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Synthesis
High Speed Internet connectivity is a vital tool for fast data collection, as well as interactions within a large community. Nepal has been hampered by low data speed connectivity, which ultimately has a serious impact on network performance of the country. There is Internet access, but Nepal lacks high-speed connectivity for research and education networks.

This project aims to bring open access to High-Speed Research & Education Network Connectivity to Nepal. Due to the unavailability of a high-speed dedicated Research and Education (R&E) Network, Nepal Research and Education Network (NREN) has not able to provide a high-speed backbone to the Research and Education Community in the country. NREN’s goal is to connect universities, colleges, government-led research organizations, and libraries to an overarching high-speed network in order to achieve the maximum benefits with minimal resource investment.

Currently, the Nepali Research and Education community, which is comprised of the institutions previously mentioned, operate over a low-speed network with an older infrastructure. NREN has observed network speeds network speed between 64 Kbps – 128 Kbps, which is not hindering advances throughout our institutions. Currently, we do not have access to communications tools such as video conferencing and other technology. This project includes an upgrade to current networks that will enable the Kathmandu area to access the Internet at 10mbps, and 5mbps in other areas.

The main objectives of this project are to connect Nepal to the Asia Pacific Advanced Network (APAN), which will upgrade Nepali bandwidth to at least 10 Mbps. This will subsequently improve network performance and enhance Nepal’s research and development capabilities. The project will also facilitate the connection to the Trans Eurasian Information Network (TEIN) phase 3, more commonly referred to as TEIN3.

As of the publication of the 12-month report, a majority of these objectives have been fulfilled on schedule, according to the project design. The major activities involved in this project are the selection of appropriate colleges to join the Network, human resource development and training, and finally network connectivity across Nepal’s primary Research and Education institutions.

This project did not attempt to solve a technological problem, but we have succeeded in taking an innovative approach to the creation of an advanced Research & Education Network in the country. As far as our short-term objectives are concerned, we have built these high-speed networks. The long-term goals, which involve changing the mind-set of universities and academics, will take longer to implement.

Development Problem
The previous unavailability of a high-speed network dedicated to Research and Education (R&E) in Nepal is the main obstacle to the Nepal Research and Education Network (NREN). We were not able to to provide the necessary high-speed backbone for the R&E community within country. This was due to insufficient bandwidth, outdated network devices, and a lack of a proper networking environment.

NREN aims to connect universities, colleges, and research institutions through this advanced, high-speed R&E Network. Our observations reflect that most of these institutions are only able to access the Internet via minimal (64 Kbps – 128 Kbps) network speeds. These low speeds do not facilitate the use of advanced video conferencing and other recent network technologies. The lack of updated networking devices, i.e., network switches, routers, and a suitable lab environment, have also served to reduce the overall networking performance of these institutions. NREN addressed these resource constraints with this project, promoting a sharing environment, and enhancing local networks for the purposes of advanced research.
Step 1: Selection of colleges

During the first phase, four universities and ten colleges were selected to be a part of the high-speed Network. These educational institutions were selected for their high student enrollments, existing network infrastructure, and administration capabilities. The list of universities and colleges is included later in the outputs section.

Step 2: Human Resources Development

Two technical workshops were arranged to train personnel involved with the implementation and operation of the high-speed Network. One session was conducted before the equipment handover, and the other was held after the Network was in place. The workshops were conducted by NREN and utilized local resources. In October 2009, The Network Startup Resource Center (NSRC) at the University of Oregon contributed to the hosting of a campus network design workshop for further human resource development. In order to continue to build a network of operations personnel, NREN plans to hold regular fortnightly half-day sessions for interaction within the NREN technical community.

Step 3: Provider provisioning and Network building

NREN is currently in detailed negotiations with three providers for the cost laying fiber and providing connectivity. Negotiations will continue until each provider has had enough time to observe the Network usage before making a commitment on recurring pricing, however; a base agreement with each of the three providers to lay fiber to a selected organization at close to cost prices was arranged. The benefit of dealing with three providers has been the opportunity to take advantage of very competitive rates from all three, as well as the ability to choose which provider works best in a given situation.

Step 4: Network Equipment:

NREN has acquired all necessary network equipment for all of the selected sites. We were able to secure many donations from various organizations such as Packet Clearing House (PCH) and NSRC. NREN has also purchased the SMR routers for end sites, as these routers have provided flexibility and modularity to the Network.

Step 5: Documentation:

The last six months of the project has mainly been spent in trying to make the Network sustainable and documenting the process. This is an ongoing process, as we realize that each institution that connects to NREN has different ideas and priorities and thus needs to be dealt with differently. There have been two areas of documentation focus:

- The technical and operations components have been documented as the engineering and operations teams build the Network and extend it. Documentation can be found in the internal wiki, and the operational experience has been presented at SANOG and APRICOT.

