Sida Evaluation 02/17

Sida Supported ICT Projects at Universities and Research Organizations in Sri Lanka

Alan Greenberg
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Department for Research Cooperation

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Sida Evaluation 02/17
Commissioned by Sida, Department for Research Cooperation

Registration No.: 2002-0563
Date of Final Report: September 2002
Printed by Elanders Novum 2002
Art. no. Sida
ISBN 91-586-8719-X
ISSN 1401–0402

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Acknowledgements

The authors wish to express their gratitude to the many people who willingly took the time to meet with us, and to openly share their knowledge, insights and opinions with us.

In particular we must thank Professor Love Ekenberg and Professor V.K. Samaranayake for their efforts in providing us with documentation, background information and insights on the projects.

Finally, we thank Mr. Jayantha Fernando and Mr. Harsha Wijayawardhana for their excellent support during the site visit to Sri Lanka.

Executive Summary

Background and Objectives:

Sida's Department for Research Cooperation, SAREC, provides assistance for strengthening national research capacity in developing countries. The current Sri Lanka research cooperation program covers 13 projects in universities and research institutes. Sida believes that a sound foundation in computers and access to the Internet has become essential for modern higher education and research. Encouraged by the positive results in several small projects, this present larger-scale project began in 1998.

Most universities in Sri Lanka are publicly funded and provide education without charge. In recent years, due to the prolonged civil unrest and other economic constraints, money for universities has been severely limited. Money for seemingly discretionary projects such as network infrastructure has been extremely hard to obtain.

The present project has several inter-related components. The first is Internet connectivity, with two sub-components: the enhancement of Internet connectivity to Sri Lanka and among the state-funded universities, and the enhancement of infrastructure within selected universities. The second major component is the PhD-level training of a number of university staff members. In this document, the entire project and its various components will be called the "Sida project".

A local Project Management Committee was created with representatives from all of the major Sri Lankan institutions involved in the project. Within the general bounds and guidelines of the project terms of reference, they had autonomy over the details of how the money was allocated and over how it was spent.

Internet and Inter-university Connectivity:

The Lanka Educational Academic and Research Network (LEARN) interconnects educational and R & D Institutions across the country. Prior to the Sida project, LEARN interconnected 8 institutions at 64kbps (kilo/thousand bits per second) and had 64 kbps of external Internet connectivity. The intent of the Sida project was to increase the bandwidth to the connected institutions, add several new institutions to the network, and increase external bandwidth.

University Infrastructure Upgrade:

At the time this infrastructure project was initiated, Sida supported research projects at three Sri Lankan universities: Colombo, Peradeniya and Ruhuna plus the National Aquatic Resources Development Authority (NARA). For each of these institutions, the Sida project provided funds for augmenting or installing a state-of-the-art campus network interconnecting all (or most) campus units, for computer science teaching facilities and for network engineering staff.

Doctoral-level training:

Most universities in Sri Lanka have very few (or no) PhD-level staff members in their Computer Science and ICT departments. Moreover, only a subset of these people is actively engaged in research. At no university is there a core critical mass of researchers allowing ongoing research and the local training of doctoral-level students.

Sida supports a program of split or "sandwich" PhD training, where student spends roughly half of his/her time at a university in Sweden, and the other half pursuing their studies and research in their home country. The intent (and result) is that the students do not lose touch with their home situation

(both personally and professionally). Eight Sri Lankan Computer Science students are currently in the process of obtaining their doctorates at Swedish universities.

Project Partners:
The project is led by the Institute of Computer Technology (University of Colombo, Sri Lanka), and by the Department of Computer and Systems Sciences (Stockholm University and the Royal Institute of Technology, Sweden).

Project Description – Infrastructure:

The grants to the 3 universities and NARA were made with the major targets of institutionalizing networking within each organization, and of bolstering the research and teaching capabilities both in computer science and in other fields that use this technology as a tool.

LEARN:
Prior to the start of the Sida project, LEARN interconnected 8 organizations. The Sida project upgraded most links to 2 mega/million bits per second (mbps), added additional lower-speed links, increased external Internet capacity to nearly 3 mbps, upgraded network hardware and added trained network management personnel. NARA, which is not a LEARN member was funded to lease an Internet connection directly from the local telephone company.

Universities of Peradeniya, Ruhuna and Colombo, and NARA:
Prior to the Sida project, the three universities had no unified campus networks. Each had a number of local area networks with (typically) the computer center, Computer Science and Electrical Engineering units connected to the Internet via LEARN. NARA had no network whatsoever. Users not previously connected either used shared dial-up connections or did not use the Internet at all.

Although the details varied among the institutions, the Sida project included the supply of: campus network fibre-optics cabling, building CAT5 cabling, network routers, switches and hubs, network servers, network management hardware/software, modem pools, video conferencing equipment, specialized research computing equipment, PCs for lab and general use, library automation, lightning protection equipment, uninterruptible power supplies, air conditioning and networking staff. In general, all faculties and departments (including administrative units) on the university's main campus were connected.

Project Description – PhD Program:

Four students were selected from the University of Colombo and four students from a total of three other universities. At the end of the process, Colombo will have a critical mass of doctorates. The other universities will have augmented their complement of doctorates, and will be better able to provide high-quality ICT education.

General Comments:

Overall, the project has been well conceived, planned and executed.

Infrastructure Component:
Institutional priorities were considered when specifying the detailed implementations and hard decisions were made in considering the various options. In no case was there evidence of implementations that would be considered "luxurious" or in excess of what a modern university would need.

One of the most important results of this project is that the government agency that funds universities, the universities, and units within universities are now willing to spend their own money, or seek other external funding, to augment the infrastructure provided by the Sida project. This "leveraging" of the Sida funding will ultimately have a significantly larger net effect than the Sida project itself.

The use of technology in the administration of the universities is decades behind that found in western universities. Campus backbone networks will facilitate integration of administrative systems. There is a current Norwegian-funded pilot project for just such a system.

The LEARN infrastructure grant has allowed the renewal and upgrading of all aspects of the network (increased bandwidth, network hardware, technical staff). In particular, the bandwidth into the country and that serving their primary customers was significantly upgraded.

The three universities and NARA now have modern campus networks. They cover all faculties and departments located on their main campuses. The project will allow the spread of technology and the Internet from just technology-focused units to the rest of the university. Video conferencing facilities were added, linked together by the enhanced LEARN bandwidth enabling inter-university teaching.

Several of the universities have satellite campuses housing some faculties. In general, the Sida project did not cover these remote campuses, resulting in a have/have-not situation within some universities.

PhD Program Component:
Seven of the eight students are progressing well. Two students have already obtained their Licentiate (roughly equivalent to a Masters degree in North American universities) and five are expected to complete their Licentiates this year. One student has effectively withdrawn.

The largest single problem area is that when the students are in Sri Lanka, it is quite common for them to become overly involved in activities at their home university. This problem is not unheard of in other disciplines or countries, but is particularly exacerbated with regard to the ICT students in Sri Lanka due to the sever shortage of trained staff in their home departments. Although the potential impact of this is great, most students seem to be managing the multiple demands well.

Evaluation Issues:

The Terms of Reference for this review raised a number of issues to be considered.

Efficiency (cost/output) and Effectiveness (goal achievement):
Each participant chose somewhat difference methodologies and network architectures. Nevertheless, in all cases, the designers were cognizant of the issues of cost and cost-benefit, as well as the particular priorities of their own institutions. Networking equipment was purchased including an extended warranty, ensuring that the equipment would remain in good operating condition (including software upgrades) until such time as local infrastructure and process was in place to take responsibility for such maintenance.

Regarding effectiveness, the project had a number of inter-related goals, a limited budget, and a limited time frame in which to implement. Each of the institutions had to make trade-offs between the competing goals. Their decisions were different, but reasonable given their institutional needs. In all cases, the resultant network is currently operational, and has been met with delight by their users.

Human Resource Development:
The ICT project meets its intended goals regarding increasing Sri Lanka's research infrastructure and ICT research potential, putting in place the networking expertise to ensure that this networking infrastructure will survive and thrive, and to generally augment the ICT capacity of the country.

It is accepted (and demonstrable) that Internet access is a core requirement of modern university-based research. By providing a major quantum jump in network access to all researchers on the four affected campuses, and augmented inter-university and international bandwidth to all LEARN members, the Sida project clearly meets the first aspect of this goal.

The operational status of all parts of the infrastructure project speaks to the issue of putting in place the staff to build and maintain such a network.

The last aspect will take time to verify, but it is clear that the PhD candidates themselves, the networking staff involved in the project, and the students in technical programs who are being exposed to the network and benefiting from it will all contribute to the pool of ICT experts within the country.

Effect of Connectivity:
Over and above the benefits described in the previous section, there are a host of others facilitated by the high speed and ubiquitous network access. Other benefits include:

- Local and remote access to library catalogues and increasing online collections;
- Improved ability to collaborate of research among Sri Lankans and between Sri Lankan and offshore researchers;
- Facilitation of programs such as the split PhD program;
- Ultimately, distance education at all levels will be facilitated as connectivity spreads;
- Relief for a variety of mundane tasks associated with university research and administration.

Computer Literacy and Administrative Functions:
A major effect of the Sida project had been to raise the awareness level of computing and networking in all areas of the university. Without this awareness, many of the other benefits will not come into existence, as this awareness feeds the process by which local resources (staff and money) are made available resulting in a variety of second-order effects. Computers and network access are slowly but increasingly becoming an integral part of university life for many students.

Other than limited library applications, a few payroll applications and word processing, the administrative use of computers in Sri Lankan universities is virtually non-existent. The Sida project is beginning to provide the infrastructure allowing this problem to be resolved. The current NORAD pilot initiative to install student information systems at several universities is a good example. On a mundane but nonetheless important level, at least one university is mandating that virtually all senior administrative communications use e-mail instead of the more traditional paper-based methods. This would have been impossible prior to the Sida project.

Sustainability:
Sustainability has several aspects: equipment lifetime; post-Sida sustainability; routine upgrades and network growth; and income generation:

- The salient question is how long can the newly installed equipment reasonably stay in service. Experience has indicated that the answer is generally up to 10 years, with some upgrade(s) along the way. Optimally, replacement should occur earlier.

- Post-Sida project sustainability revolves around whether the sources within the Sri Lankan university system and government will take responsibility for the costs associated with connectivity (international and local), hardware maintenance and engineering staff. The reviewers have been assured that this issue is being fully addressed.
- The need to fund routine upgrades and network growth is also understood. It is expected that these will be funded from internal sources, plus external sources such as Sida, ADB, JICA will no doubt be approached to support specific growth areas.
- Income generation is likely to come largely as a form of transfers from within the system (such as LEARN charging the universities for services). Other sources are not likely to be a major source of funding.

