snows for several times in winter. Since the efficiency of the batteries gets much less at cold temperature, it is required to put more back up batteries and keep the batteries as insulated as possible. For that we have put the batteries in boxes with glass wool as the insulation.

9. Financial Data

Porters carrying the equipment to the relay stations

Nepal Wireless Networking Project was selected by APT in consultation with the Ministry of Internal Affairs and Communications (MIC) Japan. A grant of USD 146,300 was approved by Asia Pacific Telecommunity for the following budget details to implement wireless networking project under APT ICT – J3 program.

S.N.	Budget Headings	Amount USD
1	Planning and Investigation	2,000
2	Equipment Procurement	122,400
3	Correspondence and Shipping fee	2,000
4	Business Trips	15,200
5	Miscellaneous	4,700
	Total Amount	**146,300**

Table 5: Budget approved by APT for Nepal Wireless Networking Project

As it is mentioned in the allocated budget details, most of the grant was for buying wireless equipment, computers, power sources, and telemedicine equipment. The amount set aside for business trip was for the travel and daily expenses, and consultations fee for the Japanese experts to come to Nepal and help to implement the project.

Moreover, the Mustang District Development Committee (DDC), which is the implementing partner of the project in Mustang, provided a total of USD 18,500 for paying the local expenses such as, porter charge, transportation, logistic, cost to build stone wall fencing at the Kagbeni Relay, and pay for the local technicians for one year. Mustang DDC has also provided a room for server at its building.

The Ministry of Finance of Nepal Government, with the recommendation from the Ministry of Information and Communication, Ministry of Local Development and Ministry of Health, helped to make custom and duties free including VAT to import wireless and telemedicine equipment from abroad. Equipment such as computers, switches, routers, cables, solar panels, backup batteries, uninterrupted power supplies (UPS), inverters and power accessories were bought in the local market in Nepal.

The following is the details of the budget approved by APT, and the expenses incurred from the APT budget in each budget heading.

Summary of Income and Expenditure - APT Pilot Project, Nepal (January 1 2009 - December 31, 2009				
S.N.	**Items**	**Budget Approved (US$)**	**Budget Spent (US$)**	**Variance (US$)**
1	Planning and Investigation	2,000	2,444.75	-444.75
2	Equipment procurement	122,400	125,057.99	-2,657.99
3	Correspondence & Shipping fee	2,000	2,193.90	-193.90
4	Business trips for Japanese Experts	15,200	13,967.41	1,232.59
5	Miscellaneous (Handbook and workshop)	4,700	2,605.71	2,094.29
	Total	**146,300**	**146,269.76**	30.24
	Total Fund transferred by APT in US$		**127,780.00**	
	Total Cost spent until 31 December 2009 in US$		**146,269.76**	
	Residual Amount to be received from APT		**18,489.76**	

Table 6: Summary of Income and Expenditure of the APT Grant 2009

(Note: Financial Statement and original receipts of all the expenses have been sent to APT, Bangkok)

Given the total amount spent on the project to date US$164,769.76 (US$146,269.76 from APT plus US$18,500 from Mustang DDC) and the number of total villages connected as 15 villages, the average per village implementation cost was $10,984. To provide Internet

and VoIP telephone services while supporting education, healthcare, e-commerce, and weather monitoring system in remote Himalayan region at that cost is fairly reasonable.

The following table shows the percentage of the APT contribution spent on each budget head, which gives an idea of the expense distribution. Please note that only 1.7% of the approved budget has been spent for "Planning and Investigation" head.

S.N	Budget head		Amount Spent USD	% of the total Budget
1	**Planning and Investigation**		**2,444.75**	**1.7%**
2	**Equipment Procurement**		**125,057.99**	**85.5%**
	Wireless equipment and Accessories	63,930.06		
	Solar and backup power	18,747.78		
	Computer and telemedicine	35,741.53		
	Tower and miscellaneous expense	6,638.62		
3	**Shipping and Correspondence**		**2,193.90**	**1.5%**
4	**Business Trip**		**13,967.41**	**9.5%**
5	**Miscellaneous (Handbook and workshop)**		**2,605.71**	**1.8%**
	Total		**146,269.76**	**100.0**

Table 7: Percentage of the total APT budget spent on each budget head

From the above table one can see that almost 85% of the APT contribution was spent for buying the equipment such as wireless equipment and its accessories, solar panels and power backup systems, computers and telemedicine equipment. Only 15% of the APT contribution was spent for planning and investigation, shipping and correspondence, business trip for the Japanese experts, printing handbooks and miscellaneous heads.

