A sustainable model for ICT capacity building in developing countries

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Abstract

System administrators are often asked to apply their professional expertise in unusual situations, or under tight resource constraints. What happens, though, when the "situation" is a foreign country with only basic technical infrastructure, and the task is to build systems which are able to survive and grow in these over-constrained environments?

In this paper we report on our experiences in two very different countries – Cuba and Ethiopia – where we ran a number of ICT projects. In those projects we assisted local universities to upgrade their ICT infrastructure and services. This included skills and process building for local system administrators.

Based on our experiences we formulate a model for sustainable ICT capacity building. We hope this model will be useful for other organizations doing similar projects.

1 Introduction

Universities are one of the many actors in international development programmes across the world. They actively participate in fields such as health care, food security and ecological management to name a few.

Many of these development programmes use Information and Communication Technology (ICT), but there are hardly any ICT-only programmes[1]. ICT is seen and actively promoted, by the Organisation for Economic Cooperation and Development (OECD), as a way to achieve the Millennium Development Goals[2].

In this paper, we report on our experiences in organizing ICT-for-development programmes. One of our objectives is to build sustainable ICT capacity in our partner's institution. This paper highlights some of our activities over the last ten years. We also formulate a model, which we hope may be of assistance to others providing similar aid.

We begin by establishing background and context (Section 2). Currently running programmes in Cuba and Ethiopia are described in the following sections (Section 3, 4). In each of those sections we first sketch the programme and continue with a discussion of the ICT-specific aspects (Section 3.2, 4.2). Section 5 proposes a model, based on our experiences, for other organizations using ICT in their development programmes. In Section 6 we give our conclusions and share our plans for the future (Section 7).

2 Background

Before we can report on our activities it is necessary to have some background information regarding the financing and coordination of our programmes.

The programmes we have been involved in were organized by the Flemish Inter University Council for University Development Cooperation (VLIR-UOS). Since early 1998, VLIR-UOS has been the responsible actor for the Belgian government, on behalf of the Flemish universities, for all university cooperation for development[3]. The Belgian federal government finances VLIR-UOS through the ministry of development cooperation (DGOS). From the received funds, 60% is required

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[1] According to OECD figures (Table 19. Aid by Major Purposes in 2010, http://www.oecd.org/dac/aidstatistics/47452930.xls, accessed 9 August 2012), development aid is largely targeted at *Social and Administrative infrastructure*. There is no specific tracking of development aid of ICT programmes, although Communication is included under the more general infrastructure heading *Transport and Communication*. For European institutions that's 39.7% of Social and Administrative infrastructure aid, compared to 6.4% for Communication aid (Belgium is 28.6% versus 0.7% respectively).

[2] See http://www.oecd.org/development/20611917.pdf, p1 "Introduction" and p2 "How can ICTs be integrated into development programmes?"

[3] Alternatively, the Commission Universitaire pour le Développement (CUD) is the responsible actor on behalf of the universities in the Walloon region of Belgium.

to be spent in the developing world.

The key role of VLIR-UOS is to act as a facilitator for the programmes. That is, the universities propose programmes, that can be executed after approval by VLIR-UOS and DGOS. VLIR-UOS is responsible for the general policy, selection, observation and evaluation of the executed programmes. VLIR-UOS is accountable to the Federal government for the use of the funds.

VLIR-UOS provides the Flemish universities several different frameworks to use for development cooperation programmes. Some programmes are short, lasting only one year and hope to achieve regional impact. Other programmes focus on long-term goals and aim at a country-wide impact. These programmes last ten years, but can be extended up to fifteen years[4].