Impact on the Country:
On a global scale, the single largest impact of the Sida project is that the involved Sri Lanka's universities are now in a position to compete with institutions elsewhere. Having at least a few universities in this "modern" status improves the country's image in academic circles.

Far more important, however, is that the universities aided in this project are now exposing students (and staff) to this "brave new world" of computers and the Internet. Each of these people will carry with them a bit of understanding of what the technology can do.

Next Phases:

As follow-ons to this project, there are a number of opportunities. All should be contingent on locally committed funds to support the ongoing costs of the present project at the end of the Sida funding period.

Internet and Inter-university Connectivity:
There will be continued requirements for increased connectivity amongst LEARN members and to the international Internet. It is reasonable for Sida to continue funding such new upgrades, particularly in aid of universities that were disadvantaged during the last decades of civil unrest.

University Infrastructure Upgrade:
The present project has only addressed a small fraction of the campuses in Sri Lanka. It is recommended the Sida continue the program, with priority support for those campuses housing Sida-funded researchers (other than those addressed by the present project), and those housing ICT and physical-science units which are the ones that are most likely to heavily benefit on the short term. Medical schools should be another priority, presuming they have the interest and intent to integrate the technology into their programs. Lastly, universities in the areas disadvantaged by civil unrest should receive priority.

PhD-level training:
This program will prove invaluable in helping computer science training and research in Sri Lanka, and it is recommended that it continue. Moreover, it is recommended that each group of new split PhD students have a dual composition: half from a single school; half spread out over various schools.

Caveat:
There are some in Sri Lanka who believe that there are too many universities, too many campuses, and too many computer science departments. It is a significant socio-political issue, and will not be addressed by Sida but Sida must gauge the intent of the government in this respect, so that its investments can be made effectively.

Overall Conclusions:

The Sida Project can rightfully be deemed to be successful. Funding has been used effectively, with due regard to the specific needs of each institution, and with the synergistic deployment of the Sida investment with those funded by other sources. Where there is fault to be found, it is largely due to the limited terms of reference of the project (such as limiting the investments to specific campuses). The resultant networks are not on a par with the best networks in the west, but they are of sufficiently high calibre to allow the institutions to compete internationally.

Perhaps the largest long-term benefit is that the project has been instrumental in getting all levels of management (within the institutions and government) and other funding organizations to provide additional one-time and operational funding for research and education networking and computing infrastructure. In the long term, the funds made available through these channels will far exceed the Sida contribution. Such funding would have been significantly reduced (or non-existent) in the absence of the early Sida support. The project has not only provided enhanced research capabilities (to both Sida and all other research groups), but has allowed the spread of ICT within the curriculum of technologies-oriented faculties and to the entire undergraduate/graduate student communities. Moreover, it is allowing ICT to finally penetrate into the administration of universities. Ultimately, it is facilitating the general ICT awareness and literacy of the education community and in turn, the Sri Lankan public.

The split PhD program will add 7–8 new doctoral-level staff members to university ICT programs. At the University of Colombo, the total number of PhDs should allow the computer units to actively pursue research programs as well as begin their own doctoral-level training. At the other beneficiary universities, the new graduates will relieve the severe pressure on their current staffs, and increase both the quantity and quality of computer science undergraduate teaching.

1 Background and Objectives

1.1 Background

One of the fundamental tasks of Sida's Department for Research Cooperation, SAREC, is to provide assistance for strengthening national research capacity in developing countries. Swedish support to research cooperation with Sri Lanka dates back to 1976. Over the years, bilateral research cooperation between Sri Lanka and Sweden has gradually shifted from provision of small research grants managed by national organisations like the MARGA Institute and the National Science Foundation (NSF, earlier NARESA) to long-term scientific cooperation and partnership between Sri Lankan and Swedish institutions. The current program for research cooperation covers 13 projects run by Sri Lankan universities and administered by the University Grants Commission (UGC) and NSF. Support efforts target a wide range of sciences: biotechnology, biochemistry, electrical engineering, marine ecology, regional development/poverty alleviation, university staff development, library development, ICT as well as UGC and NSF infrastructure.

Sida believes that a sound foundation in computers and access to the Internet has become essential for modern higher education and research. Sri Lanka is the first country where Sida began supporting ICT projects in a substantial way. It started with the commissioning of a Local Area Network (LAN) at NSF in 1996 with a prime objective of making scientific information on CD-ROMs available online to the scientific community of Sri Lanka. Encouraged by the positive results of this project, a new chapter in Swedish assistance for the development of science and technology began in 1998 with the commencement of the present project.

1.2 Institutional Context

Most universities in Sri Lanka are publicly funded and provide education without charge[1]. There are currently 13 such universities. All government funding for these universities is managed by and funnelled through the University Grants Commission (UGC). For all intents and purposes, the various universities compete with one another for funds, although this is done in a collegial, participatory manner.

In recent years, due to the prolonged civil unrest and other economic constraints, money for universities has been severely limited. Moreover, even when nominal allocations have been made, they have not always materialized in reality.

Although the government continues to provide constrained funding for research through the NSF (among other agencies), money for seemingly discretionary projects such as network infrastructure has been extremely hard to obtain.

National Aquatic Resources and Development Agency (NARA) is a research organization supporting the Ministry of Fisheries and Aquatic Resources. It is the principal National Institute charged with carrying out or coordinating research, development and management of areas related to aquatic resources. It is funded through various government sources and from foreign grants. It is neither part of LEARN, nor funded through the UGC.

[1] The exceptions are generally private universities that are affiliated with (or arms of) offshore, foreign universities. They charge tuition to cover their costs, and issue degrees under the name of the foreign university. The one exception is the new Sri Lanka Institute of Information Technology (SLIIT). SLIIT operates under the auspices of the government and its infrastructure was largely government funded. It charges fees to (presumably) recover its operating costs, and is authorized to issue degrees. It also has arrangements with foreign universities to issue degrees under their name(s).

1.3 Project Overview

The project has two related components. The first is Internet Connectivity, with two sub-components: the enhancement of Internet connectivity to Sri Lanka and among the state-funded universities, and the enhancement of infrastructure within selected universities. The second major component is the PhD-level training of a number of university staff members.

In this document, the entire project and its various components will be called the "Sida project".

1.3.1 Internet and Inter-university Connectivity

The Lanka Educational Academic and Research Network (LEARN) interconnects Educational and R & D Institutions across the country. LEARN was formed in 1990, and began providing full-scale Internet connectivity in 1995. It interconnects and provides external Internet access to those university and institutes funded through the UGC.

Prior to the Sida project, LEARN interconnected 8 institutions at 64 kbps (kilo/thousand bits per second) and had 64 kbps of external Internet connectivity. The intent of the Sida project was to increase the bandwidth to the connected institutions, add several new institutions to the network, and increase external bandwidth. As part of this overall infrastructure grant, the project provided core networking and infrastructure equipment at LEARN plus funding for network support staff.

1.3.2 University Infrastructure Upgrade

At the time this infrastructure project was initiated, Sida supported research projects at three Sri Lankan universities: Colombo, Peradeniya and Ruhuna[2]. For each of these universities, the Sida project provided funds for:

- augmenting or installing a (near) state-of-the-art campus network interconnecting most or all campus units;
- computer science teaching facilities;
- network engineering staff.

As part of the campus network infrastructure, video conferencing facilities were included which (coupled with the increase inter-university bandwidth) will facilitate multi-institution teaching and research.

Sida also has historically funded research at the NARA. Accordingly, NARA was also provided with funds to invest in ICT technologies, thus augmenting their research capabilities.

1.3.3 PhD-level training

Most universities in Sri Lanka have very few (or no) PhD-level staff members in their Computer Science and ICT departments. Moreover, only a subset of these people are actively engaged in research. At no university, perhaps except Colombo, is there a core critical mass of researchers allowing ongoing research and the local training of graduate-level students.

Sida has generally found that if a developing country PhD candidate is sent to graduate school offshore and remains there for the entire time of study, there is a high probability that the student will not return home after graduation. Moreover, at times the subject matter of the graduate work ill-prepares the student for research at home. The split or "sandwich" PhD program has been developed to address these problems. Under this program, a student spends roughly half of his/her time at a university in

[2] Since that time, Sida support of research has been expanded to include research units at three additional universities, for a total of six.

Sweden, and the other half pursuing their studies and research their home country. The intent is that the students not lose touch with their home situation (both personally and professionally). Depending on the country, there may be some formal requirement that the student return home after graduation. Regardless of such a requirement, Sida has found that a large proportion of the graduates who participate in this "sandwich" program do return home and begin to form core research units.

The Sida project has identified 8 Sri Lankan Computer Science students who are currently in the process of obtaining their doctorates at four Swedish universities. Four of the students are from the University of Colombo, two from the University of Ruhuna, one from the University of Peradeniya and one from the University of Moratuwa.

1.3.4 Swedish Partners

Several Swedish universities play a critical part in the entire project. The Swedish-based aspects of the project are led by the Department of Computer and Systems Sciences (DSV), a unit of the IT University, located in Kista, Sweden, just outside of Stockholm. The IT University is a joint venture between Stockholm University (SU) and the Royal Institute of Technology (KTH). DSV is responsible the coordination of all aspects of the Sida project in Sweden.

The 8 PhD students are hosted by DSV (3) and departments at Chalmers Institute of Technology (2), Uppsala University (originally Mid Sweden University) (2), and Halmstad University (1).

In addition to their obvious involvement in the PhD program, DSV staff also acts as advisors in the infrastructure program.

1.4 Evaluation Objectives

The purpose of this evaluation is three-fold:

- Document the concepts of the project and trace their evolution over the period of the project;
- Evaluate the efficiency, effectiveness and benefits of the projects;
- Analyse options for follow-on projects in Sri Lanka as well as similar projects elsewhere.

1.5 Review Project Team and Methodology

The review team consisted of two experts from Canada and the United States. Between them, they have nearly 80 years experience with computing and communications technologies, over 50 years experience with university research and technology environments, and over 30 years experience working with developing countries.

The methodology was to review all documentation provided prior to and during the site visits, and to discuss the project with all of the principle people involved in the project, as well as a cross-section of researchers, administrators and graduate students. Site visits were conducted to the Universities of Peradeniya, Ruhuna Colombo and Moratuwa, and NARA in Sri Lanka, and DSV in Sweden.

2 Macro Project Description – Infrastructure

The infrastructure grants to the 3 universities and NARA were made with the same general intent of institutionalizing networking within each organization, and of bolstering the research and teaching capabilities both in computer science and in other fields that use this technology as a tool.