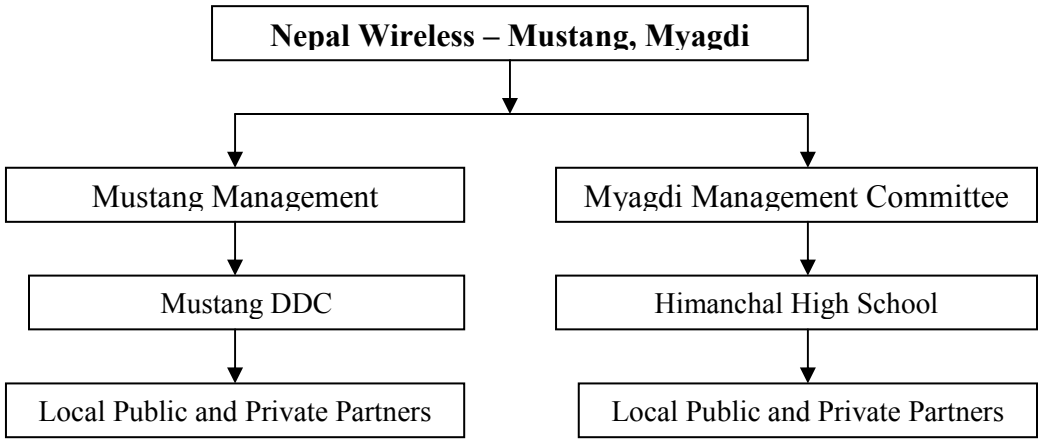
All the administrative expenses including the office expenditures, and staff salary were taken care of by ENRD. There have been some extra expenses such as installation cost, food and transportation cost for the volunteers, stone wall fencing for Kagbeni relay, salary for local staff, and website development for Mustang DDC etc, which were taken care of by the district government. If this project were done by a business firm or INGOs or by government agencies, the total cost for implementing the project, would have been much more than what has been spent.

10. Management Structure

The local network operators configuring the wireless radios

The financial support of APT had come through E-Networking Research and Development. Even if ENRD helped to implement the project, it will be handed over to the local communities and local business partners, who will own and run the network on the long run. Until all the centers start operating smoothly ENRD will provide technical and training support for the network. Furthermore, ENRD will provide technical support in future to extend the wireless network to wider areas. In order to make the project run smoothly, a management structure as given in the following diagram has been set up.

It has been already mentioned that the wireless network has been divided into two sectors, Myagdi sector and Mustang sector in order to manage it smoothly. The main reason we divided the network in two sectors was because those areas are separated by high Himalayas and it is difficult to manage the network on both sides of the Himalayas from one place.



The Mustang sector of the network is managed by the Mustang District Development Committee (DDC) under which a wireless management committee has been formed. The reason we chose Mustang DDC is that it has put significant amount of money (approximate US$18,500) to help bring the wireless network in Mustang. All the local expenses and logistics for building the network was paid from the support that came from Musang DDC. Local representatives from the villages have been put in the management committee so that they can come up with their own ideas and make their own plan on how to use and maintain the wireless network. The committee has invited local businessmen to become business partners of the network; however, nobody has shown interest so far.

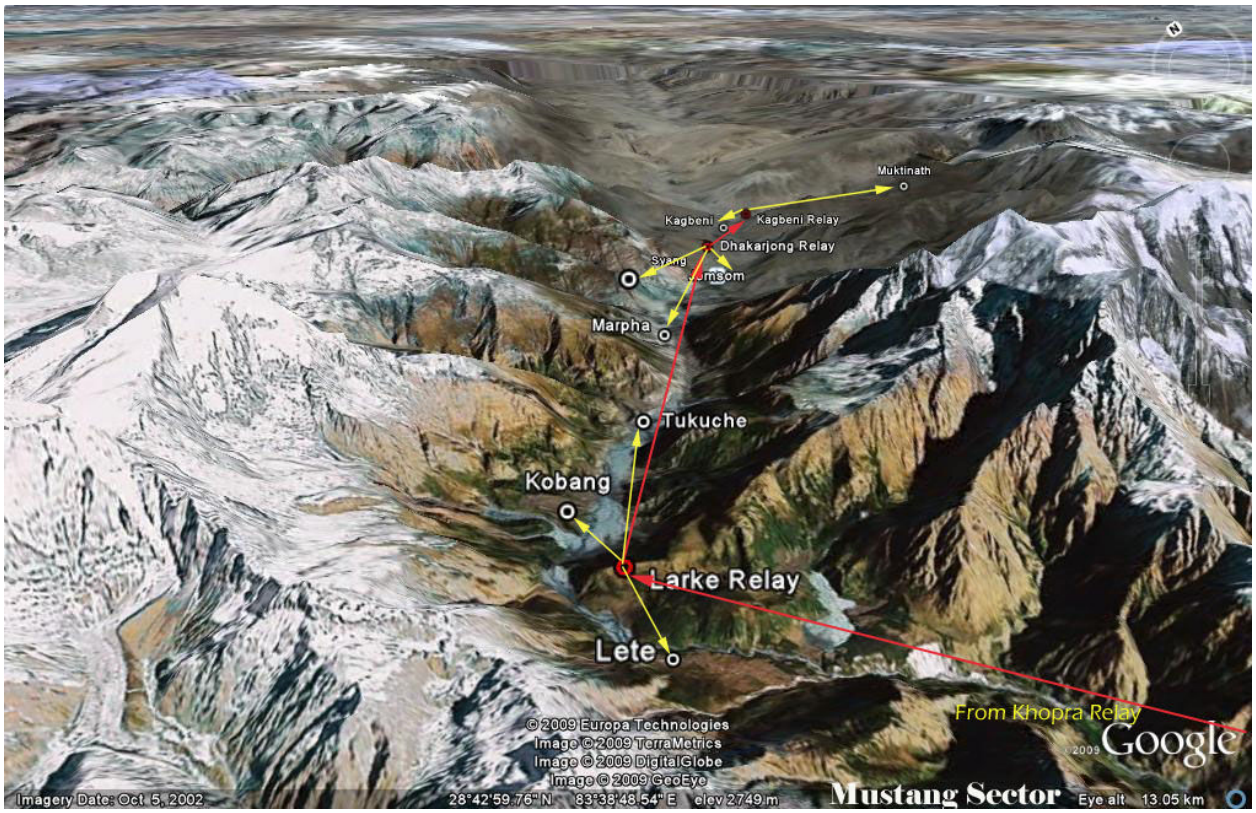
The Myagdi sector of the network is managed by Himanchal Higher Secondary School. This is an interesting fact to know why a school is chosen for the management of wireless network. While most schools in Nepal are solely academic institutions, Himanchal Higher Secondary School has long been engaged in a number of community development projects, including animal husbandry, forest conservation, handicrafts and income generation as well as vocational training programs. An elected management committee of 7 members that meets regularly and makes policy decisions governs the school including the projects it runs. Thus, Himanchal Higher Secondary School has several years of experiences to run wireless network in Myagdi area. Moreover, the facilities at the relay station of Khopra and Mohare were built with the help of Himanchal Higher Secondary School of Nangi village.