In terms of duration and available budget, the largest framework available is the *International University Cooperation* (IUC) programme. The main objective of the IUC programme is to:

> Empower the local university as institution to better fulfill its role as development actor in society.
>
> This objective is to be attained through the implementation of a coherent set of interventions, guided by the strategic plan of the partner university, aimed at improving institutional policies and management and the quality of local education, research and societal service delivery.
>
> *Source* `http://iuc.vliruos.be/index.php?language=EN&navid=507&direct_to=Objectives_and_features`

The IUC programmes takes 30% of VLIR-UOS' budget. Currently there are ten active IUC programmes spread over several countries: Cuba, Ecuador, Ethiopia, Kenya, Mozambique, Peru, South Africa, Suriname and Tanzania.

Another framework that can be used for university development cooperation is the *IUC crosscutting*. The key idea is to organize theme-based and programme-wide initiatives, that is, initiatives which "cut across" and benefit multiple areas. For instance, ICT capacity building is one of the main themes. Another crosscutting programme is the *North South South (NSS) Cooperation programme*. The objective of this programme is to improve the process of institutional capacity building through collaboration with other partners running a IUC programme. The VLIR-UOS website `http://iuc.vliruos.be` contains more information about these and other programmes.

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[4]After the tenth year the participation becomes competitively assessed and budgets are more limited.

3 Case study: ICT capacity building in Cuba

In 2003 VLIR-UOS started an IUC programme with the university of Santa Clara, Cuba. The university, Universidad Central Marta Abreu de las Villas[5] (UCLV), is located in the most central region of the country. Santa Clara (see Figure 1) is a typical Cuban town that isn't overrun with many tourists. The burial place of Ernesto Che Guevara, located at the outskirts of the city, attracts its share of tourism but few tourists stay overnight in Santa Clara.

Next, we will first give an overview of the whole IUC programme at UCLV. Following that, we will describe our experiences in the ICT infrastructure part of the programme.

3.1 Programme context

The programme's focus is not limited to ICT infrastructure. There are many different projects:

- ICT infrastructure.
- ICT in education.
- Library development.
- Capacity building for communication in English for academic purposes in international collaboration.
- Institutional development.
- Improving the quality of graduate and postgraduate education and research programmes in plant and animal sciences.
- Strengthening undergraduate and graduate education in pharmaceutical sciences.
- Environmental education and development of clean technologies.
- Strengthening research and postgraduate education in computer sciences.

Development cooperation in Cuba, in the broadest sense, is in some cases very similar to development cooperation in other developing countries. In other cases it is *very* different.

As a first example, historically Cuba has had the highest rates of education and literacy in Latin America, both before and after the revolution. All education, including University education, is free to Cuban citizens[6]. As a consequence we were able to work with very skilled people.

As a second example, the US embargo against Cuba makes normal trade and foreign investments nearly impossible. In other words, forget about easily buying hardware from the US. Even if Miami is only 366 km from

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[5]`http://www.uclv.edu.cu`

[6]The United Nations Statistics Division `http://data.un.org` reports an adult literacy rate of 100% for Cuba, compared to 30% for Ethiopia
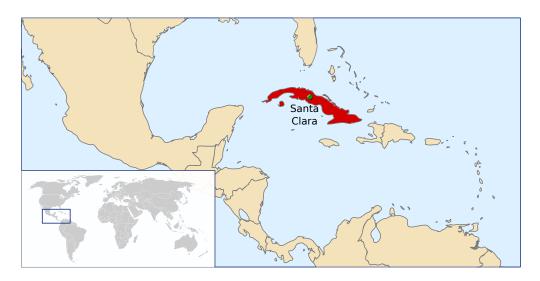

Figure 1: Map of Cuba, with the location of our project in Santa Clara

Havanna, Cuba's capital. The embargo also limits access to information. Downloading software from servers located in the US isn't always possible. For instance, popular code hosting sites like Sourceforge and Google Code have blocked access for Cuban IPs.

As a final example, the government system is based on socialist principles. The largely state-controlled planned economy influences decision making from top to bottom. It leads to situtions where people are willing to do things, but simply can't because the system doesn't allow it.

In this paper we will not further discuss the differences between socialism and capitalism. We have decided to accept the situation and make the best of it.