- The business and outreach elements of the project has met several hurdles, and we have had to modify our approach in providing services to the member institutions. We are still in the process of testing different approaches, and a summary of the approaches tested so far is provided in the annex.

Step 5: Applications:
This is an ongoing effort to identify and deploy applications on the Network that can utilize the high-speed network.
Fulfillment Of Objectives

According to the Memorandum of Grant Conditions (MGC) between APNIC and NREN, the project has among its general objectives, to establish a dedicated high-speed R&E Network among educational institutions. It has formulated four specific objectives, which must be fulfilled in order to accomplish the general goal. The specific objectives, and related detail are as follows:

1. Upgrade Network bandwidth to at least 10 Mbps among networked institutions
   
   The project has connected 15 colleges through fiber link and provides 2-10 Mbps bandwidth for testing purposes via 3 ISP (World Link Communication, Subisu Cable, and Websurfer Communication). The bandwidth was upgraded to 10 Mbps after TEIN3/APAN connectivity.

2. Establishing connectivity of APAN Network
   
   The project tested the APAN-JP link through a tunnel in July 2009. NREN is preparing necessary steps including administration between APAN, and within few weeks the colleges will be able to use this network. NREN has also been connected to the TEIN3 network through a dedicated link since January 2010.

3. Improve on Annual Pass Rate of education institutions
   
   The project has decided to remove this specific objective, because it is an issue too broad and is related to other factors outside the limits of this project. This objective will be measured within two years after the establishment of the high-speed R&E Network.

4. Enhance research capacity to conduct advance research and development in Nepal
   
   This is a work in progress. After the Network was built, we received various requests for access to specific literature. Access to materials including peer-reviewed journals, special experimental data, and high-speed video conferencing has increased since implementation. NREN has been working to facilitate these requests. Some visible results have been observed in the video conferencing activities for tele-medicine and tele-teaching.

Additionally, the project has included the following two specific objectives:

1. Connect 4 Universities including 12 educational institutions
   
   The Project has established fiber connectivity to Tribhuvan University, Pokhara University, Purbanchal University, and Kathmandu University through the 12 affiliated educational institutions within each university. We have extended the Network beyond the Kathmandu Valley during the past six months. The 12 colleges are as follows:

   - Acme College of Engineering
   - Advance College of Engineering and Management
   - St. Xavier College
   - Khowpa Engineering College
   - Kantipur City College
   - Prime College
   - Kathmandu University Main Campus
   - Tribhuvan University Central Library
   - Advanced College
   - Tribhuwan University Central Library
   - Nepal Medical College
2. Support for Network Infrastructure

NREN, through the High-Speed Backbone project, has distributed HP Procurve Switches, Linux-based SMR Routers, and Cisco Routers to the colleges to meet the objective of upgrading network infrastructure. The Network Startup Resource Center (NSRC) donated the HP Procurve Switches. They were distributed to 10 colleges on 1 May 2009 at the official handover ceremony (See Annex II for Photos). The NREN technical team has installed SMR Routers in the colleges, as well as Cisco routers in various locations as needed. Packet Clearing House (PCH) donated most of the the Access routers. The core routers were also donated by NSRC.

Project design and implementation

The project includes three activities relating to its objectives:

- Selection of Colleges
- Human Resource Development
- Connection of High Speed R&E Network

1. Selection of the Colleges

Out of the many higher learning institutions that applied to be on the Network, eleven colleges, three medical institutions, and one library were selected to be included in the R&E Network. The selection was determined by network infrastructure and student enrollments, as factors that may make the selected institutions more capable of utilizing the resources. Expressions of Interest were received from the colleges, and a MoU for R&E Network members has been prepared and in the process of ratification.

2. Human Resource Development

We held a Network Connectivity Pre-Workshop at Prime College on 25-26 April 2009. Representatives from 23 colleges from four universities participated in the two-day Pre-Workshop. The workshop covered the following topics: Network Planning and Design, CIDR and Routing Basics, Cisco Router Configuration, Static Routing, Dynamic Routing using OSPF, Advanced Routing Tutorial, BGP Basics, DNS setup, and Configuration and Routing Appliances. Two additional events are planned: Refreshment Training on Campus Network Design and a Workshop on R&E Network. These will be held as soon as possible; with the involvement of campus network experts from NSRC. Please refer to Annex III, for pictures and Annex I for course content.