Therefore the wireless project uses an organization structure in which two public partners have taken responsibility to manage the network with the technical support of Nepal Wireless as a partner. Nepal Wireless is recently registered with the government of Nepal as a not-for-profit making company. This was required by Nepal Government because E-Networking Research and Development is a NGO and it can't work as a rural Internet Service Provider.

The reason to make public partners involved in the management of the network is that the project will eventually be developed as a business enterprise with public and private stakeholders. We are encouraging local governments and local businessmen to become business partners. So far a couple of private partners have shown interest to be involved in the wireless networking business and several local governments are interested to provide financial support to connect their schools, health clinics and offices. We hope to develop the project as a business entity run by public and private partners within a year or so.

Thus there are many community stakeholders involved including local schools, local governments and businesses. This allows an avenue for democratic participation as well as risk and profit sharing. Also for meeting the legal requirement of license, Nepal Wireless has applied to Nepal Telecommunication Authority for a license to run rural ISP.

While Mustang DDC, Himanchal Higher Secondary School, and Nepal Wireless manage the network, the access to the villagers is provided through independent communication centers in each village. Each center is managed differently. Common caretaker organizations include mother's groups, school management committees, and village management committees. By running the communication centers, the respective caretaker organizations also gain an opportunity to share in the revenue produced by usage charges.



Google Earth Photo of the villages connected in Mustang district

11. Project Sustainability Model and Outcomes

Relay Station in Kagbeni

The pilot project has been just implemented in 15 villages and the network is running smoothly. The students and villagers have been able to use the Internet just for a few months only. Therefore, it will take some more time for the villagers to get full benefits from the project. While the project has been operating only a short time, it is already possible to assess some of the outcomes of the project. For example, the telemedicine program has already been found useful through tele-consulting with the doctors at Kathmandu Model Hospital. The Internet phone has helped villagers to communicate cheaply with the family members working abroad. The students have been able to use the computers for the first time in their lives and are practicing to typing. Additionally, examination of revenue streams, even if it is small now, can provide insight into the project sustainability.

After one year of operation, E-Networking Research and Development will do a detail study in 2010 to know the impacts of the wireless network and will publish the report.

11.1. Revenue Streams for the sustainability of the network

The project has connected community organizations, private individuals and businesses to the Internet that run communications center in the villages. It is a true fact that every household in a village can't afford to buy computer and have Internet connection in one's house.

In that case they get the Internet services from the communication centers run by the school or community or private communication center. This is true for most of the villages

located in the network. However, several hotels in Mustang Network can afford to have Internet in their hotel and provide Internet related services such as email, voice and video chatting, Internet phone services and virtual ATM services etc to local people as well as to the tourists. This creates a system where the communication centers collect all of the revenue from end users, while the project as whole charges the centers at a fixed monthly rate for access to the Internet. The management committee of Mustang wireless network has fixed the following monthly charges to the subscribers.

S.N.	Category of the subscribers	Monthly Cost (USD)
1	Public Schools	25
2	Government Offices	25
3	Individuals with one computer	15
4	Local NGOs, hospitals and clinics	15
5	Tourist Hotels and Lodges	50
6	Commercial Banks and Financial Institutions	100

Table 8: Monthly connectivity charge for the customers

11.2 Communication Centers' Revenue System

Communication centers use the services offered by the project to raise revenues in several ways. First, the center operates as a cyber café, charging users a small hourly fee (currently US$0.21 - $0.43) to use the Internet. On major trekking routes like Jomsom, Kagbeni, Marpha tourists are charged a higher rate (around US$2.50 per hour) to increase revenue. Thus, providing Internet access is one means of raising revenues.