3.2 The ICT infrastructure project

After ten years of active collaboration with our counterpart in Cuba our programme will close in 2013. This makes it possible to identify the key results of the ICT infrastructure project on a long term basis. The ten year programme is split into two phases: phase one was from 2003 to 2007 and aimed at capacity building; phase two is from 2008 to 2013 and aims consolidation and valorisation. In the following subsections we are going to describe these achievements.

3.2.1 Establishment of a solid network infrastructure and associated services

During the first phase the university backbone was expanded to connect all buildings of the university. The deployed backbone consisted of 7 km of optical fiber. The fiber was connected by the university staff. To make this possible the programme purchased the necessary equip-

ment (fiber verification kit, splicing kit) so future deployments could be handled too. It also gives the staff the possibility to fix fiber cuts.

At the same time the necessary services like e-mail (Exchange, Postfix, Amavis and ClamAV), dial-in[7], VoIP (Asterisk), instant messaging (Jabber), web hosting, file serving (DAS with Samba and Windows file servers), monitoring (Nagios, Munin) were implemented. To use these services each user requires a centralized account.

In each faculty a computer lab was installed. The computers were received through the Close The Gap project[8].

During the second phase, emphasis was placed on improving and optimizing the ICT infrastructure. The storage system was expanded up to 40 TB. Redundant paths were added to the network, and wireless access points were installed. Because of the annual thunderstorms and hurricanes the electrical grounding system was improved and lightning protection was installed.

To comply with governmental policies the migration to Free Software[9] technologies was started[10]. By the end of the programme the Exchange e-mail system will be replaced (Dovecot and RoundCube webmail) and the

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[7]Broadband access is not easily available in Cuba, which makes dial-in modem access the most common way for Internet access from home.

[8]Close the Gap is an international not-for-profit organization that helps bridging the digital divide by offering cost-efficient high-quality used IT-equipment to projects in developing countries. Socio-educational programs such as schools, hospitals and other projects focusing on improvement of educational and information facilities can ask for support from Close the Gap. `http://www.close-the-gap.org`

[9]Here we do not mean free, as in free beer, but as in freedom.

[10]In 2007 the Cuban government decided to move from proprietary to Free Software.

Active Directory server will run together with a Samba4 Directory server.

3.2.2 E-administration system developed

In the first phase the software development team implemented a student administration system in Java. They were able to use Ghent Universities student administration system as a starting point. The Cuban staff made the necessary changes to make the software work according to the Cuban higher education policies. Next to that, they implemented a system to manage university wide ICT accounts.

The implementation of a unified management system for administrative and academic purposes was started during the second phase. Part of the process involved implementing a enterprise messaging service bus (JBoss) that connects the different information systems at the university.

3.2.3 Internet access improved and managed

Cuba was first connected to the Internet in 1996 and currently has about 379 Mbps downstream and 209 Mbps upstream. The Internet bandwidth at the university is 2 Mbps, which is shared by 3300 computers. To compare, a residential user in Belgium has a download speed of 30 Mbps. At the time of writing there is a undersea cable (10 Gbps) between Cuba and Venezuela, but it is not yet in use. It's assumed that the cable will be in use "soon". Which has been rumored for the last two years.

Because of the growing amount of computers that need Internet connectivity our programme focused on increasing the bandwidth availability and usability. This was done through negotiations with the government and through managing the scarcely available bandwidth. A caching proxy was installed and quota on the amount of bandwidth available for each user was enforced. To manage the quota a web application in the Symfony PHP framework was developed.

3.2.4 Establishment of a central data center

During the first phase (year $1-6$) of the programme a small server room was installed. The server room hosted a couple of desktop computers that were functioning as servers. At the start of the second phase (year 7) the construction of a new and dedicated data center room was started. The data center was provisioned with HVAC, a UPS and a generator. The desktop servers were replaced with rack mountable servers. In the next to the last year of the programme (2012) Ghent University donated IT equipment that was recently taken out of service. The container that was shipped by boat contained rack mountable servers, blade chassis' and servers, 42U racks,

in-row coolers and devices for environmental monitoring.

