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Raju Paudel

IMPLEMENTATION OF WIRELESS NETWORK IN NEPAL: A CASE STUDY

TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES

BACHELOR'S THESIS | ABSTRACT

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In recent years, the Nepali government and development organizations have taken their keen interest in the questions related to access of ICT and digital exchange. Although several discussions, determinations, and promises have been made, it is difficult to determine whether any tangible development has been accomplished. The Network project in Nepal has seriously examined similar issues along with addressing all the challenges from ground level. Starting from 2002, its commitments have been made to close the digital divide in Nepal by increasing access to ICT in rural areas through wireless technology. To understand the basic procedure of the project from its root level to point of success, this thesis goes through its levels.

The Nepal Wireless Networking project discussed in this thesis is currently running as a social enterprise that provides connections to rural villages in Nepal through the community Wi-Fi project. The main purpose of thesis was to understand the implementation process of the wireless network in rural parts of Nepal. The thesis aims to clarify the need for wireless network, wireless equipment and protocols, challenges and finally outcomes of the wireless network.

To understand how this kind of project is implemented, the author studied other similar type of projects which were implemented in other parts of the world where there is similar type of geographical condition. To be more clear, the author carried out a case study about the Nepal Wireless Networking project which was successfully implemented. The author studied the report papers of volunteers and workers who were directly involved in the project during the initial phase of implementation. Since 2001, it has joined more than 200 rural villages in Nepal to the Internet. By the end of 2015, the team helped connect 12 earthquake-striken villages and is currently providing the various benefits of connectivity such as easy access to online education, government services and so on. The Nepal Wireless Networking project conducted a pilot project to distribute a community-based hybrid wireless network and Wi-Fi spectrum in remote districts around Mt. Manaslu and the Mt. Dhaulagiri region in 2016.

Despite the lack of access to proper equipment, lack of technical competence and the difficult terrain in the Himalayan mountains, the Wireless Networking project succeeded in bringing the Internet access to villages, contributing to improvements in education, health services, and income-generating activities.

Low-cost wireless networks can be used in remote locations to provide Internet access to communities scattered across mountainous regions of Nepal. Wireless networking highly demands social support for its sustainability and strong local capacity-building efforts in ICT have resulted in a group of local experts who can provide technical assistance to maintain the network in the long term.

KEYWORDS:

Wireless Network, Frequency, Transmission, Bandwidth, Server, Software, Ethernet, Radios.

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LIST OF ABBREVIATIONS (OR) SYMBOLS

Dbi	Data Base Interface
FHSS	Frequency-hopping Spread Spectrum
HN	Home Networking
HTTP	Hypertext Transfer Protocol
ISP	Internet Service Provider
Mbps	Megabits Per Second
PBX	Private Branch Exchange
PSTN	Public Switched Telephone Network
REDR	Raw Experiment Data Record
SEM	Small to Medium Enterprise
SIP	Session Initiation Protocol
SNAP	Sub-Network Access Protocol

1 INTRODUCTION

Nepal is landlocked country on the southern slopes of the Himalayas between two big countries India and China. The geography of Nepal is as follows: 64 percent of Nepal is covered by mountainous region and 19 percentage by hilly region and only 17 percentage is flat land. Approximately 28 percentage of population lives under poverty line and among which the majority lives in rural areas. Five people per hundred have a computer of their own and there are only ten telephone lines per hundred people. The mountainous and Himalayan region which covers the maximum part of the country is classified as the least developed and poorest area with the lowest human development index score.

The initial basic network was not the result of government policy or any decisions made by international effort. It was initiated by local people when there was direct need for a means of basic communication between the rural communities and the outside world. As many communities adopted the idea, the network's activities were widened and as an unexpected result it grew up into large wireless network project in pursuit of finding ways to bring internet and telephones. It took around 10 years to give shape to the project and make the dream come true despite adverse working conditions in country, such as political conflicts and natural disasters. The locations of the project are in isolated areas inhabited by poor farmers and indigenous people. So, the target group of the project were the people who are living in isolated areas who have no modern means of communication. It was not so easy to introduce information technology to those people who had never seen computers until few years ago. Many of them have no idea about the basic use of computer and consider it as no more than a mysterious box.

1.1 Background

The initial phase of wireless network project started in the very remote village of Nepal, named as Nagi, where there is no electricity and solar energy was the only energy source available. In 1997 a non-government organisation, -Networks Research and Development was established which worked closely with the local wireless network project as a technical support team. In 1998, the first telephone line was installed in village raising small hopes of communication but the quality of connection was not

performing well. This information was posted in the BBC website, which gave an overwhelming response from many foreign students and volunteers who were very eager to support and help. So, initially this project? started with donations, such as used PC and servers, technical support etc. Along with receiving small donations, the news spread and many emails were sent to many volunteers throughout the world. Finally, volunteers came together and helped to install computers and to set up networking tools along with the network. Apart from that, there were many volunteers who started teaching basic computer skills to the villagers.