Although there is much discussion about "level playing fields", it was refreshing to hear that the despite the consistent intent across the institutions, each was given the ability to decide exactly what they most needed. This was important, since the overall funding was limited and compromises had to be made at every level. The relative freedom given each institution seems to have allowed judicious decisions to be made. It is interesting, that the different universities chose slightly different approaches to wiring their campuses, with some using the more modern switch technology all the way to the desktop, and some using switches to just feed each department, relying on the older hub technology to connect to the desktop. In both cases there is a bandwidth compromise, and in both cases, the upgrade path will require some throwaway equipment. In the view of the reviewers, both approaches were viable.

The level of awareness and knowledge of the staff involved in planning this project is nearly on a par with their counterparts at leading western universities. Due to obvious needs to control budgets, the resultant networks are not quite at the level of their counterpart universities in the west, but they are close. It is worth noting that local issues (such as regular power cuts and a serious lightning problem) add complexities and cost to network solutions in Sri Lanka that are not always evident elsewhere.

Although not explicitly stated in the following sections, the Sida project provided for staff training locally and at times, offshore. Technical libraries were augmented. These and other activities helped ensure that the various groups had the knowledge and skills to carry out the projects successfully.

2.1 LEARN

Prior to the start of the Sida project, LEARN interconnected 8 organizations (the Universities of Colombo, Kelaniya, Moratuwa, Peradeniya, Ruhuna and Sri Jayawardenapura, Open University and NSF)[3]. Each university had a 64 kbps link to the LEARN hub router.

The Sida project:

- Upgraded the original eight links to 2 mega/million bits per second (mbps);
- Added 3 additional 128 kbps connections to the University of Colombo Medical Faculty, UGC and the LEARN NOC;
- Increased external Internet capacity to over 2 mbps;
- Upgraded the central routers and switches at the LEARN hub;
- Provided workstations for networking staff;
- Replaced/installed central servers for web, ftp, mail and related services;

[3] The original project documents identifies 9 institutions, but the reviewers have been informed that the Arthur C. Clarke Centre, receiving connectivity via the University of Moratuwa, has never been a full LEARN member. NSF is identified in the original project applications under its former name of NARESA.

- Provided up-to-date network monitoring equipment;
- Provided 3 network engineers to install upgrades and support the network on an on-going basis;
- Provided training for these and other network personnel both at the LEARN operations centre as well as at member organizations.

Three suppliers currently provide the external connectivity. LankaCom provides a 1.5 mbps link, with all traffic leaving Sri Lanka via satellite. Sri Lanka Telecom (SLT) provides 2512 kbps link that use an undersea cable. Another 256 kbps (satellite) link is provided by Suntel (the vendor that provides most of the inter-organization links).

In addition The Eastern University, Batticaloa and South Eastern University Academic Programme Centre have obtained low-speed connections outside this project.

Where possible, LEARN provides caching servers. A caching server will capture information the first time it is requested from offshore. If a second user requests the same information, the copy from the cache will be provided, eliminating the repeated international transit.

The network management hardware and software, coupled with trained network engineers ensures professional, reliable management of the network and performance monitoring to allow judicious bandwidth allocation. LEARN has reserved some (currently 256 kbps) bandwidth for distance learning, video conferencing, accessing on-line publications and research purposes.

2.2 University of Peradeniya

The University of Peradeniya has the largest campus of any university in the country – several kilometres across, and spanning a river. Prior to the Sida project, it had virtually no campus network. There were a number of departmental LANs, but most were not permanently connected together or to the Internet[4].

The Sida project included the supply of:

- Campus network fibre-optics cabling (combination of multi-mode and single-mode fibre)
- Campus network switches and related infrastructure
- Campus network servers
- Building network CAT5 cabling
- Building network switches, hubs and related infrastructure
- Video Conferencing equipment
- Network management hardware/software
- Network test and support equipment
- Dial-up modem pool equipment
- Specialized computing equipment for research/teaching

[4] Computer Science, Electrical Engineering and the Computing Center had LANs connected to the Internet via LEARN.

- UPS equipment
- Lightning protection equipment
- Air conditioning

The resultant campus network is the largest fibre-optic-based campus network in the country, reaching all faculties, and all buildings within the Faculties of Science and Engineering. Peradeniya opted for a fully switched network, with the switches being fed at either 1 gbps (giga/billion bits per second) or 100 mbps, and most workstations connected at 10 mbps. There are approximately 450 network ports currently installed.

The combination of both multi-mode fibre (less expensive to interconnect but more limited in capacity and distance) and single-mode will provide the university with exceptional flexibility over the coming years. In addition to its use for data, the fibre-optic backbone is being used to interconnect the campus Ericsson telephone PBX switches, providing enhanced voice services. The fibre plant has abundant unused capacity allowing for considerable future expansion.

As part of the LEARN upgrade, the main campus is now served with a 2 mbps link (microwave) to the LEARN central hub.

2.3 University of Ruhuna

The University of Ruhuna is comprised of a main campus and satellite campuses for Medicine, Engineering and Agriculture. The Sida project upgrades focussed solely on the central campus. Prior to the project, Ruhuna had minimal network infrastructure. There were a few unconnected departmental LANs. The Mathematics LAN did connect to Computer Science LAN, and that in turn was connected to LEARN. Other departments share a single dial-up line for email, with each department being allocated a time-slot on the single telephone line.

The Sida project included the supply of:

- Campus network fibre-optics cabling
- Campus network switches and related infrastructure
- Campus network servers
- Building network CAT5 cabling
- Building network switches, hubs and related infrastructure
- Computer Science PC teaching lab computers
- Video Conferencing equipment
- Network test and support equipment
- Dial-up modem pool equipment
- Specialized computing equipment for research/teaching
- UPS equipment
- Lightning protection equipment
- Air conditioning

Most departments were provided with three access points (often allocated for the unit head, staff, and student labs). The Computer Science and Fisheries Biology departments have been fully wired (typically 1 port per staff member plus provision for student labs).

The Sida project did not measurably affect the remote Faculty of Medicine or Agriculture campuses. These campuses have no internal network, and external connectivity is purely via several dial-up lines. The Faculty of Engineering remote campus was being constructed in roughly the same time frame as the Sida infrastructure was being planned and implemented. This campus has some internal connectivity between buildings, but their only external connectivity is via dial-up lines.

As part of the LEARN upgrade, the main campus is now served with a 2 mbps link (microwave) to the LEARN central hub.

2.4 University of Colombo

At the time of the project genesis, the University of Colombo had already designed a fibre-based campus network, and were in the process of tendering the fibre infrastructure[5]. Accordingly, the University of Colombo was allocated less money than either Peradeniya or Ruhuna. During the discussions following the original grant, it was decided that the University of Colombo needed somewhat more funds than had been originally requested, and this was made available to them by slightly altering the allocations of the other beneficiaries.

The project included the supply of:

- Campus network fibre-optics cabling
- Campus network switches and related infrastructure
- Campus network servers
- Building network CAT5 cabling
- Building network switches, hubs and related infrastructure
- Network management hardware/software
- Network test and support equipment
- Dial-up modem pool equipment
- Specialized computing equipment for research/teaching
- Selected workstations for senior and network staff
- UPS equipment
- Lightning protection equipment
- Air conditioning

With the addition of the Sida project funding, the University was able to leverage its original investment and complete the campus fibre infrastructure, building outlet wiring and the related infrastruc-

[5] The University of Moratuwa was Sri Lanka's first university to install a fibre backbone network, and Colombo benefited significantly from their experience – typical of the cooperative way in which the universities have worked in the past.

ture. As a result, all departments and units that were in place at the time of the installation were connected with at least 3 access points per unit (often allocated for the unit head, staff, and student labs).

The Faculty of Medicine has been similarly wired (university funded). It was originally scheduled to be connected as a satellite of the main campus, but it was ultimately connected directly to LEARN (via a 128 kbps link), with all inter-campus traffic transiting the LEARN hub. The need for the Faculty of Medicine to access central campus services will likely force this to be addressed in the near future.

At present, only the Department of Computer Science and the Institute of Computer Technology were fully wired with access points for all staff. A recent Asia Development Bank (ADB) Science & Technology (S&T) grant will allow the full wiring of all Science Faculty departments (as of August 2002, tenders were being evaluated).

As part of the LEARN upgrade, the main campus is now served with a 2 mbps link (microwave) to the LEARN central hub.

2.5 National Aquatic Resource Development Authority

Prior to the Sida project, NARA had no network. Moreover, it had no Internet capability other than through a single dialup line situated in the NARA library.

The Sida project included the supply of:

- Campus network fibre-optics cabling
- Campus network switches and related infrastructure
- Campus network servers
- Building network CAT5 cabling
- Building network switches, hubs and related infrastructure
- Specialized computing equipment for research (including 1 GIS station)
- Library automation hardware/software and CD-ROM server
- Video Conferencing equipment
- Workstations for research, administrative and network staff
- Network interface cards for older computers
- UPS equipment
- Air conditioning
- 128 kbps link to the internet via SLT (NARA does not belong to LEARN)

The intent of the project was to provide PC and Internet access to all staff members, enabling the use of modern research technology and communications with colleagues within Sri Lanka and world-wide.

3 Macro Project Description – PhD Program

Under the Sida project, eight staff members from four universities are enrolled in a split PhD program at several Swedish universities.

The traditional Sida/SAREC methodology in such a situation would be to have the students all come from the same university (or perhaps from two universities). This would enable the rapid ramp-up of trained researchers and providing the university with a sufficiently large critical mass to form a viable research group and begin local doctoral training.

In the case of Sri Lanka, it was decided early in the process to select the doctoral students from a larger number of universities. This was done primarily for equity reasons within Sri Lanka. Four students were selected from the University of Colombo (which already had a number of staff members with doctorates), two from Ruhuna, and one each from Moratuwa and Peradeniya.

At the end of the process, Colombo will have a reasonable number of doctorates. Ultimately, Ruhuna will be close, as in addition the two Sida doctoral students, there are two other staff members in programs elsewhere who are planning to return to Ruhuna[6].

Peradeniya and Moratuwa will no doubt benefit from the additional trained staff member, but critical mass will not have been attained at these universities.

Each student is assigned a PhD supervisor in the Swedish university, and a supervisor in Sri Lanka. All Colombo students have an advisor at Colombo, and the Ruhuna students are also supervised by Colombo staff. The students from Moratuwa and Peradeniya have supervisors at their respective universities.