One of the major sources of income of a communication center has been the Internet phone. The reason is that are many young people from the rural areas go to work abroad as menial labors. For their families in the villages, Internet phone is the cheapest means of communication. The following is the approximate call rates for various countries provided by three major IP phone service provider of Nepal.

Service provider → / Country ↓	World Link (US$)		Broad Link (US$)		Himal Technology (US$)	
	Landline	Mobile	Landline	Mobile	Landline	Mobile
America	0.017	0.017	0.990	0.013	0.026	0.026
Canada	0.013	0.013	0.013	0.013	0.026	0.026
China	0.020	0.020	0.017	0.017	0.026	0.026
Singapore	0.022	0.022	0.017	0.017	0.026	0.026
Hong Kong	0.023	0.013	0.023	0.990	0.026	0.026
Australia	0.026	0.106	0.030	0.10	0.026	0.200
Malaysia	0.030	0.047	0.026	0.047	0.026	0.026
India	0.033	0.033	0.043	0.033	0.106	0.106
Korea	0.033	0.060	0.147	0.057	0.026	0.067
Kuwait	0.113	0.127	0.126	0.133	0.133	0.133
Bahrain	0.073	0.093	0.091	0.100	0.133	0.133
Japan	0.033	0.133	0.026	0.133	0.026	0.200
Saudi	0.113	0.173	0.106	0.160	0.147	0.227
Dubai	0.193	0.193	0.177	0.177	0.213	0.213
Oman	0.177	0.226	0.177	0.225	0.253	0.253
Qatar	0.193	0.220	0.180	0.197	0.240	0.240

Table 9: Call rate of the Internet phone provided by different companies

The phone call rate through Internet as mentioned above was not within the reach of the people living in the rural areas. The cheaper Internet phone services were available only in the urban areas. So far most of the people in the project site had to use expensive call rate provided by the PCOs or through mobile phone of Nepal Telecom. With the support of APT, the Internet phone services have been available to the rural people as well.

The Internet phone has been helpful for the families of the people, who are working abroad. Depending upon the villages, about 30 to 70% of the young people from the villages have gone to work as menial labors in Saudi Arabia, Dubai, Qatar, Bahrain, Malaysia and India. A small percentage of the young people from the villages especially from Mustang have been able to go to work in developed countries like Japan, the US, Canada, Australia and European countries.

For the Internet phone calls, the communication centers and cyber cafes bill the user at a rate above that charged by the service providers. The call rate the users have to pay at the communication centers on average is from 50% to 75% higher than the call rate given in the table above. Even if so, the telephone call rate the villagers have to pay at the communication center is still cheaper than making call from the mobile phones.

11.2 Rural Health Clinic's Revenue System

The project has started telemedicine services through video conferencing from three rural clinics. It is testing telemedicine applications such as ultrasound, electrocardiogram, digital stethoscope, pathology test and store and forward method for providing telemedicine services. Since the telemedicine service is at testing phase right now, the villagers are not being charged for the services. However, after the sustainability of the pilot project for telemedicine, the villagers will be charged some money for the telemedicine services they will get. Tentatively, the service fee of US$ 1 per visit will be a reasonable fee. 50% of the service fee will stay at the clinic and other 50% will go to the hospital that will provide the service. In this way, telemedicine services will bring income for the sustainability of the project on the long run.

11.3. Network Revenue Streams

As mentioned earlier, the project does not collect revenues directly from end users. The wireless network management committee in Mustang and Myagdi instead bills communication centers, offices and hotels to collect revenue on monthly basis as connection fee to cover the operating cost of the network and to pay the bills of Internet connectivity to the Internet Service Provider in Pokhara. Expenditure for running the network (Table 11), currently reaches approximately US $830 per month, whereas fees collected from communication centers (see Table 10) now reaches about US $855.

S.N.	Area	Number	Connection Fee Per month USD	Income in USD
1	**From Mustang sector**			
	Government offices	7	25	175
	Schools	8	25	200
	Hotels	6	50	300
	Hospital and health clinics	2	15	30
2	**From Myagdi sector**			
	Schools	6	25	150
	Total Revenue in USD			**855**

Table 10: Approximate monthly income for the network

S.N.	Approximate Operation cost per month	Amount US$
1	Internet connection fee to the ISP including tax	350
2	Server room rent/power bill	50
3	Allowance for Relay Station in charge	100
4	1 Field Staff in Mustang	140
5	1 Field Staff in Myagdi	140
6	Miscellaneous	50
	Total	**830**

Table 11: Approximate Monthly operating and maintenance cost

Even if the project is producing just enough income now to sustain, we anticipate that revenues from the Nepal Wireless Networking Project will continue to grow with the growing user base. So far only 6 hotels in Jomsom, Kagbeni and Marpha have subscribed Internet. There are more tourist hotels in Muktinath, Lete and Tukuche villages interested to subscribe Internet soon. With the planned addition of more villages such as Rakhu, Doba, Bega, Bhurung, Dana, Kalopani, Jharkot, Jhong, Thini in 2010 revenues could easily reach over USD1, 000 per month. Ideally, this will help to cover not only the operation cost but also the expenses involved in network infrastructure.