2 WIRELESS TECHNOLOGY

Wireless technology describes wireless devices that communicate with radio frequency signals. Wireless technology is used in a variety of modern devices to provide comfort and mobility. Wireless peripherals play an important role in voice and Internet communications. There are many devices used for wireless communication, such as cell phones, Wireless phones, ZigBee Wireless technology, GPS, Wi-Fi, satellite TV and wireless equipment. Current wireless phones include 3G and 4G networks, Bluetooth, and Wi-Fi technology.

2.1 Wireless Devices Used

Wireless device is a technology for wireless local area networking with devices based on the IEEE 802.11 protocol. Wi-Fi is a characteristic of the Wi-Fi Association, which limits the use of the term Wi-Fi Certified to products that effectively complete interoperability certification.

Radio telemetry: This technology was very useful because it has many performance characteristics which include operating frequency, maximum transmission distance, data rate etc. Telemetry receivers and transmitters were used to connect distant nodes in conditions where cable runs were impractical. Murata FHSS wireless telemetry products of 2.4 GHz were suitable for the project as they were used in a range of outdoor and indoor and in harsh environments. HN-series wireless serial modems were used as they were reliable and useful for long-range communication. In the same way, SEM series wireless Ethernet was used to ensure wireless connectivity between distant Ethernet nodes with high-speed. SNAP series access point was used in providing seamless serial-to-Ethernet connectivity with wireless nodes which was very useful in transmitting data to server application [1].

Antennas: Most of the connections were point-to-point where high focused 24 dBi antennas were used. In the city Pokhara, 15 dB Omni directional antenna which propagate in all directions and two deliberant radios with 15 dB were used. The use of omni-directional antennas aimed to save money because being a gain antenna system, it is possible to cover long distances compared to the default Omni-directional antennas. They also provide ease of management and handling as they requires less equipment

installation. It is possible to shoot signals around corners with a hi-gain antenna and it is much reliable and cheap mode of connection. An access point and dual directional antennas were setup which made process easy to undertake [2, 3].

IP management: All network devices were being allocated static, local, IP addresses (192.168.1.x). Bandwidth differ between 8 Mbps on short point to point links to 12 Mbps on long links.

Picture 1. Relay station [6].

2.2 Configuring the Wireless Server

System administration was enabled by network server which was in Pokhara which delivers a number of facilities to network users. The server was Pentium IV system computer with double hard disks which operates a Fedora Core 5 Linux distribution. An extra third-party was configured for highest termination to prevent breakdown. All disks were a duplicate copy which were changed synchronously, meant to function as a Redundant Array of matching Disks formation. Linux was used because of large abundance of high quality open software and standard distributions. It was available online and it was tested and verified in various production environment which made it a perfect choice for a server. At that time, many technicians were only trained on Microsoft, so the choice of operating system as Linux gave a slight maintenance problem. In the absence of remote expertise for support, the system was made to be maintainable by the local volunteers. The system was maintained by the usage of graphical user interfaces and the routine progress of maintenance and software management.

Nowadays, the server runs following software packages which facilitate service to users as well as network management [1, 2].

I. Asterisk PBX: It is built on the SIP protocol to interface system phones with Nepal Telecom. It is an open source telephone exchange which allows both incoming and outgoing phone calls. A person in Pokhara answers the incoming calls and then it is transferred to the appropriate extension on the system. With the assistance of Grand stream network telephones, Cisco ATA-186 phone connecters, Xtenlite software phone and the server let users to keep calls from within or outside the system. It was made possible to make calls or to receive calls from other parts of the globe by using an extension number. In this way, the system worked similarly to VoIP systems in other systems also, like in Skype. Call logging is performed by PBX which later can be displayed through a web interface. To Interface to the PSTN, the Sipura SPA-3000 was used [6,7].

II. The internet server and Apache**:** HTTP is a popular open source server. It provides web pages customized for internal access, which means it provides links to network administration resources and a directory. Links to other services which the server provides and other useful external links are some of the intranet portals provided to the internal clients. At present, the server hosts a minimal page that is accessible to the external world. This is because the limited bandwidth of server external traffic competes with the traffic generated by the villagers browsing the Internet [6].

III. Named-The Domain Name Caching Daemon: During the maximum use of internet, this network service caches domain name requests. It helps to highly minimize the Internet access address for domain names, such as google.com or yahoo.com which is accessed by users and stored by the software. To decrease the traffic to the ISP by an order of magnitude, all the system clients are constructed to use the server as their main server. This results in loading the page faster. What we know is that the server finds the addresses but cannot locate the data.

IV. Samba: It helps to collect the names and addresses of different computers on the network. It acts like a master of a work group and a cross-platform server which permits to distribute files on the system. It also lets both open and PIN secured shares. As a new machine or computer, the file server makes configuration very easy because all the required software are kept here. It helps to backup data from server within the system in any computers which protects data from loss and failure in hardware.

V. MySQL: Software packages which also includes Asterisk and phpBB are supported by this open source database. It can be managed by means of phpMyAdmin with a web browser.