The students spend roughly half of their time in Sweden, and half in Sri Lanka. Since most courses that they take are reading courses and not classroom-based, the divided time is not an issue in this regard. It is generally the intent that the students spend alternating 6-month periods in each country, but the timing details are not rigid.

The program also calls for the Swedish supervisor to travel to Sri Lanka once a year, and the home supervisor to similarly travel to Sweden.

Appendix 1 lists all students along with details of their program dates, research and advisors.

[6] One funded by ADB, and the other on private funds, both studying in Australia.

4 Process

DSV in Sweden, and the Institute of Computer Technology at the University of Colombo were jointly responsible for all aspects of the Sida project. A local Project Management Committee (PMC) was created with representatives from all of the major Sri Lankan institutions involved in the project[7]. Within the general bounds and guidelines of the project terms of reference, the PMC had autonomy over the details of how the money was allocated and over how it was spent.

As part of the initial applications and negotiations, allocations were made to the three universities, NARA and LEARN.

The PMC worked with groups from all of the participating organizations in Sri Lanka, as well as with DSV in Sweden. The methodology ensured that the project goals would be met in a timely manner. Moreover, it ensured that the all partners benefited from the overall large size of the project and the bargaining leverage that it afforded. Annual planning and report documents were produced.

[7] Specifically, representatives from the universities of Colombo, Rehuna and Peradeniya, NARA and LEARN, with Prof. V.K. Samaranayake acting as the project coordinator and leader of the PMC.

5 Comments on the Projects

5.1 General

Overall, the project has been well conceived, planned and executed. It is clear that all of the people involved (in both Sri Lanka and Sweden) believe in what they are doing, and have sufficient skills and experience to play their roles in an effective and efficient manner.

5.2 Infrastructure Component

There was abundant evidence throughout the infrastructure project review that institutional priorities were considered when specifying the detailed implementations. There was no evidence of equipment being purchased simply because money was available, or of any implementations that would be considered "luxurious" or in excess of what a modern university would need. Moreover, there was abundant evidence of hard decisions and compromises being made throughout the projects, because the funding, as generous as it was, was not sufficient to build the robust, future-oriented facilities that would have put these universities at a par with leading western universities[8].

By mutual agreement, LEARN and their members have taken a very conservative position regarding distribution of IP addresses. Specifically, of the overall IP address space allocated to research and education in Sri Lanka, LEARN has chosen to hold back significant addresses for future use and distribute only limited addresses to the current LEARN members. Most members have taken a similar conservative approach within their campuses, and distributed external addresses only where needed. This has resulted in much of the overall university population using addresses that are within a "private address space" and not directly reachable from outside. Although this is counter to how many western universities have operated, it has few real implications on the user population, with the one notable exception that the community is virtually invulnerable to outside hackers trying to penetrate their systems.

It is clear from many reports that one of the most important results of this project is that the UGC, the universities, and areas within universities are now willing to spend their own money, or go after other external funding, to augment the infrastructure provided by the Sida project. This "leveraging" of the Sida funding will ultimately have a larger net effect than the Sida project itself. The types of enhancements that are being driven by the existence of the Sida project are:

- extensions of campus networks to reach departments and buildings not included in the Sida project;
- creation or upgrading of departmental facilities that were not part of the original project;
- purchasing of additional computers and departmental servers;
- increased UGC technology funding;
- formalization of direct UGC funding of LEARN;
- application suites (such as administrative systems and library systems) that only make sense if there is a network infrastructure in place.

[8] It must be noted that although the networks are not a match for the leading western examples of campus networks, they are at a par with typical campus networks in the west. Moreover, the use of computing on Sri Lankan campuses is typically far below that of their western cousins, placing fewer demands on the network.

The use of technology in the administration of the universities is decades behind that found in western universities. Other than a bit of word processing and perhaps a payroll application, there is virtually no computerization. Specifically, there are no student records or human resources technology-based systems in place and all records are maintained manually. On the academic side, most libraries are beginning to use computer-based system for their catalogues, but there is strong resistance from the academic staff. One university that implemented a computer-based catalogue several years ago is still forced to maintain their card catalogues[9].

The Norwegian Agency for Development Cooperation (NORAD) has recently begun a pilot project with three universities (Colombo, Moratuwa and Ruhuna) to install a student administrative system at those universities, and there are plans to use the same system at other UGC universities once the pilot studies are complete. We were told that the file formats and structures will be identical across universities, so that it should be possible to have good cooperation among the universities in the implementation and use of this system. The campus network infrastructure provided by the Sida project is an invaluable boost to this NORAD project. In fact, at Ruhuna, with virtually no prior network infrastructure, its implementation would have been impossible.

5.2.1 LEARN

LEARN upgraded all aspects of their infrastructure under the Sida project. In particular, the bandwidth into the country and that serving their primary customers was significantly upgraded.

The original proposal called for a final international bandwidth of 1.0 mbps. In fact, due to increased local competition, good negotiations and the general lowering of international bandwidth costs, they have acquired more than 2 times that amount.

One measure of the quality of the LEARN investment is how they are rated by their larger customers. In most cases, they are viewed very well. The review team received only one report of dissatisfaction, and that was from the University of Peradeniya (further comments in the following section).

Most universities reported that they were not fully utilizing the 2 mbps links connecting each university with the LEARN hub. The primary cause is that Internet access is not yet widely used within their campuses. The high cost of international bandwidth also acts as an inhibitor requiring universities to constrain usage. It was felt that the current level of connectivity would likely suffice until they developed better-populated campus networks. Once Internet access is commonly used across the campus and particularly for academic purposes (undergraduate, graduate and research), bandwidth upgrades will surely be necessary.

5.2.2 University of Peradeniya

The University of Peradeniya has created the largest fibre-optic based network in the country. Their campus is very widespread (although contiguous) and the network covers the entire campus. The network has a "diameter" of 4 kilometres.

The density of coverage varies depending on the level of technological awareness of the faculty or department. Specifically, those areas that currently had a high density of computers and some existing network/Internet access were given a larger number of connections per department. Those departments with minimal or no previous connectivity and few computers were given far fewer connections and cumulative bandwidth. Given the limited funding available, this makes good sense. Nevertheless, the installed connectivity to the less computer-intensive areas often exceeds the coverage in similarly "low tech" areas in the other universities reviewed.

[9] Many western institutions were faced with a similar situation when they began their computerization of library catalogues and resources.

The decision was taken to use a "switched" environment throughout the campus, instead of a combination of switches and older technology hubs[10]. Hubs are less expensive but could allow all computers to occasionally use speeds up to 100 mbps. Switches are more expensive, and this project's funding limits restricted the speed of the computer connection to 10 mbps. However, switches allow greater management control, much greater security and the implementation of sophisticated networking capabilities (such as VLANs[11]). This decision shows a high level of sophistication coupled with a planned or hoped for availability of funds to upgrade to faster switched once the need is established.

Moreover, Peradeniya opted to use Network Address Translation (NAT) for all campus workstations. This allows all workstations to directly access services outside of the campus[12] and more functionality to the end-user without requiring Network Operations Center intervention. This approach has since been implemented by the University of Colombo as well.

Peradeniya was serendipitously given a favoured status with LEARN, in that the bulk of their international traffic goes though the SLT undersea cable instead of the slower satellite link used by the other universities[13]. This notwithstanding, there have been faculty complaints that overseas performance is slow, and the university is planning to contract for a dedicated link from SLT. The technical people at the university do not expect any marked performance improvement with this new link.

The university is making significant headway in having computers accessible (both physically and logically) to the student and staff population. All Engineering and (soon) all Science students will take basic computer literacy courses. The penetration is lower in the Arts Faculty, but it is understood as a requirement. A new IT centre is being constructed which will be open 24 hours per day, although there is a current funding issue regarding the computers for this centre (but which will presumably be solved).

With the increased availability of networking infrastructure and student labs, the university is gearing up to ensure that all students will actually use these facilities. Currently e-mail is provided for staff and a subset of students, with the rest being encouraged to use public mail facilities such as Hotmail. However, the university is in the process of installing a mail server that will provide direct service to all students.

5.2.3 University of Ruhuna

The Sida project allowed the implementation of a sophisticated backbone network at the University of Ruhuna's main campus. The network spans the entire campus, with terminations in all departments (academic and administrative).

Of the universities that were reviewed, the Ruhuna main campus seems to have gone the furthest to provide some basic level of computing for all students. Ruhuna has no formal intensive Computer

[10] Both a switch and a hub are devices to allow one incoming Internet connection to be connected to a number of local computers. A switch inspects each information packet and sends it to the correct destination. With a hub, all traffic is "seen" by all computers, with (supposedly) only the correct destination retaining and using the data.

[11] VLAN stands for Virtual LAN. Software in a switch allows you to partition a physical network into pieces such that selected machines connected to it "think" they are on a private LAN. This enables you to have (for instance) a library VLAN, where each department could attach a computer to their local part of the network, but the computers could talk to each other as if they were all on a private network located in a single room. VLANs are particularly useful for building very secure networking environments.

[12] Without NAT, a server (web proxy, mail, etc.) must act as an intermediary. With NAT, direct connections outside of the campus are possible (although Peradeniya will still use proxies for performance purposes).

[13] When the overall LEARN bandwidth was allocated between the universities, blocks were given to each university, and Peradeniya happened to end up with the non-satellite link.

Science program[14], but there are courses that can be taken in conjunction with other programs. We were told that despite most of these courses being optional, virtually all students (including Arts) take some level of computer science introductory courses. Those that excel are given the opportunity to take a second and perhaps third course (one per year). The number of students taught in the succeeding courses is at least partly limited by the number of trained instructors. Virtually all students are given access to computer labs, and are encouraged to use e-mail (either university provided or through services such as Hotmail).

It is furthermore interesting to note that each academic department seems to have its own lab. This is a good news/bad news situation. The lack of faculty facilities means that each lab is relatively small, and increases the need for supervisors. However, the departmental facilities (no doubt driven by that fact that many departments occupy separate buildings and it is natural for them to allocate their own space for their students) mean that each department has taken ownership of the problem (unlike the distributed campuses mentioned later in this section). This sense of ownership is important, as it increases the likelihood that each unit will allocate some of its scare resources to support technology.

Expectations regarding access to and use of computers seems to have been raised more broadly and higher here than at other universities. Despite Ruhuna being the only university that is being reviewed that does not have an intensive formal computer science program, it is the university that seems most likely to integrate computers into its culture. The university is blessed with a Vice-Chancellor who insists that his subordinates communicate with him primarily via e-mail, so the computer orientation should hopefully spread among the staff as well as the students.