11.4. Economic Opportunities and Growth

An additional benefit of the project is an increase in spending and economic opportunities in the region. This includes some jobs offered through the project and business generated by the project, either directly or indirectly.

11.4.1 Jobs Created

So far, the project has created a few part-time and full time jobs as well as volunteer opportunities. However, full-time jobs are not fully paid, as the project is not yet generating sufficient revenues to pay full pay to the full-time staff. Although they are not paid a full-scale salary, staff of the project may receive other incentives such as training, and most jobs are still viewed as desirable as there are few cash-paying jobs available in the area.

As we expand the wireless network to more districts in coming years, more jobs will be created. Many villages from different parts of the country have shown their deep interest to bring Internet and start Internet related services in their areas. The villagers are raising money from different sources to bring Internet in their villages.


Narayan Poudel, Mustang


Subash Gurung, Pokhara


Birendra Gurung, Kaski


Raju Sunar, Mustang

Photos of some of the network operators working for Nepal Wireless

List of some jobs created by the project		
S.N.	**Job description**	**Schedule**
1	Network technician cum manager in Myagdi	Full time
2	Relay Station in charge at Mohare	Full time
3	Relay Station in charge at Khopra	Part time
4	Network technician cum manager in Mustang	Full time
5	Network technician in Chandrakot	Part time

Table 12: Jobs generated from the Nepal Wireless Networking Project


Most of the installation team members were volunteers.


Setting up routers and switches at Khopra

In addition to those jobs, the project has created volunteering and internship opportunities for software developers and fresh college graduates with computer science as major. The following is the lists of the national and international volunteers, who actively helped to set up the network during the installation period.

S.N.	Name of the volunteer	Country	Status
1	Gaurab Raj Upadhaya	Nepal	Networking and routing specialists: Designed the network
2	Indiver Badal	Nepal	Networking and routing specialists: Designed the network
3	Philip Mucci	USA	Computer Engineer. Built Server in Pokhara and Kathmandu
4	Henry Corrigon Gibbs	USA	Undergraduate student from Yale University. Helped to install Alvarion radios, routers and switches at the relay stations
5	Anas Mehmud Ebraheem	Iraq	Network Engineer. Helped to configure the MikroTik radios and provided training to local people on MikroTik.
6	Jonny Martin	Newzealand	Network Engineer. Helped to put the Cisco routers and switches at the relay stations
7	Hari Bhusal	Nepal	Network Engineer. Helped to install radios in Mustang
8	Roshan Lal Joshi	Nepal	Kathmandu University Graduate. Helped to install radios in Mustang during the installation period
9	Bibek Shrestha	Nepal	Kathmandu University Graduate. Helped to install radiosin Mustang during the installation period
10	Santosh Baral	Nepal	Pulchok Engineering College graduate. Helped to install wireless equipment in the villages and create an website for Mustang DDC
11	Dhiraj Ghotane	Nepal	MBBS from China, volunteering for telemedicine program

Table 13: List of the volunteers, who worked for the installation

Besides, the project provided the best opportunities to the volunteers to learn how to set up long range wireless network in a very difficult geographical terrain. After working with Nepal Wireless Networking Project for two months, Roshan Joshi and Bibek Shrestha got new jobs in the wireless networking field in Nepal. Right now, four students from Kathmandu University have signed up for internship for the Year 2010 with ENRD. The students of Gandaki College of

Engineering and Science of Pokhara helped to customize php bulletin board, and local e-commerce software.

Moreover, Gaurab Raj Upadhaya, Indiver Badal, Philip Mucci, Henry Corrigon-Gibbs Jonny Martin and Prasanna David are always available to remotely monitor, and fix the network and application problems if that happen. They are also the main technical persons to design the network, to do the troubleshooting in the servers, and make them run smoothly. That is why the project does not require hiring highly skilled network engineers. Their support has been great and the project is saving huge amount of money to hire highly skilled network engineers. However, on the long run the project will train a few local people to produce system engineers for the network.

11.4.2 Business opportunities created

At present, it seems that business opportunities for the manufacturers of information and communication technology in rural Nepal fairly limited. Nepal Wireless Networking Project, however, is trying to stimulate both large and small-scale ICT businesses in rural Nepal. After the successful implementation of the APT pilot project, we are very hopeful that there will be more groups including the central and district government interested to build similar wireless networks in other parts of Nepal. There is great potential for ICT business because 80% of the populations of Nepal live in the rural areas. There are schools, health clinics, and government offices as the potential customers.

On a large scale for now, Nepal Wireless acts as a consumer to Nepal Telecom, the Nepali ISP (WorldLink), the Nepal Hydro Power Company, local computer stores, and global wireless equipment manufacturers. The project bought almost USD124,000 worth of equipment from Israel, Japan, Singapore, Australia, Taiwan and China. Some of the equipment were bought through local vendors and some were bought directly from the manufacturers. On a smaller scale, Nepal Wireless also hires many local community members in the informal labor sector for help with various projects.