VI. WebMin: With the help of this web based administration, all tasks needed to keep the server in operation can also be performed virtually, for example network configuration, account management and security.

VII. SSH: If an administrator wants a secure access to the server from any part of the globe, the Secure Shell Daemon helps with it. Every aspect of the system can be analysed, diagnosed, upgraded, and modified with the help of this interface from any part of the world.

Picture 2. Volunteer Working in the Server [5].

2.3 Relay stations and power supply

On the mountain tops, there were two Relay Stations which transmit the signal over the pass to create backbone and connects villages. In this site, power from the main grid lines was not connected. They had to use the power generated from the sun, wind and from the human power which is known as bicycle generator. There were many wireless devices, an Ethernet hub, and a laptop computer in each relay station, so this was not trivial. Many used devices ran on AC power which meant 12 V DC had to be converted into 110V AC power, which required a set of inverters. It was challenging and complicated to manage the power with limited resources [5].

Picture 3. Wind Generator and Solar Panel [5].

3 TESTING PHASE

In 2003 testing was conducted to measure the feasibility of connection to Pokhara to access the Internet. Back at that time, links using 802.11b technology were small for such long distance. So, it was necessary to find out if available commercial equipment at that time could help to construct such a long-distance link. Some volunteers from other countries helped by donating D link 900 AP access points which were used during the testing phase. Nevertheless, for the whole project, it was quite expensive to invest at that time.

3.1 First Phase of Implementation

For the first phase of network implementation, two relay stations were constructed. The Jana server which is free software was used for internet connection to the communities with a dial-up assembly in Pokhara. It worked for a half year but the cost was very high for telephone and internet connections. After that, it was changed to a dial-up connection of a 64Kpbs with the help of wireless connection from one of the ISP called WorldLink [8].

Picture 4. Relay Built in First Phase [6].

3.2 Second Phase of Implementation

In this phase, the implementation of project was expanded which added many important network services. It replaced many pieces equipment that were malfunctioned in the first phase and finally the backbone for the network was built stronger. This was possible due to the World Bank grant which was supplemented from the International centre for Applied Studies in Information Technology. In the second phase, technology for Wireless Ethernet Radios such as Motorola, ascendance, Tranzeo, smart Bridges were used [8].

Picture 5. Putting Canopy in Second Phase [5].

4 ACCESS TECHNOLOGY AND SERVICE PROVIDED

At the initial stage, services were provided through very simple equipment due to shortage of funds. Many wireless equipment were used ones which were donated.

4.1 Access Technology

The available services were provided mainly through used laptops and computers. Slowly and gradually additional equipment has been facilitated such as internet telephony equipment, tele teaching/telemedicine and network cameras with high resolution etc. Typically, Pentium I and II computers were used in the network which were given by different donors.

In addition to the Internet telephony system, there were added number of telephone users in different villages. With the help of this technology, the users can directly dial a telephone number the same way as in landline. In this process, before the call is placed on the Nepal telecom public switched telephone network, PSTN, the call is routed through the network server. There are 4 Sipura SPA -3000 Wi-Fi-to PSTN adapters, 8 GrandStream Budgetone network phones and 5 Cisco ATA adapters which run this functionality. Where there is no hard phone, the client software which is also known as soft phone can be used [8].

4.2 Coverage of Network and Service Provided

Currently this Network is providing connectivity and different ICT facilities to more than 15 communities of more than 8 village development communities. It has built two relay stations which has helped to send the signals through the highland passes, a base station server facility and a connection to the hospital in Pokhara. The Network provides the following services:

I. Internet: Available to students, teachers, community members, and tourists. Computer labs are established in two villages.

II. E-mail: open accounts accessible through nepalwireless.net or other net mail Services to residents. The mail server and web, along with http://NepalWireless.net. Development of local content with the REDR.

III. Telecommunication services: users can make calls by Internet telephony and software (PBX) on the network server. The "Voice over Internet capability" is used for PSTN calls in the CNT and abroad.

IV. Online teaching: providing online classes by means of system cameras to fulfil the demand for skilled instructors. Tele-education program piloted from secondary school of Nagi to more other secondary schools in other villages.

V. Telemedicine: Collaboration with Hospitals in Pokhara. Health facilities are accessible to public in distant parts of the country through audio and video conferencing. A pilot telemedicine programme is installed in the village of Nagi. Many villagers are treated to date.

VI. Community discussion: Using an online discussion forum, the villagers can have community discussions in their own language. Many villagers from all levels of education are using the network [4].