As noted in section 2.3, the installed network did nothing to support technology at the university's three remote campuses (Medicine, Agriculture and Engineering). This was apparently done based on the desire to focus the support on the campuses housing Sida's supported research units. However, it is unfortunate that some (perhaps token) connectivity could not be provided to serve the report campuses (perhaps 128/256 kbps links). It is even more curious given that some of these campuses do have some minimal internal technology infrastructure, and they are served by Ruhuna's central e-mail facility (via the ancient UUCP protocol). Both the study and practice of engineering in more developed countries depend critically upon a good knowledge and extensive use of computers and computing techniques. The same is true of medical studies and the sharing of medical information for both practice and research[15].

These remote campuses are currently connected only via dial-up lines, although the Faculty of Agriculture will soon be moving to a 128 kbps leased connection.

5.2.4 University of Colombo

Since the University of Colombo was the most advanced university with respect to Computer Science and (planned/funded) campus networking and computing technology, it was allocated the least resources under this project. This amount was later increased based on PMC negotiations. The net result is that Colombo is now roughly on a peer level with the other universities with respect to campus network infrastructure. They are still far more advanced in their ability to teach Computer Science (both from a staff and infrastructure point of view).

[14] Ruhuna does have a Computer Science department and does offer a CS program, but it is equivalent to what would be called a "minor" program in the US.

[15] The genesis of the infrastructure project was the support of the research units already funded by Sida, but the infrastructure project was deemed to cover the rest of the campus as well. Units that fortuitously were co-resident on the same campus as the original Sida research units tended to benefit far more than those which occupied physically remote campuses.

They are less advanced than some regarding the integration of computing into the lives of students in non-technology-oriented programs. Virtually all students in the Management, Commerce and Science faculties have access to computers and take some level of computer courses. Although there is a lab available for Arts students, it is not yet widely used.

Based on their level of connectivity (a 128 kb link) and their integration of computer technology, Colombo's Faculty of Medicine is among the most advanced in the country. However, it still lags well behind its western cousins.

5.2.5 National Aquatic Resource Development Authority

Prior to the Sida project, NARA was at the same level as some of the non-technology departments within universities – they had virtually no technology other than stand-alone computers and one dial-up line. Many of the stand-alone computers were extremely old. Moreover, unlike most universities, they had no engineering or computer science unit to use to bootstrap the rest of the organization. Accordingly, they had much farther to go.

Given this, they have done a remarkably good job. The physical network infrastructure is now excellent. Helped by the relatively small size of NARA, they have spread the technology uniformly throughout the organization. One suspects that the influx of previously absent technology will allow new research techniques and hopefully improved research to flourish.

Like the universities, NARA is suffering from extreme budget pressures. Also like some of the universities, they find the current mode of budget allocation refreshing (they are told how much they will actually get, instead of being given optimistically inflated estimates which are not delivered).

That notwithstanding, they are investing in various technologies (with Sida and other donor support) such as a library information system and GIS capabilities. They seem to understand that the new technology will allow wider access to their information, presumably with payoffs both in research itself and the direct application of their research to address real-life problems.

Although all institutions in Sri Lanka face a problem of attracting and retaining good technical staff, NARA seems to have a particular problem. One person did the design and installation oversight. A senior administrator (presumably as a complement) said that the organization would be in serious trouble if the person left. We only later found out that the network administrator was a Sida split PhD student (biological sciences) who was in fact leaving for six months the following week. Although we were assured that a replacement was being trained, it shows the thin level of coverage that is implicit in supporting complex technology in such a small institution such as NARA.

The new infrastructure is also being used for administrative applications, although admittedly starting with rather mundane ones such as time cards for employees.

5.3 PhD Program Component

5.3.1 General Comments

Overall, the PhD training component is going well. Seven of the eight students are progressing reasonably. Two students have already obtained their Licentiate (roughly equivalent to a Masters degree in North American universities) and five are expected to complete their Licentiates this year. One student (from Peradeniya) has for all purposes disappeared, and has reportedly moved to Australia with her husband. Of the five students still working on their Licentiates, one has been somewhat delayed due to family problems, but the supervisors believe that the program will be completed in a timely manner.

Given that computer science and engineering is Sri Lanka (as in many places) tends to be male dominated, it is worthy of note that three of the eight original students were women.

5.3.2 Focus while in Sri Lanka

The largest single problem is that when the students are in Sri Lanka, it is quite common for them to become overly involved in activities at their home university. This problem is not unheard of in other disciplines or countries, but is particularly exacerbated with regard to the ICT students in Sri Lanka. The cause appears to be quite clear. The schools represented (particularly Ruhuna, Peradeniya and Moratuwa) are so short of staff, that when these students are back in the country, it is natural for them to be at least partly absorbed back into their university's infrastructure.

It is important to note that although their services are gratefully received, in general the university is not demanding them. The students typically feel obliged to help their home departments. This is true even in the case of the students from the University of Ruhuna, where the students are actually living in Colombo during their time in Sri Lanka (as their office space and advisors are at the University of Colombo); they regularly travel back to Ruhuna explicitly to help out. The way it was explained was simple: *"They feel like part of a family, and of course they help."* In general, the desperate shortage of trained staff at the universities (other than perhaps Colombo) makes it difficult not to have these students take up some of the slack when they are in the country[16].

It is difficult to generalize on the impact of this. In some cases, it is clear that the additional home-university work impacts the student's ability to do their doctoral work. In other cases, the students appear to be sufficiently disciplined to ensure that they keep progressing on their doctoral work, presumably carving the university work from personal time (or perhaps sleep).

It is the belief of the reviewers that this interaction with the home university indeed cements the relationship and virtually guarantees that the student will return to their home university at the completion of their doctoral studies. At the same time, such activities can come perilously close to seriously impacting the student's doctoral progress. Local research supervisors AND the students previous employment supervisors must be cautioned to monitor and manage the situation carefully[17].

5.3.3 Contact and Continuity while in Sri Lanka

There were also significant comments in Sweden regarding the lack of network bandwidth between Sweden and Sri Lanka, and the resultant inability to do substantive collaborative work. This was at least in part driven by the belief that the actual international bandwidth was less than 1 mbps. In fact, it is more than twice that amount, with surplus bandwidth available within the country. Moreover, there is additional bandwidth available for specific identified research applications. The perceived poor performance may be related to the type of traffic (perhaps with interactive applications being routed via satellite) or other technical issues, and this should be investigated.

The other group of negative comments centred around the difficulty of "advising" students when they are half a world away, and the lack of local supervisors with appropriate knowledge areas (understanda-

[16] The University of Ruhuna is a case in point. They have just one computing/networking staff member with a doctorate. At the time of this review, he was out of the country for several months on a personal matter, leaving the department with zero doctorate-level specialists (his position was temporarily filled by someone from the Physics Department – a particularly capable person, but without the same background).

[17] The network supervisor at NARA spent some time describing how much effort and long hours he had put into the design and implementation of their new network. It was only by accident that the reviewers discovered that in fact he was a split PhD student (in a non-ICT discipline) and that the previous six months had been his half-year in Sri Lanka. It is not known what if any time he devoted to his PhD studies, but based on the description given by him and his employer, it may not have been much (or perhaps all of this was bravado, and he was indeed diligent with his studies).

ble when these students may be working in fields as yet unexplored in Sri Lanka). It was felt that more effort could be made to find local (Sri Lankan) mini-advisors with knowledge in the student's areas of need (perhaps in mathematics departments or other related fields). These people would not be the primary advisor, but available for help in specific areas.

It was generally felt that these problems could be alleviated if the length of stay in Sri Lanka were less than 6 months. Four months was suggested as a possible alternative. This would clearly require more air trips, but as the supervisors (both Sri Lankan and Swedish) are not using all of their allocated trips, the budget should easily cover this. It was also noted that perhaps this would be less disruptive on the students' personal lives. Overall, all parties seemed to think that this was an idea worthy of careful consideration.

5.3.4 Other Issues

It is worthy of note that there were comments that the local supervisors and other Sri Lankan staff also have benefited from this program, both during their stints in Sweden (for the local supervisors) and during the Swedish visits to Sri Lanka.

6 Evaluation Issues

The following questions were posed in the project Terms of Reference

6.1 Efficiency and Effectiveness

To assess and compare the overall efficiency (cost/output) and effectiveness (degree of goal achievement) of the implementation and running of the ICT project among the five organisations involved (four universities and NARA) as well as to assess the efficiency and effectiveness with which the organisations have attained the three objectives of the project. Furthermore, explain the cause(s) behind the differences in efficiency and effectiveness among them, if any. Make an analysis in retrospect if the ICT project's original design and set-up have been appropriate with respect to the goals set-up and stated in their respective application.

In terms of efficiency, each institution chose somewhat difference methodologies and network architectures. Nevertheless, in all cases, the designers seemed to be cognizant of the issues of cost and cost-benefit, as well as the particular needs and wishes of their own institutions. No blatant or subtle examples were discovered where cost-effectiveness was not a duly considered issue. Virtually all networking equipment was purchased including an extended warranty, ensuring that the equipment would remain in good operating condition (including software upgrades) until such time as the local infrastructure and process was in place to take responsibility for such maintenance.

It should be noted that although the various groups selected somewhat different network design philosophies, they all worked together to select one brand and general type of networking equipment. Thus they met their individual needs while not sacrificing the ability to negotiate a single bulk order.

Effectiveness is a far more complex issue. The project had a number of inter-related goals, a limited budget, and a limited time frame in which to implement. Each of the institutions had to make trade-offs between the competing goals, and to some extent, their decisions were different. Among the competing goals were (not necessarily in any priority order):

- High performance;
- Ubiquitous campus/faculty coverage;
- Long lifetime;
- Extended coverage within departments (1+ port per staff member);
- Compatibility with existing infrastructure;
- Server and related infrastructure;
- Ability to upgrade (with respect to coverage or performance);
- Staff to install, service the network.

Each institution presumably considered this set of criteria (or a subset), and made their decisions and trade-offs. Although the decisions were at times different, there is no evidence that in light of their local priorities, they were taken incorrectly.

Several examples will illustrate:

- Some universities chose to provide three switch ports per user department. This means that any further re-distribution within the department will require additional local expense (but saved project funds). Other universities were more liberal in allocating ports to departments, particularly if a department was along in a building.
- The decision on whether to provide general users with 10 mbps or 100 mbps connections was made differently at some institutions.

Different network management tools were selected at different institutions.

There will also be differences in ultimate effectiveness that are not due to the details of the implementation, but to the general philosophies of the organisations. The simplest area in what to understand this is how fast computing and networking will spread to non-ICT-oriented departments. Ruhuna seems to be addressing this somewhat more aggressively than the other institutions, perhaps giving them an advantage in the ubiquitous spread of ICT. But it is not as a direct result of the Sida project decisions, rather because of independent ones that were made prior to and during the project.