Additionally, some users are using the Internet for business-related purposes. The Internet phone services have created a good business for the owners of hotels and rural communication centers as well. Moreover, Nepal Wireless is in a process of getting license to help villagers start money remittance services in the rural areas by using the Internet

connectivity. The people from the villages, who are working abroad, will be able to send money to their families using the remittance services. Also it will create some jobs for the local people.

Nepal Wireless has successfully tested virtual ATM system developed by Thamel.com for one year in a famous tourist destination called Ghorepani. Using that system, the tourist can enter the information of their credit cards by themselves in the secured website created by thamel.com and process it. It takes just a minute or two to get the credit cards processed through the Internet. With the service once available, tourists can pay the bill and even get cash if they need. That will be very helpful for the tourists when they travel to Muktinath, Kagbeni, Marpha, Tukche, and Lete villages that get quite a numbers of tourists every year.

An agreement has been made with Thamel.com to introduce their virtual ATM machine system at the hotels and communication centers in Mustang and Myagdi. According to the agreement, tourists will be charged from 5 to 8% service fee for each transaction depending upon the amount of transaction. The service fee will be divided 50/50 to Thamel.com and the communication center. It is clear that there are three potential benefits from the virtual ATM system. First benefit is that tourist might spend more money in the region if they can pay using their credit cards. The second is that the local operators will make some money from the commission of the transaction. Third, it will create some job opportunities for the local people.

Thus, many of the services offered yield direct and indirect business benefits for sure. As mentioned above, the plan to create an e-commerce system in the network will hopefully increase benefits to business in near future.

Students at Gyanodalya Secondary School, Kalopani, Lete

12. Successes and Lessons Learned

Testing radio link in Lete village

12.1 Successes of the pilot project

When the Nepal Wireless Networking Project was started in 2003, it was among the first grassroots movements to use ICT for rural areas in developing countries. So far we have built several small wireless networks in different parts of the country and have successfully implemented as many services as possible.

However, building the wireless network across the Himalayas was not an easy task to accomplish. Considering the very unfavorable geographical barriers, and the difficulties for building four relay stations on the isolated high mountain tops from 3,000 m to 3,700 m high to connect Mustang district to Pokhara, the project is quite challenging. We consider the following to be our main successes so far:

- Connected 15 schools and villages to the broadband network in the Himalayan region.
- Extended access to the wealth of information and global communication available on the Internet to an area where few thought was possible.
- Successfully piloted new technologies such as telemedicine, teleteaching, e-commerce, VoIP phone services and weather monitoring system.
- Created an ICT business opportunities in the rural area.
- Made every effort possible to adapt technologies to the local context
- Developed a model of public and private partnership by involving local partners and district government for implementing the project.

12.2 Lessons Learned

APT ICT J3 project was the biggest project, Nepal Wireless Networking Project implemented in a time span of one year. Over the years, many lessons were learned that might be of use to other interested groups undertaking similar projects. We would like to share those lessons in two parts: First, those of a technical nature and, second, those of a more practical nature.

12.2.1 Technical Lessons

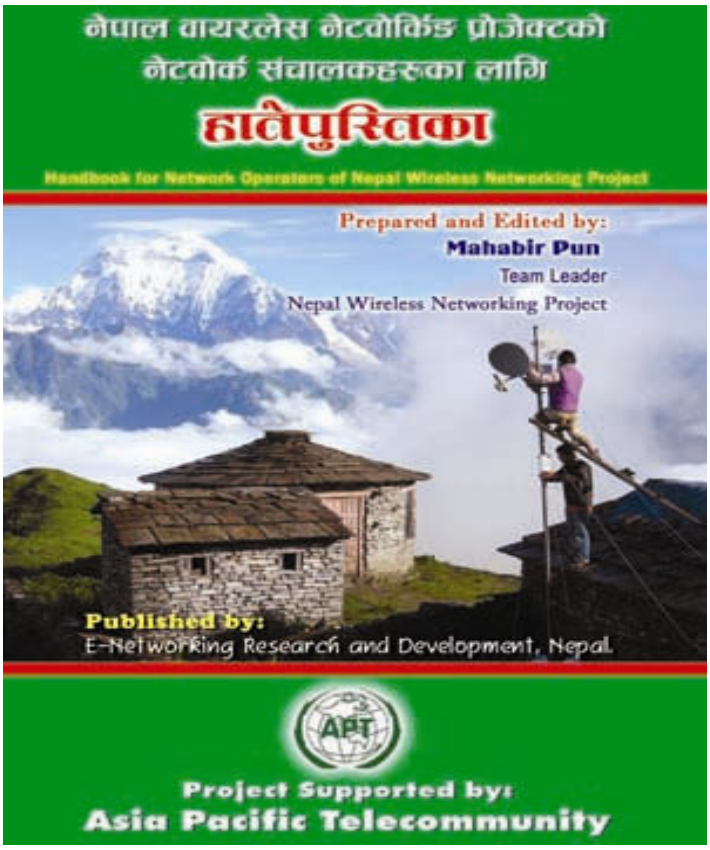
Through our project, we learned several lessons about the technical aspects of setting up and linking a community wireless network. These include the following:

A. Device Capability: We have found that the throughputs and range of the devices are much more in the remote areas, where there are no interferences. Therefore wireless devices exceed manufacturer specifications especially when it is used in the areas far from the cities like the Mustang area of the Himalayan region. One reason might be that the line of sight from a high mountaintop to other mountain top is very good.