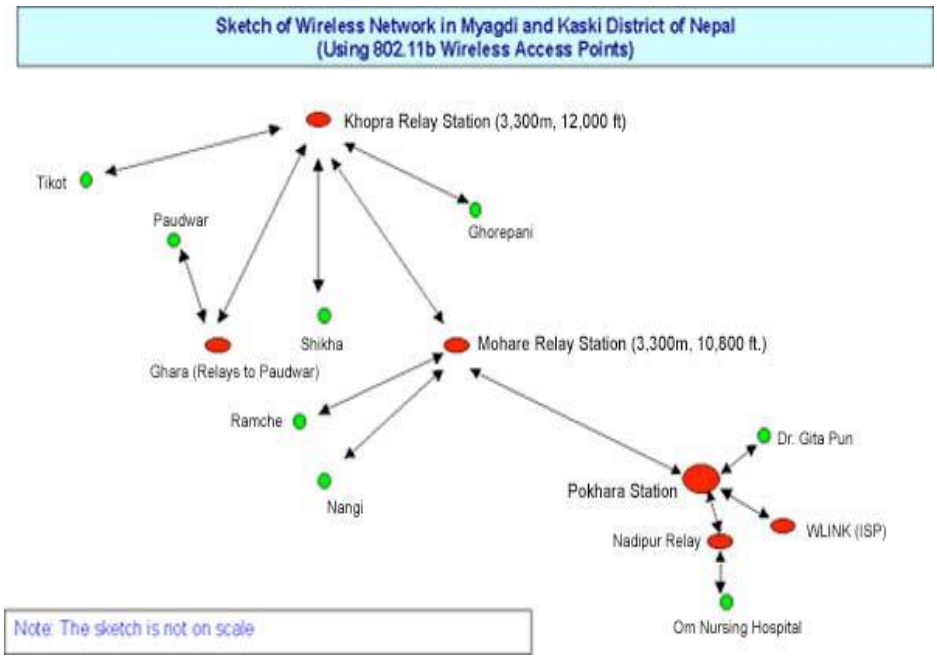

Figure 1. Sketch of Wireless Network [6].

5 ANALYSIS OF PROJECT OUTCOME

A survey which was conducted by E-Networks Research and Development to know the outcomes of the project gives the following information of usage demography and usage characteristics. The survey was conducted by interviewing the local people.

5.1 Statistics of Users

To find the demographic data of user of wireless network, a survey was conducted among the users. Demographic information was collected about users, such as age, sex, marital status, education, occupation, and income. The results show that the users are mainly young members of the community, 83% were under 30 years old. In addition, men tend to use services more than women, 72% of users were men. Overall, an average user was comparatively more qualified. The literacy percentage was about 100% which is expressively more than the state literacy level of 54% conveyed by the Central Bureau of Statistics. Literacy level reflects good sign of primary expression. On the other hand, it also shows that there are many students who have not completed their school yet. Statistics on professions display that agriculture is by far the major profession, followed by professions in the service area. In fact, to disclose income level is problematic due to anxiety of social disgrace, revenue level displays that maximum users have earnings below $ 150. This is a substantially lower GDP per capita, perhaps reflecting lower incomes in the surveyed areas [5].

5.2 Users Behaviour

Users access wireless network services in Nepal for several motives. One of the main reason to carry out the survey was to find out the interest of users to approach the services. Undoubtedly, the majority of users were using the email service, to browse news via www service and for the telephone service. These results indicate that the main reason to access the network are for interaction and to get information about updated news. Another area of interest is the usage patterns, that is, how often users access to services after they have begun to do so. Many of the issues dealt with user pattern and the result was most of the users i.e., about 59% were irregular user and regular users

were about 38%. The pattern of use has also revealed that users use the service in mornings or evenings but very few uses in afternoon. Lastly, the survey exposed that there are many long-term users, 58% had access to network services for a year or more. This data was based on remote users who have to cross long distance by walking, and the outcomes show that they have to travel a substantial distance to as well.

5.3 User Advantages

More importantly, the survey sought to determine whether users have specifically benefited from the Wireless Network project in Nepal. Several survey questions address this issue, the first of which was asked directly whether respondents have saved time and money due to the availability of services. The findings denote that many users have saved time and money using the scheme. Further findings have shown that time savings have been used for academic education, family business and revenue making use of the network. As the network is closely linked with the region's schools, an additional advantage that has been found as local students have benefited from access to the network. In the direct question, 60 of the 65 students interviewed said their studies were benefited from access to the network. Another question was about the purpose of use of the network and they have responded that they use the Internet to collect reading materials, while many of them use it to chat with friends.

5.4 Analysis of Revenue

The Wireless Network project implemented a management structure that lets community associations to manage the communication centre in the local community. This formed a system where communication centres collect most of the revenue from the users while the entire project carries communication centres for a reduced access fee.

5.4.1 Communication Revenue

Communication Centres use the facilities accessible by the Nepal Wireless Networks Project to increase revenues in some ways. Basically, the functions of the centre such as a cybercafé, which charges users a little hourly amount (currently US $ 0.5 - US $ 0.9) to use the network. On main hiking routes, tourists pay a higher fee (US $ 2 per

hour) to increase revenue. At schools, students and teachers pay a smaller monthly fee to the Communication Centres.