A review of the original application indicated that the project has been true to the original intents. Some details have changed due to changing environment, and this is what one would expect given the project time-frame and the rapidly evolving technology on which the project is based. As previously indicated, the PhD program did opt for taking some students from universities that are not within striking-distance of having a viable research capability, but this was duly considered and agreed to by all parties. The original applications called for using some of the funds for enhancing library holdings (both books and journals). Although some funds were used for books, a decision was taken not to allocate funds for journals. The high cost of journals was deemed to be too high to make this a good investment for this project's funds. The PhD students have good access to journals while in Sweden, and arrangements were made for specific copies to be delivered via e-mail while in Sri Lanka.

6.2 Human Resource Development

To assess the contribution of the ICT project to the overall objectives of SAREC programme in Sri Lanka, i.e. human resource development and strengthening of research capacity and to give some concrete examples, if possible, of the effects of the ICT Project might have had on these overall SAREC objectives.

The ICT project meets its intended goals of:

- putting in place a major quantum increment of networking technology to act as an enabler for all research activities in Sri Lanka, and in particular for the SAREC-funded activities;
- putting in place the networking expertise (through the hiring of network engineers) to help ensure that this networking infrastructure will survive and thrive;
- training additional doctoral students to augment the ICT research capabilities in Sri Lanka, create "experts" in ICT sub-disciplines who can later help the industry as a whole, and to partially address the serious shortage of middle and senior level university ICT instructors.

Regarding the first item, it may be worth looking at the rational for building a large campus network and providing external Internet connectivity that was used by this project's principal reviewer at McGill University in the late 1980s. The rationale was simple. We believed that if we did not put such a capability in place, and do it quickly, our ability to function as a large research university would be severely impacted. It would become increasingly difficult to attract new academic staff, and to retain

existing staff if our capabilities were not on a reasonable par with those at similar organizations elsewhere. Similarly, our ability to ubiquitously spread the use of ICT into virgin areas (such as libraries) where we perceived large paybacks would be impacted without the networking infrastructure and connectivity.

Part of the benefits of the overall Sida project is indeed the direct, perceivable benefits. These are already quite visible and their impact will grow. The other part is the decrease in capabilities (with respect to the world-wide research and teaching environment) if the project had not been entered into.

Concrete examples are difficult to identify, and when found are often not of monumental impact. In many cases, technology acts as a catalyst facilitating activities but not necessarily playing a major role in the process. A trivial example is the head of the Chemistry department at Ruhuna telling us that now they can order chemicals online, a process that is almost like magic compared to the previous lack of current information and bureaucracy that they had to contend with. This alone will not cause a revolution in Chemistry research in Sri Lanka. But it is one less impediment for them in competing with the worldwide research establishment.

In all disciplines, collaboration is easier with rapid, reliable e-mail. Although it is unfortunately unusual, there are even examples of how the new networking capabilities are being used by Sri Lankans at different institutions to collaborate with each other. Across international boundaries, joint papers are now being authored where before the long delay times (due to inadequate international bandwidth and the lack of departmental network connectivity) made the effort too painful to bother with.

In terms of the PhD training component of the project, the long-term results can only be extrapolated at this time, as all of the doctoral training is still ongoing. Nevertheless, in talking to several of the candidates, it is clear that they do intent to return to their institutions in Sri Lanka (indeed, they are apparently contractually bound to do so), The four Colombo staff members will bring the size of their department to a very respectable 13 people with doctorates. Ruhuna currently has just one ICT staff member with a doctorate. Adding two more triples this, and with a prospect of two more being added funded by other sources, the department will begin to approach a viable size (even if one or two ultimately leave).

One cannot ignore the potential impact on the ICT industry as a whole. For instance, one of the current batch of sandwich PhD students is rapidly becoming a computer security expert. This expertise will be needed within the larger ICT community in Sri Lanka, and having access to such a local resource will have unpredictable (but surely positive) benefits for the industry and the country. Of the network experts currently employed by the project, some will migrate to industry. Lastly, there is now a large number of university students in technology programs who are being exposed to these modern networks. The skills that they possess upon graduation will be enhanced by the presence of the Sida project.

6.3 Effect of Connectivity

The effects of connectivity to the Internet on improvement in higher education and research at the above-mentioned universities. Provide specific examples of relationships (cause and effects) between connectivity and improvements in higher education.

Some of the examples requested have been cited in previous sections of this report.

Examples of the benefits of connectivity (both internal and external) include the following areas.

- The ability to have a catalogue of library holdings, maintainable by librarians at networked workstations, accessible from stations within the library, in offices and labs on campus and via the Internet. This will not only make the library collection more accessible to the staff and students, but the knowledge of the holdings will make them accessible to those at other universities, increasing the documents usefulness, and perhaps reducing the need to acquire multiple copies.
- Research collaboration with foreign colleagues will become more common and easier. Although collaboration existed in the pre-Internet world, it has now taken on a new form and certainly a more "virulent" form[18]. Sri Lankan researchers will now be better able to participate.
- The sandwich PhD program surely benefits from the enhanced connectivity in a number of ways (these benefits accrue in all fields of study, not only computer science):
  - PhD students can maintain contact with their home institution and local supervisor while in Sweden;
  - PhD students can maintain contact with their Swedish supervisor while in Sri Lanka;
  - Although the split PhD program predated the global Internet (and its predecessor educational networks), it is surely more effective with it.
  - The Internet at least partially relieves some of the personal pressures on families split apart due to going to universities abroad.
- Students at all levels use the Internet for research projects and course papers, augmenting local library capabilities.
- The enhanced connectivity is beginning to be used for various forms of distance education. With the severe shortage of staff at the more rural universities, the ability to broadcast courses between universities will significantly enhance the quality of education. Although this is just being started within ICT departments, once the technology is more mature, it will surely spread to other disciplines.
- Ultimately, there may be other forms of distance education used, including the importation of courses from offshore institutions.
- Internet connectivity provides relief in all sorts of mundane tasks, the example of purchasing chemical supplies mentioned earlier being just one of them. Another example was the acquisition of critical parts to be used in an undergraduate physics lab (the non-critical parts were all manufactured locally).
- The administration of universities will be transformed as networking and connectivity become ubiquitous.

6.4 Computer Literacy and Administrative Functions

The overall of effect of computerisation on computer literacy and administrative functioning of the universities and provide concrete examples of improvement in administrative management due to computerisation.

[18] Although this is not a technically correct use of the word *virulent*, the intent is to show that the Internet has allowed collaboration to spread widely in many previously unimagined directions.

A major effect of the Sida project had been to raise the awareness level of computing and networking in all areas of the university. Without this awareness, many of the other benefits will not come into existence, as this awareness feeds the process by which local resources (staff and money) are freed up resulting in all sorts of second-order effects.

Specifically, all of the universities reviewed had ongoing projects to build networked computer labs. Although this process would surely have happened without the Sida project, it would have been delayed, and stretched out on a far longer timeframe. Moreover, it would have ultimately produced a less functional set of labs. These labs are now allowing students to use computers for a range of activities that would not have been otherwise possible:

- use of computers for course and lab reports;
- access to library catalogues (both the local university catalogue as well as those elsewhere in Sri Lanka and throughout the world);
- Internet access for recreation and coursework;
- e-mail for recreation and coursework;
- the provision of computer literacy courses with actual hands-on components (previously not always possible!).

With each additional use, whether directly related to schoolwork or not, these students become more familiar and comfortable with the technology.

The literacy goal should be that 100% of university students graduate with a competent ability to use computers and the Internet as tools, and comfort level that allows them to treat this as a normal thing. The Sida project will help make this a reality at the three supported universities. The Sida project is not sufficient to allow this to happen but it is a required prerequisite. For the universities that have not received Sida infrastructure support, the LEARN connection does provide some ability to start introducing students to the Internet, but presumably with far less success given the lack of ubiquitous networking on campus.

Regarding administrative management of the university, it was something of a culture shock for the reviewers to be confronted with the mountains of paper used in the university. With the possible exception of some payroll applications (and a few very limited library applications), computers were in short supply, and networks non-existent. The Sida project is beginning to provide the infrastructure to allow these problems to be resolved. The current NORAD pilot initiative to install student information systems at several universities is a good example. Although it is being done at the forward-looking University of Moratuwa without benefit of direct Sida networking support, it is difficult to imagine this happening at Ruhuna without the Sida infrastructure.

One presumes that finance, human resources and other related administrative functions will ultimately be moved over to computer-based systems. It would appear that there is a fair amount of administrative process uniformity across the different universities, so the widespread deployment of systems may be reasonably feasible.

Similarly, the efforts at Ruhuna and elsewhere to depend far more heavily on e-mail instead of paper presume the ability of every administrator to use e-mail. This would have been impossible to do in such a short period of time without the Sida project.

6.5 Sustainability

Discuss and analyse the issue of sustainability of the investments made in the infrastructure at the mentioned universities in terms of annual reservations of funds for operation (including cost for international connectivity), maintenance and depreciation of equipment acquired in the framework of this project after the external funding has ended. Analysis of the prospects for income generation.

There are several components to this question.

6.5.1 Equipment Lifetime

There are several aspects to defining the lifetime of networking equipment. The details for PC workstations and servers are quite similar.

The "current" lifetime, during which the product is still being manufactured and sold, is extremely short. It is not at all uncommon that by the time the equipment is delivered, installed, tested and in-production use begun, the equipment it technically obsolete. By obsolete, it means that the exact model is no longer in new production, and that it may or may not be possible to buy upgrades for the equipment. This was indeed the case with much of the equipment purchased for the Sida project.

Depreciation lifetime is a measure of how accounting procedures allow you to treat capital costs as current this-year expenses, and of how the market value (the amount for which you could sell the equipment) changes over time. Neither is relevant in this situation. Despite some belief that universities should depreciate capital equipment just as commercial organizations do, it is not currently the case. Similarly, although the market value of equipment depreciates very quickly (somewhat in line with the "current" lifetime above), this is also not important, as the universities have no immediate interest in selling the equipment. Because of this rapid depreciation in market value, there is also little interest in using the equipment as a trade-in for an upgrade[19].

Lastly, there is the question of effective lifetime of this equipment. Experience shows that networking equipment probably has an effective lifetime of about 10 years. By the end of that period, it is significantly behind current equipment, typically unable to meet current performance objectives, and will be maintainable only by cannibalizing other units. PC equipment probably has a somewhat shorter lifetime, and fibre-optic and copper media a somewhat longer lifetime. However, typically 4–8 years into this period, additional needs start becoming important, and viable alternatives (perhaps not found) will need to be sought to augment or if possible replace the infrastructure.