B. Device Usefulness: People around the world are using the Wi-fi devices mostly for connecting Internet at their homes or in their communities. The project has tested that the technology can also be useful for delivering telemedicine, tele-teaching and telephone services at much cheaper cost and easier way.

C. Network Backbone: When setting up a long range wireless network, it is essential to have a strong backbone with reliable equipment and high throughputs. In our case, this equipment was the 5.7 GHz Alvarion and Motorola Canopy BH-20 even if it is much more expensive than other equipment. Those equipment were used because they are carrier class equipment.

For the last mile connectivity, the Wi-fi equipment that are easily available in the market such as MikroTik, Ubiquity, EnGenius are good enough. For Access Points, MikroTik has complete package for monitoring and maintaining the networks.



Handbook for the Wireless network Operator in Nepali Language

D. Required Training for setting up a Wi-fi network: Our experience tells that one does not have to be a trained IT professional or college graduate to install community Wi-fi wireless network. With some trainings and guidance, even the village team members can setup and operate the network. With the financial support from APT, Nepal Wireless has also published a handbook for the rural wireless network operators in Nepal language. The operators can follow the directions given in the book to install radios, and do other troubleshooting.

E. Training for Local People: Having the involvement of local expertise or capable individuals is critical to the sustainability of the project. They must be trained and used to maintain the technical aspect of the network whenever something goes wrong. Sending experts from the cities unless it is required to fix the technical problem is not feasible.

F. Power at the Relay Stations: Power is the most challenging needs to be met at the isolated relay stations without any power from the grid line. Try to solve the power need by using varieties of power sources such as solar, wind, hydro and human operated bicycle generator. If there is a small mountain stream nearby with at least 10m head, it is economically feasible to use micro hydro generator even if it can produce 1 KW power.

G. Record Keeping: While building wireless networks in the rural areas it is very important to keep manuals for every piece of equipment in a central location. Maintain a record of all passwords used and backup the configurations for all devices and computers. Always have duplicates of every piece of equipment on the network and make notes of every failed experiment. In our network we have set up a Wiki to put all the information of radio configuration and equipment inventory.

12.2.2 Practical Lessons

The followings lessons are of a more practical nature and address the use of the network in a social environment.

A. Growth of Users: The project has found that young people can quickly learn how to use the Internet, and play games from their friends. We have found that it will take months or weeks, not years, for villagers who had never used computers before to write e-mails, chat online, to play games, and to share ideas using computers. It just happens if it is available.

B. User Training: We found an imperative need to ensure that the users are kept fully trained to maximize the potentials offered by the network to the maximum number of villagers. Therefore occasional short-term refresher training programs in each of the villages is needed.

C. Job Opportunities: The project has learned that even a small network can create several jobs in a developing country like Nepal, where very little jobs are available for college graduates.

13. Future Goals of Nepal Wireless Networking Project

Relay tower at Dip pointing high to Mohare Relay station

While we are satisfied some with our successes to date, we also realize that there are many areas where we can improve and expand the net work. In particular, we would like to concentrate on the following areas as we move forward.

A. **Provide additional resources needed for the tele-medicine installation:** The goal is to make tele-medicine a viable health opportunity for rural community. While we have invested in some of the necessary technology, further work and investment is needed to reach a point where the telemedicine works perfectly helping to address the shortage of doctors in the rural clinics. The major investment required for tele-medicine is for buying video conferencing equipment, digital equipment for ultrasound, ECG, vital sign monitoring, x-ray reading, etc.

B. **Start tele-training program:** Based upon our experience by running telemedicine program between Dolakha Hospital and Kathmandu Model Hospital for the last one and half year, we have seen that a wireless network will provide tele-training program for the rural health workers and teachers. This will actually be a virtual training program in

which the trainees will be staying in the rural areas and the trainer will conduct the training from the city centers.

C. **Expand the virtual ATM services and remittance services:** One of the important future goals is to make the virtual ATM service available in as many tourist destinations as possible. Also we would like to start remittance service in the area from where maximum numbers of young people have gone to work abroad. It is very important for the sustainability of the network. As for helping people to sell and buy the local people in the local market, we will provide training to local people on how to use local e-commerce site created.

D. **Provide quality of broadband services:** The high internet bandwidth cost is the bottleneck for providing quality broadband services in Nepal. The market price for 1 Mbps dedicated internet link on average is higher than US$ 500 per month. The villagers in the remote areas can't afford such a high cost. At this situation the only way to provide Internet services is to provide shared Internet connection. Right now the 14 villages that are connected to the network of APT project are sharing 512 Kbps of Internet bandwidth. However, the Internet bandwidth cost is coming down because Nepal Telecom and private operators are getting cheaper Internet connection from India through optical fiber line. The plan is to upgrade this connection to 1 Mbps or more to Mustang project when it gets cheaper and the number of users grows.