Therefore, the provision of Internet access is a means of increasing revenues, too. For telephone calls, the billing structure was done per minute, resulting in a surplus between user fees paid. The project is making $ 0.01 per minute for calls to landlines supplied by Nepal Telecom (NT). Communication Centres are making between US $ 0.02 and US $ 0.15 per minute for local calls and US $ 0.02 to US $ 0.12 per minute for long distance local calls. This surplus is the main source of income for the Communication Centres. Telephone services were provided to the people of Ghorepani in January 2006. After that, services were rendered in different villages at different times. In addition, some Communication Centres have begun to conduct elementary computer skills charging between $ 5.00 and $ 15.00 per student per month. This increases their income and develops computer skills for people of all ages in the community. Now, six villages have lessons with enrolments of 10 to 20 students in each community. The name of the villages that operate are Paudwar, Shikha, Tikot and Majhgaun during the summer holidays [5].

5.4.2 Network Revenue System

The operating expense of the network currently amounts to about $ 290 per month, while the rates charged by the communication centres now reach around $ 225. On the other hand, Network communication charges about $ 0.01 per minute billed by the national telecommunication provider of Nepal, giving rise to an additional advantage. With an estimated billing of $ 80 per month, the network generates more than $ 300 per month and can cover almost its operating costs. Schools pay US $ 110 now, that schools use the network for the maximum time. Revenues of $ 10 per month for each village will start charging a fee for the four newly added villages (Majhgaun, Chandrakot, Tolka and Lopre). In addition, the Tatopani communications centre is still not operational because the inhabitants of the town have not decided whether they would establish a communications centre. They are planning to run a communications centre in the near future. Tatopani will charge $ 20 to access costs per month, as it is one of the major tourist cities. The Tatopani communication centre can produce much more revenue than other communities, paying more usage fees to tourists from the Mustang area. This city is also on the Annapurna Trail Circuit. With the growing user base, it is expected that

revenues from Nepal's wireless networking project continue to grow. With the addition of more other villages (Ghandruk, Landruk, Lamagaun and Dana) and a quickly rising user base of income, revenue could easily reach $ 400 per month in a few years. Preferably, this will cover not only the cost of the transaction but also network infrastructure costs.

6 ECONOMIC OPPORTUNITIES AND GROWTH CREATED

The project has a considerable impact on the local economic activities. Directly and indirectly, it has great impact on the life of local people. Employment and business opportunities are the major outcome.

6.1 Jobs Created

So far, the project has created many part-time, full-time jobs and volunteer opportunities. However, full-time employment is still not fully disbursed, as communication centres still do not produce enough income to pay a full-time employee. Although communication centre operators do not receive a salary scale, communication centre workers can receive more incentives and most works are still considered desirable since there are few cash payments work available. Other than these job opportunities, the project has created volunteer opportunities and placements for software developers and university students with a computing background. For example, the Research and Development Network (ENRD), an NGO operating in the ICT sector, took students from the Faculty of Information Technology from Kathmandu to the villages for around two weeks to teach basic computer skills to villagers. Students have contributed to develop the first PHP dashboard in Nepal. The ENRD has also organized a training program for the villages. Teachers and students of the Gandaki Pokhara Science and Engineering Faculty are customizing the PHP board, developing software libraries for management and locally made e-commerce software and organisation software for the project. The applied experiences of this project for university students will be very helpful to them [8].

6.2 Business Opportunities Created

While business opportunities in rural Nepal are quite limited, wireless network acts to stimulate businesses in both large and small scale. On a large scale, wireless network project acts as a consumer of Nepal Telecom, Nepal Hydro Power Company, ISP World

Link of Nepal, local computer stores and wireless apparatus producers. As expected, the project is reimbursing $ 200 a month for the telephone bill and $ 180 a month for Nepal's ISP web service provider. It also recompenses an average of about US $ 160 monthly. It also pays about US $ 150 per month in average to the power company. In addition, the project purchased local computer network equipment and accessories from local traders valued at about $ 10,000 during the period of implementation. This quantity does not represent the sums used by 15 villages to purchase computers and computer equipment for their school or communication point. The project has spent $20,000 for the purchase of wireless equipment from world markets. In addition, the survey results that at least some users are using the Internet for commercial purposes. Store owners in the villages are using the phone to order suppliers of building materials in the larger cities as Beni and Pokhara. As a result, these numerous facilities accessible yield indirect business assistances. Several owners in the area of Ghorepani (a tourist town) have begun to learn how to send emails and chat with Yahoo and MSN Messenger. Himanchal Secondary conducted a tourism program in the village in 2012 and brought four groups of tourists in the villages. The wireless network was very useful for organizing the tourism map of the country as it provided the tools for instant communication between towns and travel companies to Pokhara. As mentioned earlier, it is hoped to generate an e-commerce structure on the network that will help village residents to trade local products in the local market which will certainly increase profits for businesses in the near future.