6.5.2 Post-Sida Project Sustainability

The Sida project provides operational funds for an approximately three-year period. After that time, it is understood that local funding sources in Sri Lanka are expected to take over ongoing responsibility. There are several major components to this:

- International connectivity (via LEARN)
- Connectivity within Sri Lanka (via LEARN and direct connections)
- Hardware maintenance
- Engineering staff

[19] Note that it is not uncommon for a supplier to give an inflated trade-in value for upgrading equipment, but this is in fact just a way to mask a higher-than-normal discount and keep customer loyal to the supplier's products.

The issue was addressed to the UGC and to the PMC as well as several individuals. The answers universally were:

- LEARN is being transformed into an Institute. It will be located at the University of Moratuwa (including the administrative function that currently resides at the University of Colombo). LEARN will be funded directly by the UGC (plus presumably some fees from its member universities) and the UGC will provide adequate funds to preserve the level of service experienced under the Sida project.
- It was stated unequivocally that the operating costs, including local and international bandwidth now borne by Sida, will be covered by a combination of these revenue streams (in fact, LEARN's charges to universities predate the end of the Sida agreement, thus freeing up some Sida money that has initially gone to bandwidth providers).
- Networking equipment was purchased with a 5 year extended warranty. The UGC and the universities confirmed that funds will be allocated to cover these costs at the end of the warranty.

The only issue not fully confirmed related to the network engineers employed under the Sida project. Their continued employment needs to be confirmed, and it is also unclear how their current salaries, some of which are above normal university pay scales, will be integrated into the steady-state system.

It is generally understood that any further Sida infrastructure support would likely be contingent of satisfactorily integrating this ongoing support into university, LEARN and NARA base budgets.

6.5.3 Routine Upgrades and Network growth

In networks such as those installed at the three universities, NARA and LEARN, there is a regular need to upgrade. Overall performance, coverage range, number of network nodes and functionality will continue to demand additional resources.

All of the groups that were interviewed seem to understand that well. There is no doubt that, to the extent possible, all will be willing to invest their own discretionary funds in additional network infrastructure. They will also surely be seeking external funding for parts of this growth. Sida, ADB, JICA and others will no doubt be approached over the coming years.

This is fair, as long as the additional funds will be used primarily for growth, and that they are coupled with local investment, to the extent that such local discretionary money exists.

It should be noted that bandwidth costs are expected to decrease over the coming years, and to some extent, bandwidth growth can be funded based on the lower per bit cost. However, experience elsewhere indicates that the demand for growth is very likely to outstrip the shrinkage in costs.

6.5.4 Income Generation

LEARN has opportunities for income generation and is, in fact, exercising them. They are already charging their university members a fee based on their connectivity and usage.

LEARN could also get into the business of providing connectivity to other sectors. Given the active ISP and competitive bandwidth provider marketplace, they should clearly not try to compete directly with those suppliers. However, it could be deemed to be reasonable to provide access to other parts of the public sector and the not-for-profit community. This sort of ancillary activity for a national research network was quite common in the early days of the public Internet. It is less common now that there is are commercial suppliers in this business. Experience in other countries indicates that although this might be a reasonable thing to do, it is not likely to be a major revenue generator. Competition with commercial ISPs is not recommended for LEARN.

The Institute of Computer Technology at the University of Colombo is one of the few pools of high-end computer skills in the country. As such, they have done much contract work for the public and private sector. This has earned them significant money which is used both to augment staff salaries (and aid retention) and to fund other projects within the unit. This is a model that can be used elsewhere, once there is a sufficiently large pool of talent available. It is never likely to be major source of funding, but it can be of significant benefit[20].

Some universities have used their labs and staff to offer courses to the public, to the government, and even to the private sector. They tend to use the facilities in off hours. As this can be viewed as service to the public, and one that earns needed revenue, it would seem to be a good thing. However, in some cases, there has been strong criticism levied at the departments that have done this, particularly by student groups who feel that other groups are using "their" facilities. In a country where student activism is a major factor, this needs to be factored into any decision to generate revenue in this way.

6.6 Impact on the Country

A brief overview and assessment of the results and impact of Sida's support to ICT at Sri Lankan universities on the country. An assessment of the role of universities for the development of ICT in Sri Lanka.

On a global scale, the single largest impact of the Sida project is that it has pulled Sri Lanka's universities into a position where they can compete with institutions elsewhere. Prior to the advent of the Internet and the general use of computers, a university could compete based on their academic staff and physical facilities. In a few short years, the introduction of ubiquitous computers, networking and Internet connectivity added a new major criterion to the evaluation of universities. Prior to the Sida project, despite the early incarnations of LEARN, Sri Lankan universities were at a definite disadvantage. The Sida project has helped all of the connected universities reduce this disadvantage. For Colombo, Ruhuna and Peradeniya, this has been a major reduction. Having at least a few universities in this "modern" status helps the countries image in academic circles.

Far more important, however, is that the universities aided in this project are now exposing students (and staff) to this *"brave new world"* of computers and the Internet. Each of these people will carry with them a bit of understanding of what the technology can do. The impact need not be large in each case. It may be only that word processing can make pretty documents, or that e-mail can be used to talk to a relative overseas. But it is one more person who will go about their lives with that seed of knowledge. Wherever they work after graduation, the exposure that they had to technology in university will likely impact their work and in many cases their employer as well.

Over and above this "literacy" exposure, the universities are also training students in various levels of professional ICT skills. These people are generally employable and employed upon graduation (not always true for other disciplines). As such they are partially satisfying the high demand for ICT professionals in the public and private sector. As ICT is viewed a major economical enabler, the universities are playing an absolutely essential role in helping the economic and ultimately the social development of Sri Lanka.

[20] Schools located away from Colombo may unfortunately find that there is not a large market for such expertise in their region, since most of the government and industry ICT activities currently occur in or near Colombo.

7 Next Phases

Seen from the Sri Lankan perspective, what could be the next phases of the ICT project at Sri Lankan universities with respect to models for funding and the sources of funding?

There is a quietly spoken opinion that there are some several things very broken with the Sri Lankan university system. These beliefs are certainly not universally held, but were heard from a several sources within both the university system and government, and at senior levels of both.

- There are too many universities, and too many campuses. Social and political pressures have encour-aged the creation of at least one university in each province or region. Moreover, dividing the faculties within a single university among distributed campuses not only provides university facilities in more electoral districts, but also keeps the number of students at any one site at a more manageable number (and thus less prone to disruptive activities).
- There are too many computer science departments. It is important that each university have the ability to teach basic computer skills and provide core technical infrastructure. However, by increas-ing the number of departments, each with expectations of becoming focused ICT training centres, it is increasingly difficult to build an adequate critical mass (for teaching and/or research) within each one.
- The access to universities is restricted to the "best and the brightest", but many of those who gradu-ate are not employable because the courses that they have pursued do not lead to jobs, or are in disciplines with limited job openings. Examples of the former group are many Arts graduates, and of the second are Agriculture students (where there are annually perhaps 500 graduates and 100 job openings).

These are not problems that Sida can solve, or even address. But any future programs must take these issues into account. Moreover, it would be good if Sida were aware of what, if any, actions that the government or the UGC may be planning to take in consideration of these issues.

The review team was given assurances on many levels that funding will be forthcoming to replace all of the "operational" money that Sida put into the infrastructure part of the present project. Clearly, if there are to be any follow-on projects, these assurances need to be "locked in". Moreover, methods must be found to permanently fund the staff positions at salaries that will allow the universities to retain at least some of the staff who have been trained while employed by this project (some will inevitably leave for various reasons, but none should leave because the terms of their employment went downhill following the termination of the Sida funding).

7.1 Internet and Inter-university Connectivity

It is presumed that any level of connectivity enabled by the present project will be maintained at its termination.

There are more universities to interconnect and to upgrade, and it is reasonable for Sida to consider funding these under terms similar to those in this project. The bandwidth industry in Sri Lanka is more mature now than it was 4 years ago, and that should help any negotiations in this respect. It is suggested that among other priorities, Sida consider support of those universities that were particularly disadvantaged during the years of civil unrest.

It is not clear at the moment if additional Sida funding is reasonable with respect to International connectivity. With the expected removal of the de facto monopoly on international cable connectivity, bulk Internet connectivity purchase costs are expected to drop even more.

7.2 University Infrastructure Upgrade

It is neither expected nor reasonable that Sida will be requested to provide additional general infrastructure at any of the universities/faculties funded under this program. It is expected that the incremental additions (both in detailed areas served and number of ports) will be funded within the normal university budget process. This does not preclude that any of these universities might request grants for specific targeted areas, particularly in the areas of computing equipment (as opposed to general network infrastructure).

How to handle the campuses of these same universities that were not addressed in this present project is less clear. At one level, it was partially the decision of the university not to include a specific campus (such as agriculture at Ruhuna). On the other hand, if all such campuses and faculties had been covered, there would probably have not been sufficient funds available to provide the reasonably comprehensive level of coverage implemented by all three universities. It is recommended that such proposals be duly considered, but perhaps with at least a nominal contribution coming from the university or UGC.

Universities that have not yet been the recipients of major networking grants should be considered for future grants. Special consideration should be given to those campuses that are likely to have ICT or physical science-intensive programs, as they are the ones that will benefit the most in the short term. Medical schools that have the interest in moving into the technology age in a major way should also be favoured. Should the peace process continue progressing, universities that have been cut off from the rest of Sri Lanka in recent years should also have higher priorities.

All such decisions should be made in light of the issues raised at the beginning of section 7.

7.3 PhD-level training and Research Capacity

The split PhD program is providing 7–8 Sri Lankan university staff members with doctoral-level training. There is no doubt that this will help the involved universities by helping them approach having a critical mass of active researchers, and more immediately, by increasing the pool of staff members capable of teaching advanced courses and organizing computer science programs.

There is a general perception among all those interviewed that this program is most definitely beneficial and should be continued. There is less consensus regarding whether the new groups of PhD students should be grouped together coming from just a few universities, or should be more spread out.

There are two extreme models that could be used. In the first model, future PhD candidates are taken from universities that do not yet have a sufficient critical mass of research-oriented staff members with doctorates. Sufficient numbers will be taken from any university so that on their ultimate return following their graduation, there will be sufficient people to form a core research group and to begin active post-graduate training of other students within (or primarily within) their own institution. This is the model that is the focus of the original Sida/SAREC split PhD program. The assumption is that it is of the utmost importance that capable, sustainable research groups be formed, and that these groups will then start training doctoral students to fill the other needed positions in the country (both active researchers, and those who will primarily focus on undergraduate education in the "non-research" oriented universities and institutes).