3. Connection of High Speed R&E Network

In July 2009, the NREN local network was connected to the APAN network through a tunnel. The bandwidth for the tunnel was donated by one of the private ISPs – World Link Communications. Members were able to utilize up to 10 Mbps of bandwidth through this special donation. In January 2010, NREN was connected to the TEIN3 network at 45 Mbps. This network was not yet formally accepted, but should be accepted before the end of March.
Problems Faced

1. Lack of knowledge about the benefits of R&E Networks

We encountered a general ignorance in regard to the benefits of high-speed Internet connectivity to a dedicated Research and Education Network among Nepali educational institutions. We have generally tried to address this issue with more high-level discussions and presentations by NREN boards to the appropriate college / university administration.

2. 'Chicken and Egg' Situation with 'Local network buildout vs. International R&E Connectivity'

We realized it would be necessary to both upgrade and extend the local network as well as joining the international R&E network. It would have been too difficult to simply build the local network without any special connection to the international R&E Network, and in the absence of a local network, there was not a significant benefit to being a part of the international network. We solved this problem by tunneling from the local network core to the international R&E Network on a temporary basis. We have since gained access to the international network via the TEIN3 network, which has created a more permanent solution.

3. Technical difficulties in forming interconnected networks

The administration and the technical team have encountered some difficulties during fiber installation and IP renumbering efforts. All of the colleges have IP addresses starting from 192.168, so it has taken nearly two months to replace these new IP addresses. There were also technical problems regarding necessary equipment and the need for each of the colleges to procure such equipment or equipment upgrades. All of these issues were relatively minor.

Of the above challenges, the first problem proved to be the most detrimental. While there are some institutions that appreciate the value of the high-speed network, most are not able to differentiate it from the regular Internet. As the Internet has become more prevalent during the past few years, there are not much resources accessible over the R&E Network fabric but not over the regular Internet. Because of this widely regarded perception, some institutions believe NREN is just another ISP network, whereas some see us as an 'incomplete' feature, as we can't provide access to Internet. While this hurdle has forced us to re-think our strategy of not providing Internet access to members, we continue to try to convince and demonstrate the benefits of the Network to our members and prospective members. We have been studying the efforts in many other countries on how to tackle this mind-set. Video conferencing, special tele-teaching sessions, access to restricted materials on different academic websites, etc., may be useful.

Project outputs and dissemination

NREN has achieved following preliminary outputs based on the activities conducted by the project:

1. Human Resource Development

The Pre-Workshop on Campus Network Connectivity has built confidence in the capabilities, willingness of, and cooperation among participants. The course has provided an avenue for sharing information, and participants were able to discuss their particular concerns in relation to their specific conditions. This session has opened the way for the next necessary steps, which include the acquisition of knowledge related to Network Planning and Design, Routing, DNS Setup and Configuration, BGP, and Routing Appliances will further enhance the collective network information knowledge base.
2. Upgrade of Network Equipment

The devices distributed by the project team has improved the existing network performance and facilitated easy troubleshooting in regard to network irregularities. The HP Procurve Network Switches, currently consisting of 56 ports (with planned upgrades to 80 ports) has given wide access coverage and facilitates management at different locations.

3. Fiber Connectivity

The majority of participating colleges had no prior fiber link, and they previously accessed the Internet via wireless or ADSL connections. The fiber links installed through the project have broadened the Network’s facilities, services, and speeds. The fiber network was commissioned to the private operators and all work involved with this aspect of the project, including survey and installation, was undertaken by these private contractors. The installation of the fiber links was followed by the installation of SMR routers by NREN staff.

4. Bandwidth Upgrade

In the context of Nepal, the bandwidth provided by the project is specifically for the purpose of the Research and Education Network. To enhance the benefits of this project, one of our service providers has donated 10 Mbps of Internet connectivity, through which we have created a tunnel to the international APAN network.

5. International R&E Connectivity

Since the network built with the project is used to deliver the international connectivity provided via the TEIN3 project, all current and prospective members are able to utilize the network.

6. New Model for R&E Networks

One of the main achievements of this project has been to establish a R&E network in a country via public-private partnership. Most of the cases we studied discussed similar networks, built with a government initiative or substantial government investment. In contrast, our Network has been built privately with contributions from the beneficiary members and other donations, special pricing, and other considerations by private sector providers. This entrepreneurial venture may be a good model for development in other countries.

Project Dissemination

To promote the activities and project results, NREN has undertaken the following activities:

1. Mailing list and Wiki

   The project has resulted in the creation of a mailing list containing contact details from 25 institutions, including the pilot colleges and workshop participants. The wiki and mailing list were created to facilitate open discussion as well as a means to disseminate information related to the project and relevant topics.