7 PROJECT ANALYSIS, CHALLENGES, AND RECOMMENDATION

7.1 Cost Analysis

To evaluate whether the project has been successful, it is beneficial to consider if the resources used by Nepal Wireless are justified by social benefits and advantages. It is important to consider how the project could use the funds and what reimbursements they would get in that case. Based on the indication offered above, the project has claimed that the funds used by the Project, wireless networks have been well used and have led to a viable community system that will maintain to produce assistances for several years. The Inclusive capitals spent on the project were less than $ 50,000, much less than many parallel programs of similar type. The project has stretched to a point where the minimum user charges have minimal functioning costs. As the network grows and incomes increase, it will also cover the cost of building infrastructure. In carrying out this analysis, it is important to keep in mind that the network application is still new and the coverage is continuously growing. Therefore, an analysis of the rate of return now would be premature and would not indicate the total socio-economic benefits of the project.

7.2 Challenges and Problems

Technically it was very difficult to work at high altitude.Many equipment did not support and frequent broke down of equipments with unknown reason was common. Frequent lighting was very common and to install reliable earthing was tricky job.

Radio telemetry

• Reliability of the radio has been a problem. Several radios broke for unknown reasons even though reasonable precautions had been taken.

• Point-to-point connections require more equipment and energy. Techinican want to increase point to multipoint which requires Aerials with wider aperture angle, but differences in altitude make it difficult task.

• Reliability of the relay station (Pokhara - RS1 - RS2) should be increased as much as possible.

• It is also necessary to have reliable earthing for lightning arrestors [6].

IP management

• should use the subnet to ensure that bandwidth is used efficiently.

• some type of dynamic addressing should be entered for the network computers. DDNS could also be used for dynamic addressing.

• Bandwidth analysis and control is required which will help to identify problematic links and bottlenecks.

• Maximum bandwidth is desirable, even in long-term bonds. 5.2 GHz.

• Routing local traffic and e-mail messages from the Internet helps to store Bandwidth

• a high-quality videoconferencing solution is required to remote tele-service which has been in limited success T.E [10]

Power Management

• Some radio should be used at each relay station. The use of a computer board (SBC) with multiple wireless interfaces 5.2 GHz antenna equipment is preferred to improve efficiency.

• Monitoring of voltage levels, and possibly on / off programming On Ethernet is desirable. Various microcontrollers and integrated HTTP Servers provide this functionality.

7.3 Success of the Project

Nepal's wireless network project was one of the first basic moves to use ICTs in rural areas of developing countries. In the context of unfavourable political circumstances, including the king's autocratic regime and the Maoist revolution, the project has been quite radical and has received the interest of the entire world. The following are the key achievements of the project:

• Expanded approach to the means of information and universal communication to Internet in an area where there was no proper infrastructure.

• succeesed in of implementing new technologies such as telemedicine and distance education.

• created of ICT commercial advantages in the rural area.

• made an effort to familiarise the technologies to their local context

•sustained the atmosphere of an organization led by volunteers

•advanced the project step by step for revenue. [12]

7.4 Legal and political challenges

Political volatility was a major difficulty to the Nepal Wireless Network Project. First, the king's oppressive regulation caused a situation in which the import and use of wireless network equipment was to the limited level, although there have been cases in which this technology has been used against the Government. Second, the war in rural Nepal has made work tough. The project had to be executed as it was always facing shutting down threats and villagers were frequently unenthusiastic to participate due to worries of violent behaviour by government soldiers and Maoists. Preventive trade laws for importing and using wireless tools had made purchasing equipment from the outside very difficult and costly to use. In addition, a license fee of $ 200 per year was set for all wireless devices used in the wireless network project. Consequently, the project had smuggled all wireless equipment from the United States, Canada, and Singapore to construct the network from the start. Now, the truth is that trade regulations remain obstructive as earlier, even after the establishment of democracy in Nepal. The project

is now in crucial discussion with the Nepal Internet Service Provider Association to liberalise the import and use of industrial, scientific, and medical services band (2.4000 to 2.4835 GHz and 5.7250 to 5.8250 GHz). The project arranged a one-day session in Kathmandu by inviting the government minister, political leaders, government officials to report on the progress of the project and discuss existing regulations and the legal issues. Based on the interaction of the seminar, the Nepal Government's program has recommended to the Government of Nepal to adopt liberal ICT policies and the use of wireless technology for information technology which is available to the rural population in Nepal. Some of the outcome of the meeting were:

1. License 2.4000 to 2.4835 and 5.7250-5.8250 GHz (ISM band) and license to import and use without having to pay any additional cost.
2. Release of VoIP
3. Responding to liberal ICT policies to reduce the licensing fee has given service providers relief and small corporate holders can also start ISP companies in rural areas and provide the cheapest Internet services.
4. Grant provision to community organizations that are interested in establishing Enterprises that provide Internet Services in the Community (CISP) in all district headquarters in Nepal, use of wireless technology to expand the network to isolated communities in the region. Currently ISP is in 60 of the 75 districts of Nepal.

7.5 **Recommendation and Planning**To make the project more efficient it was recommended to replace many equipments which were not so favourable at high altitude.Here some recommendations and better planning techniques are described.