The second model is to take students from a wider number of schools, with the implicit understanding that (since the total number of students will be rather limited), no one school will end up with a sufficiently large research group in the near future. In this model, the aim is not to generate research capabilities as such (although some of the ultimate graduates will no doubt allocate some of their time for research), but to provide the trained staff to quickly ramp-up ICT training in a much larger number of schools.

The first scenario will also address this need, but it will take far more years. At best, Colombo can start training PhD's within a year or so, and it will be many years before they ramp up to sizable number of doctoral graduates. Other schools are even further away from this goal. So with this model, it will take much longer for the regional universities to build an ICT staff capable of running anything other than very introductory training programs.

It is the recommendation of this report that Sida continue with the bifurcated model that was used for the first group of ICT split PhD candidates. That is, take a group of students from one university who, on return, will form a research-capable group – one that is sufficiently robust as to not be overwhelmed by administrative and undergraduate teaching responsibilities. In parallel with this, take a similar number of candidates from other schools (probably not more than two per school, and one is acceptable). It is understood that on their return, these people may do some research, but their prime responsibilities will be to build a modern undergraduate teaching department.

This two-pronged model continues to focus some of its resources to building an ICT research capability, and some of building generic ICT infrastructure. It may be that this latter group is funded not under the SAREC program, but under general ICT development support, but that is an internal Sida issue.

Consideration should be given to adjusting the period spent in each country, perhaps lowering it to 4–5 months. Once research topics are established, attempts should be made to identify secondary advisors in Sri Lanka who can help the students in particular topic areas.

For PhD candidates who are successful in obtaining their doctorates and return to Sri Lanka, Sida should consider a program providing post-doctoral research funds including the opportunity to continue collaborative research with their Swedish colleagues. Such funding not only will encourage active research, but will reduce the chances that the returning staff are not entirely dominated by their teaching and administrative responsibilities.

Alternatives for ensuring that Universities with postgraduate and research programs have adequate ongoing access to current journals should be investigated in conjunction with any future projects.

8 Overall Conclusions

Although the PhD program is only partially complete, the reviewers feel confident in declaring the overall project a success.

8.1 Infrastructure

The intent of the infrastructure project was to position LEARN and the affected universities/campuses allowing them use and benefit from modern communications technologies, and this has been accomplished. The project realistically did not try to make these facilities absolute state of the art (as viewed in 2001/2), but rather aimed at a base level allowing the institutions to compete with peers around the world.

In all cases, decisions were made ensuring a good return on the investment. Compromises were made allowing each institution to address its goals and priorities within the general guidelines of the project. There is abundant evidence that the institutions work well together, benefiting from each other's strengths and therefore leveraging the Sida investment.

It is unfortunate that the overall funding and project goals did not allow more universal within each affected university. In the case of the University of Ruhuna in particular, it is unfortunate that there is now a "have/have not" situation between these main campus and the satellite campuses.

It is clear that the Sida project has been instrumental in getting all levels of management (within the institutions, UGC and the government) and other funding organizations to provide additional one time and operational funding for research and education networking and computing infrastructure. In the long term, these funds made available through these channels will far exceed the Sida contribution, but would have been significantly reduced (or non-existent) in the absence of the early Sida support. Moreover, it appears that internal funding sources (existing institution budgets, UGC) have agreed to fund the ongoing costs associated with the facilities constructed under the Sida project.

The project has not only provided enhanced research capabilities (to both Sida and al other research groups), but has allowed the spread of ICT within the curriculum of technologies-oriented faculties and to the undergraduate/graduate student communities. Moreover, it is allowing ICT to finally penetrate into the administration of universities. Ultimately, it is facilitating the general ICT awareness and literacy of the education community and ultimately the Sri Lanka public.

Sida should strongly consider continuing this program, allowing additional expansion (both in scope and bandwidth) of LEARN, and the boot-strap funding of campus networks.

8.2 PhD Program

There is a strong belief that the majority of the eight students enrolled in the split PhD program under the Sida project will complete their studies and return to their home universities.

At the university of Colombo, the addition four staff members with doctorates will boost their research capability and provide additional people to carry the teaching and administrative load (allowing other staff members to devote additional time to research). Moreover, the university will then be better placed to embark on an active (and ultimately aggressive) post-graduate education program.

At the other universities, the repatriation of the newly trained will relieve the short-term pressures caused by their absence and augment the minimal number of doctoral graduates within their institutions. This should allow and encourage the augmentation of focused computer science training as well as core ICT literacy training.

Sida is encouraged to continue the PhD training of Sri Lankan students, with the dual focus of increasing research capacity and of increasing ICT training at the undergraduate level.

Appendix 1: Table of PhD Students

Summary OF PhD Split Programme Students Undergoing Training

Name	Affiliation	Swedish Supervisor (Affiliation)	Local Supervisor (Affiliation)	Research Title	Start of program	Licentiate Granted
M A L Kalyani	University of Ruhuna / Dept. of Computer Science	Prof. Richard Wait (Uppsala)	Dr. D N Ranasinghe (Colombo)	On using Mobile Agent for Load Balancing in High Performance Computing	August 1999	Planned 2002
K M S Liyanage	University of Peradeniya / Dept. of Statistics & Computer Science	Prof. Sven Tafvelin (Chalmers)	Dr. Kithsiri Liyanage (Peradeniya)	Efficient Filtering for Denial of Service Attacks	June 1999	Probably left program
H L Premaratne	University of Colombo / Dept. of Computer Science	Prof. J Bigun / Prof. Bertil Svensson (Halmstad)	Dr. A R Weerasinghe (Colombo)	Recognition of Printed Sinhala Characters towards an OCR System	June 1999	Planned 2002
M K Silva	University of Colombo / Dept. of Computer Science	Dr. Richard Wait (Uppsala)	Dr. A R Weerasinghe (Colombo)	Cache Friendly Algorithms in Scientific Computing	August 1999	Planned 2002
S J Paheerathan	University of Colombo / Inst. of Computer Technology	Prof. Benkt Wangler (Stockholm, Skovde)	Dr Ajith Madurapperuma (Colombo)	Improving Process Management Capabilities of Message Broker EAI Tools with Process Repositories	June 1999	Planned 2002
P P M Jayaweera	University of Ruhuna / Dept. of Computer Science	Prof. Paul Johannesson (Stockholm)	Dr. Gihan Wickramanayake (Colombo)	A Methodology to Generate e-Commerce Systems: A Process Patterns Perspective (P3)	June 1999	Granted April 2002
D E W Vishaka Nanayakkara	University of Moratuwa / Dept. of Computer Science & Eng.	Prof. Sven Tafvelin (Chalmers)	Dr H Y R Perera (up to 31.8.2001) Dr. Gihan Dias (from 01.09.2001) (Moratuwa)	Traffic Management in Bandwidth restricted networks: Measurement, Traffic modeling and Congestion Management	August 1999	Planned 2002
Kasun De Zoysa	University of Colombo / Dept. of Computer Science	Prof. Sead Muftic (Stockholm)	Dr. Nalin Ranasinghe (Colombo)	Multi PASS: Multi-Party Security System	January 1999	Granted December 2000

Appendix 2: List of Interwiev Subjects

Affilation	Interview Subject
Chalmers Institute of Technology	Prof. Sven Tafvelin
CINTEC	Ajit Ekanayake, Director/CEO
DSV, IT University (Stockholm University & Royal Institute of Technology)	Prof. Love Ekenberg Prof. Bengt Wangler Prof. Paul Johannesson Prof. Sead Muftic Dr. Lars Askar Rudolfo Candia Gloria Dixon Svard
Embassy of Sweden	Mrs. Ann Marie Fallenuis, Charge d'Affaires Anders Eriksson, Deputy Head of Mission
Government of Sri Lanka, Department of External Resources	Mr. Faiz Mohideen, Director General
Lanka Education & Research Network (LEARN)	Dr. Gihan V. Dias, Technical Manager Shantha Pernando, Consultant/.Senior Lecturer, Dept. of Computer Science & Engineering Nalak Nanayakkara, Network Engineer Chamara Gunaratne, Systems Engineer Dr. K.G.P. Dharmawardana, Senior Lecturer
NARA	M.A.R. Kularatne, Director General Sumithra Thalakada, Head, Library & Information Division
National Science Foundation	Prof. Ranjan Ramasamy, Chairman
PhD Students	Kasun De Zoysa Prasad M. Jayaweera Munasinghe Kalyani Malik Silva
Sida	Anita Sanstrom Tomas Kjellquist Afzal Sher
University Grants Commission	Prof. B.R.R.N. Mendis, Chairman Prof. L.L. Ratnayake, Vice-Chairman
University of Colombo	Prof. Samaranayake, Director, Institute of Computer Technology Dr. Nalin Ranasinghe, Senior Lecturer Mr. J.P. Sananthilleke, Lecturer Harsha Wijewardhana, Consultant to University and several government ministries Dr. Ajith P. Madurapperuma, Senior Lecturer, Dept. of Computer Science Mr. D.A.S. Atukorale, Information Systems Manager, Sida IT Project Mr. D.A.S Atukorale, Lecturer
University of Halmstad	Prof. Josef Bigun
University of Peradeniya	Dr. Nimal Ratnayake, Senior Lecturer, Dept of Electrical and Electronic Eng.; Head, Dept of Computer Sciences Dr. Vijaya Kumar, Chairman, Dept. of Chemistry Prof. Kapila Goonesekera, Vice-Chancellor
University of Ruhuna	Camillus Jayawardena, Director, Computer Centre Dr. Sunil Kulatunga, Acting Director, Computer Centre Mr. Chandana Wimalaratne, Network Engineer Prof. Ranjiith Seneratne, Vice-Chancellor
University of Uppsala	Prof. Richard Waite

Appendix 3: Acronyms

Acronym	Definition
ADB	Asia Development Bank
gbps	giga/billion bits per second
GIS	Geographic Information System
ICT	Information and Communication Technology
kbps	kilo/thousand bits per second
LEARN	Lanka Educational Academic and Research Network
mbps	mega/million bits per second
NARA	**National Aquatic Resources Development Authority**
NORAD	The Norwegian Agency for Development Cooperation
NSF	National Science Foundation
PMC	Project Management Committee
S&T	Science & Technology
SAREC	Sida, Department for Research Cooperation
SLT	Sri Lanka Telecom
UGC	University Grants Commission

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Department for Research Cooperation

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Department for Natural Resources and the Environment

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Department for Research Cooperation

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