2. Meetings

   Two formal meetings, as well as some informal meetings have been organized to gauge the response of the major stakeholders. These stakeholders include: University Grant Commission, Department of Education, Tribhuvan University, and Katmandu University, as well as the heads of the participating colleges. These events have created the
opportunity for the dissemination of the information related to project activities. Photos from these events are in Annex III.

3. Focused Outreach

NREN board members and staff members have given presentations to the Tribhuwan University Vice Chancellors office, Kathmandu University Faculties, National Academy of Science and Technology, International Center for Integrated Mountain Development (ICIMOD), Institute of Medicine, and Ministry of Science and Technology among others. These meetings and presentations have focused on the overall benefits of R&E Networks, NREN’s public-private partnership model, and long-term viability of the project.

Capacity Building

The project has included following capacity building activities related to its objectives:

- The Network Connectivity Pre-Workshop was held on 25-26 April 2009, which enhanced personnel skills, as well as institutional capabilities for troubleshooting problems related to networking, devices, and applications.

- Ten HP Procurve Switches, as well as SMR Routers have been donated, marked with a formal Handover Ceremony on 1 May 2009. This equipment has built the institutional capability of the colleges.

- The half-day Orientation workshop, which was held during the Handover Ceremony at Prime College, covered the HP Network Switch and SMR Router installation. This course trained participants in the basic functions of this equipment, and also provided controlling guidelines about the switches and the routers to participants.

- As the subject of institutional capacity building, the project has installed fiber connectivity at the twelve colleges affiliated with four participating universities.

- NREN supported the WirelessU.org workshop, held in Pokhara over two weeks in collaboration with the Nepal Wireless Project. This workshop was targeted mainly towards rural connectivity.

- Advanced video conferencing facilities are now facilitated by NREN to its members via the equipment supplied by the Nepal Wireless Project and on loan from commercial providers. This has enabled the Kathmandu University to conduct regular engineering classes with professors in Delft University in The Netherlands.

- NREN has also prepared a short-term course on online research and investigation for new members.

Project Management

This project was managed by the secretariat of the Nepal Research and Education Network (NREN). Different components of the project were conducted in parallel in order to facilitate the work.

As is to be expected in any large infrastructure project, there were some unavoidable procedural issues that we were able to overcome with adequate correspondence and some schedule adjustments. We did not encounter any major problems in administration, but in some cases there were administrative hurdles and procedural delays. The Government of Nepal requires projects to go through an approvals process before receiving foreign grants. There was a very complicated process in getting a customs waiver for an
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educational donation from NSRC, and some local political problems delayed equipment installation and training.

The Technical management of the project was lead by the Technical director of NREN, with support from the secretariat. This involved negotiation with service providers and the selection of and appropriate provider, and scheduling installation. Apart from minor technical glitches, we did not encounter any problems.

No major change in project management was initiated after the interim report.

Project Sustainability

As the project proposal envisaged, the project should have moved towards sustainability efforts only towards the last quarter of the first 12 months. MoUs have already been signed with members for network connectivity, and they have agreed to pay for the cost of operations after the grant period has ended. This has succeeded to some extent. As the Nepali fiscal year starts in mid-July, we have entered a period during which time some members are not paying for their connections. The service providers have given us leniency.

In the longer term, the project should sustain itself, as the local network built with the ISIF grant is connected directly to the International APAN and TEIN3 network with a high capacity link. But as noted in the problems section, many institutions are weary of having to maintain different links for Internet and for R&E Network connectivity. Depending on the members’ feedback, as well as pursuant to local regulations, in the long term the NREN will possibly have to combine Internet access as one of the services offered.

At present, the effort has been to make the member institutions understand that after the grant period has ended, membership fees are expected to cover the Network operation costs.
ANNEX I: Technical Workshop Course Outline

NREN Activities brief
International R&E Videos
NREN Network Planning and Design Consideration
CIDR and Routing Basics
Lab: Cisco router configuration basics
Lab: Static Routing
Lab: Dynamic Routing using OSPF

Advanced routing tutorial
Lab: BGP Basics
Lab: DNS Setup and Configuration
Lab: Web Server Configuration and Setup

Extra Topics (if time permits)
IPv6
Routing Appliances

Time: 10 AM to 5 PM
Lunch Break: 1:00 PM to 1:30 PM
Tea Breaks: Before Lunch and After Lunch
ANNEX II: Documentation of Approach

[Flowchart diagram]

Process Completed

NREN Membership Flow Chart V1.0
2009-12-10
ANNEX III: Photos

Few Pictures from Training Workshops
Photos taken during Equipment Installation and Fiber Connection