7.5.1 Demand analysis

People in rural areas want to communicate with both people in the rural and urban areas for many reasons because communication is a vital part of their daily social, political, and economic activities. Because of this, there is a high demand for high speed internet

access. Demand studies are used in developing broadband projects to determine and must take into consideration the following:

(i) The level of demand for different internet services at acceptable prices, so that the rural population can afford it.

(ii) The minimum level of financial costs needed to satisfy the demand.

iii) Collection and analysis of the measurable statistics of the given population of the rural area, the economic position of individuals in the community, geography (terrain), traffic and tariffs.

iv) Collection, compilation, and analysis primary micro economic data of the population of the rural area involved, including companies and institutions, by means of information gathering tools, such as questionnaires and interviews.

v) Use of econometric modelling techniques to determine the demand functions.

iv) Appraising and dissemination of the results, with an evaluation of their relevance to the goals of the institutions that require the demand estimates for the provision of the internet access. [9]

7.5.2 Geographical Survey

A geographical survey selects and determines the precise location of all settlements in a rural community. This can be done using advanced Geographic Information Systems (GIS) techniques. A geographic information system (GIS) is used to combine software, hardware, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information. GIS allows for viewing, interpreting, and visualizing data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS is used to deal with problems by viewing data in a way that is quickly understood and easily shared. GIS technology can be incorporated into any enterprise information system framework. Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a CAD

program, and geo-referencing capabilities. With auto-rectified imagery becoming more accessible, heads-up digitizing is becoming the main avenue through which geographic data is retrieved.

7.5.3 Bandwidth

Bandwidth can be explained as the data rate based on the network connection or the interfaces that connect to the network i.e. it represents the capacity of the network connection. Bandwidth is denoted in terms of bits per second (bps). When estimating bandwidth, it is vital to understand the distinction between theoretical throughput and real-world throughput. Bandwidth is one of the more critical factors in the design and maintenance of a functional network. Unlike a server, which can be configured, bandwidth is one of those elements of network design that is normally utilized efficiently by configuring the network correctly from the beginning. In deploying broadband, estimate the traffic structure and the daily traffic per person in the community. The daily traffic multiplied by the population of the intended rural area and by 365 days makes up the estimated annual demand for the internet services. With this data, the amount of bandwidth required for the deployment can be determined. To determine how much bandwidth will be needed, the process begins with inquiry about what the users will be doing on the network. A network analyser can be used to detect the amount of traffic applications sent across a network. [13]

Another method to determine bandwidth is to manually download a file from an email or from a trusted website. The average bandwidth can be determined by observing the transfer rate and computing the highest and lowest rates. We need to run an automated speed test using a site that pings. This is an easier way to figure out bandwidth as it is entirely automated.

7.5.4 Network Architecture Design

Network architecture refers to the design of the layout of the network, comprising of the hardware, software, connections, communication protocols involved and mode of transmission, which can be wired or wireless. It is vital to know about the network architecture because it displays a framework for the provision of the network's physical components and their configuration, its operational methods, as well as data format used

in operating the network. In designing the architecture used for deployment of WiMAX and Wi-Fi in community, the process should be divided into stages with each stage handling core areas of the design. [10]

7.5.5 Technical lessons learnt

To make the network more efficient,first and second phase of implementation can give some ideas that how the network quality can be improved.Many equipment was unable to function which can be replaced with suitable wireless equipments.

1. Capacity exceeds 802.11b device specifications Manufacturer: Many 802.11b wireless devices are higher than the manufacturer's specifications when applied in remote areas where there is no interference. In pilot, it was found a covered access point with a score of 300 meters on the outside had a range of more than 30 km with locally made antenna with 2 Mbps connection speed.

2. The device is weather sensitive: Some wireless devices are weather sensitive. While the climate of Nepal is quite rough and lightening is very common during the spring season, project lost eight radios due to the weather conditions. Good grounding procedures are needed to reduce the loss.

3. The Wi-Fi device is useful to provide services not only to connect the Internet. People around the world use wireless devices to access the Internet in the priority in their homes. The project has known that technology can be further convenient than people have assumed. The project has shown that technology can be very beneficial for providing telemedicine and tele-learning options. The wireless network can also be operated to deliver telephone services to isolated mountain communities, where services of Telephony companies cannot come up with a much cheaper and easier way to connect the Wi-Fi network in the landlines of the telephone company. Telephone facilities were the key source of revenue to make the project supportable.

4. The long-range network must have a strong backbone: When setting up a network, it reaches more than 15 km, it is essential to have a solid backbone with a reliable and high bandwidth equipment. In case of this project, this apparatus was the BH-20 of Motorola Canopy 5.7 GHz, even though it is much more costly than other product.

5. It takes short training to create a Wi-Fi network: Experience tells us that there is no need to be qualified in IT field or university graduates to install the Wi-Fi wireless network. Many of these members of Nepal and an international team of volunteers have no experience in creating a wireless network when the project started. Today even the members of the community team manage the network. Some of the network workers have secondary education, whereas others only have primary education. An 89-year-old man is serving to support a relay station, although he cannot read English very well. This experience tells us that only building a server need professional help from a qualified person.