E. **Put more backup power at the relay stations:**

We found that solar power sources that we have put at Khopra relay station relay during the peak monsoon rain is not enough. We solved that problem temporarily by using a kerosene generator. Therefore we plan to put more solar panels for backup power at the relay stations in order to increase performance and uptime.

F. **Extend the network to more surrounding villages:** With the APT support, we connected only 14 villages in the network. However, we have now built strong backbone and we can extend the network to many more villages. For example, from Todke of

Myagdi we can extend the network to western region of Myagdi district and at least 15 villages can be connected. From Mohare Relay, we are planning to connect Ghondabandhe of Baglung district from where we can connect at least 10 villages in that region. Similarly, many more villages can be connected if we build a relay station at Durlung that can be linked to Chandrakot Relay. By bringing network service to more villages, we plan to provide a revenue stream both for the village and for the project. Of particular interest is the establishment of an Internet cafés at Annapurna Base camp and a rescue request system at Thorang Pass (5,416 metres, 17,769 ft). Also by building a relay station on the mountain top located on the East side of Jomsom, the wireless network can be extended as far as to Lo Manthang, which is near the Chinese border. Before 1991, Upper Mustang was closed to the foreigners. Even though foreign visitors have been allowed to the kingdom since 1991, tourism to Upper Mustang is regulated. Foreigners need to obtain a special permit to enter, which costs US$500 per 10 days per person.

G. Collaborate with potential partners to set up climate change monitoring system: Nepal Wireless is currently in the process of setting up collaboration with Dr. Arnico Panday, Research Assistant Professor at the Department of Environmental Sciences of the University of Virginia, in Charlottesville, VA, USA. Dr. Panday studies the interactions of air pollution and climate, studying the formation of atmospheric haze in Nepal from air pollutants emitted in the Ganges Basin and within Nepal, as well as the effects of this haze on meteorology, air quality, glaciers, and monsoons. He has field research sites in two regions of Nepal where Nepal Wireless has good coverage - Mustang and Makwanpur. By June 2010 he is setting up stations equipped with instruments to measure atmospheric black carbon, ozone, carbon monoxide, and particulates at Sim Bhanjyang in Makwanpur, and on Dhumba Ridge near Jomsom in Mustang District. He is also installing a network of automated weather stations in and around these sites, and a Cimel sun photometer in Pokhara that will be part of NASA's Aerosol Robotic Network (Aeronet). He will work with Nepal Wireless to link these sites to the internet, so that data can be accessed remotely.

Some of the weather stations in Mustang District will be co-located with existing Nepal Wireless relay stations (for example Dhakarjong). The station on Dhumba ridge

will be connected either to Dhakarjong relay. Sim Bhanjyang, Makwanpur, provides an interesting opportunity for Nepal Wireless. Dr. Panday is installing his instruments on and next to the transmission tower belonging to Radio Palung, which sits on a 2,600 meter peak that has a clear line of sight to both Hetauda (where Nepal Wireless has an access point), and to Mohare Relay in Myagdi, as well as to large rural regions of five districts. Building a relay station in Sim Bhanjyang that is connected to both Hetauda and Mohare would connect together Nepal Wireless's infrastructure in two different parts of Nepal, and would provide alternative ways of routing traffic. At the same time it would allow Dr. Panday to connect together all of his stations through one intranet. If he succeeds in obtaining additional funding, Dr. Panday is interested in setting up weather and climate monitoring in Upper Mustang and in Manang Valley, and in working with Nepal Wireless to build additional relay stations needed to connect to upper Mustang and across Thorong or Tilicho Pass to Manang.

14. Final Report Presentation Program organized

ENRD organized a formal program at the Ministry of Information and Communication with Minister of Information and Communication as the chief guest. The goal was to formally present the final report of APT project to the Ministry of Information and Communication and to raise awareness of the importance of ICT to the political leaders and government bureaucrats.

Mahabir Pun is presenting final report of APT project.

Attendees at the final report presentation program

Attendees at the final report presentation program

Among the 52 attendees, 16 were the members of parliament of different political parties. Others were the members of National Planning Commission, members and officers of Nepal Telecommunication Authority, high level government bureaucrats from different government ministries, members of different organizations working in the field of information and communication technology, and journalists from different media.

15. Conclusion

Finally, we would like to thank Asia Pacific Telecommunity very much for the support it provided for the ICT pilot project in Nepal. Without APT's support, it the wireless network in the Himlayan region of Nepal would not have come to exist. We hope this final report will give the readers an understanding of its technical design, implementation and uses. Over the past few years, Nepal Government has also given some attention to bring ICT in the rural areas. With the support from Asian Development Bank, Nepal Government is implementing a big e-governance program in the coming years. We hope that Nepal Wireless Networking Project will be able to present a successful model for the government to follow in planning future endeavors. As Nepal stands on the horizon of a bright new political future, we appeal to government, civil society, and the private sector to take initiatives that will help grassroots projects such as the Nepal Wireless Networking Project to help bring the promise of information technology to all.

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