6. Wireless network project must provide technical and management training for the local population: The project must use local experts so that the local population can support to retain the technical part of the network. Their participation is crucial to maintain and sustain the project.

7. Addressing and routing should be done with hostnames: The use of a steady directing system from the foundation allows the network to raise fast. The routing system runs the capability to inspect, analyse, redirect traffic, and ensure service quality.

8. Instructions and documents should be retained as follows: The network administrator must configure manually each piece of equipment in a central location. Having a team Inventory would be a good idea. It is important to maintain the backup configuration for all devices and computers. Taking copies of any computer on the network and taking actions of each unsuccessful test is vital. [13]

7.5.6 Management structure

At present this project is run by local community school as a public enterprise. It has organisational structure involving many community stakeholders such as schools, local businesses, and local governments. It is a democratically participated enterprise for sharing of both profit and risk. The elected management committee of the school makes the policy and take decisions of the project as well. In conclusion, this project is part of Himanchal High School's income-generating programs because it is working purely as an ISP.

In the near future, the project plans to start a company with limited liability which also includes the public stakeholders which may be local governments or a private partner.

So, the structure of future management team will be different after that and this will provide the additional services.

In the same way, the project is planning to get funds from local government on yearly basis for networking the other villages also. As many political? leaders has shown their interest to expand the project in their area as well, it will be groundwork to start campaigns for awareness of ICT to ground level.

8 DISCUSSION

During 2000, Nepal was in initial phase of introducing internet service to public. At that time even for the people living in urban areas did not have the easy access to internet, because it was expensive and were less aware of ICT. So, dreaming of providing internet and internet based services in very isolated village at that context was a tough challenge because the local people even had not heard about internet and never seen a computer before. Despite the tough economic, political, and technical circumstances, they succeed in implementing a simple wireless technology.

As already mentioned in the phases of project in detail, the author I has his personal findings about the project. The main strength and challenges of the project are highly dependent on one central team which is led by Mahabir Pun. The dependency on one person can may risk the project in case of development and sustainability. Limited trained person can also be complication for further expansion of the project. So, the project should find and train personnel who can take the responsibility of daily maintenance and installation.

As there were many technical challenges during the implementation, other wireless options and technologies can be more effective. IEEE 802.22 can provide strength for long distance service where signals can transmit more than 50 km. It is more economic as it transmits signal with unused television channels. Utlilising a laser link is another option which help to overcome weather based interference and easy to connect long distance users. Distributed systems can be a good option for the project as it is, for example, a Multichannel Multipoint distributed system as it offers maximum bandwidth with long range.

Network management is very important factor for continuous operation. The distant analysis and reparation of problems is particularly vital to address in long-distance WIFI networks. The link administration software can be good option for operation in rural areas. It can be notified what the conventional signal strength should be for an assumed wireless connection. This can be an indication for the expected application demonstration. It can be easy to speedily account any deviation. Backing obligatory for network management should be on basis of gathering the wireless conformation and system topology information centrally, calculating the strength and sound level in each

connection, spotting any causes of interference in the similar network as well as end-to-end networks.

Based on the project analysis, the project has supported various aspects of life. It is true that project cannot run with ICT infrastructure but even at the initial phase it has focused more on other assets like developing online content and supporting coordination mechanism for business. The project tried to address social capital to influence other various capital assets. Consequently, possibilities are generated to impact natural and economic assets through prompting social capital.

9 CONCLUSION

In recent years, much notice has been paid to the development of ICT in the field of global progress, however, there are insufficient concrete examples of success. This project is one of successful start, and an example for planning future efforts. While Nepal faces a brilliant new political future, this thesis appeal to the government and public society, to establish substantial policies that help grassroots projects to promote information technology at all. It is hoped that vision of developing this project should be from limited liability company to replicate the network also in other parts of Nepal successfully. The lack of infrastructure in rural areas and high installation costs compared with urban areas are the two main obstacles in building a wireless network that meets the needs of rural communities, especially when interfering with other modes of communication. The purpose of Wireless Network Project was to develop a low cost-based Wi-Fi communication system that is easily located in rural areas to share knowledge and participation in society. The portability of the system was determined by experiments and field trials. The extensive expansion of the developed system can play an important role in bridging the gap between remote communities. The use of aerostats results in a total cost of the reduced system. The creation of multiple point-to-point links will surely share the bandwidth available, but most rural areas do not require high speed, so using Wi-Fi with point-to-multipoint tuning is a possible solution. The wireless network can also be used immediately to deal with emergencies such as floods, earthquakes and other natural disasters affected areas where the connection is affected. Having satellite internet in rural areas can provide two choices for networks, whether via cable or wireless networks. Yet, wireless options offer different benefits in the countryside. The rural population is spread, so that the wireless network can save the cable cost, it is also easy to install in difficult wireless situations, installation time can be reduced, but also more reliable than the usual problems.

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