This equipment is now installed in a new data center room at the university. However not all equipment is being used. Currently the campus power grid is under provisioned and not capable of serving three phase electric power in the new data center. Another problem is that the in-row coolers make use of a centralized water based cooling system. Currently we can not afford to purchase the chiller to cool the water. We were aware of these problems when we shipped this material, but our partners insisted[11] on shipping it. They are now looking at ways to get the power grid upgraded. We are at the same time looking for a decommissioned chiller or another alternative.

3.2.5 Human capacity building in software engineering, system and network administration

In order to build the necessary human capacity we organized several training courses in Cuba and Belgium. Every year several Cuban ICT staff visited Ghent University for several weeks. During these visits the staff worked with our guidance on their projects. When the staff returned to Cuba, they organized training for their co-workers so the gathered knowledge was shared.

The importance of these visits can not be underestimated. It gives the Cuban staff the necessary exposure to current and upcoming technologies. By connecting with peers in the field of system and network administration and software engineering they can learn new ways of problem solving. Whilst at the same time we can learn from them too. Another advantage of these exchange visits is that they can use unrestricted and fast Internet access. This makes researching ('googling') far more effective.

Several training courses were also organized in Cuba. For instance, training on data center design and management was held when the university received the donation of servers and data center equipment. We also helped with the design of the network. Training on web-development with the Symfony PHP framework was organized to increase the productivity of the web developers and to move to agile web development. To manage their servers DevOps practices were introduced and a short training course on configuration management with Puppet was given.

It is important to mention that the Cuban ICT staff didn't need much training. They are very skilled and adapt very easily to the new technologies we introduced. During our visits it was sometimes sufficient to give a short introduction on a particular topic, which they

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[11]Which isn't that unreasonable, you never know which funds or opportunities will arise in the future.

would study and implement by our next visit. It is amazing what they can achieve considering the difficult conditions. They are so used to their system that they know how to manage the system for their benefit.

Our experiences in ICT for development aren't limited to Cuba. In the next section we will discuss the programmes we are running in Ethiopia. Similar to this section we are going to start with providing the necessary context of the two programmes before going into the ICT related projects.

4 Case study: ICT capacity building in Ethiopia

VLIR-UOS has two IUC programmes in Ethiopia. The first programme is with Mekelle University[12] (MU) and was started in 2003. In 2007 a second programme was started with Jimma University[13] (JU). In Figure 2 you can see that Mekelle is located in Tigray, the Northern province of the country, while Jimma is located in the Southern part of Ethiopia.

Before we report on the ICT specific part of the programmes we will first give an overview of the other projects in each programme.

In contrast to the programme in Cuba (Section 3.1) these programmes have a more multi-disciplinary approach as can be seen in the next subsection. In the following subsection we report on our experiences.

4.1 Overview of the MU-IUC and JU-IUC programme

The overall objective of the MU-IUC programme is to contribute towards sustainable livelihood in the Tigray region. The projects are:
- Enhancement and optimization of ICT usage.
- Upgrading of the library services.
- Cluster support service.
- Enhanced crop production through improved irrigation water management and water-saving techniques.
- Socio-economic research for sustainable rural livelihoods.
- Ecological integrity and sustainable management of standing waters.
- Land degradation and rehabilitation at the scale of the Geba catchment.
- Appropriate farm technology for vertisol[14] management.

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[12]http://www.mu.edu.et.
[13]http://www.ju.edu.et.
[14]A Vertisol is a soil in which there is a high content of expansive clay that forms deep cracks in drier seasons or years. http://en.wikipedia.org/wiki/Vertisol

In comparison, the JU-IUC focuses on the impact of the Gilgel Gibe hydro-electric dam in terms of human and animal health, ecology and agronomy. Joint research is undertaken in different disciplines in the Gilgel Gibe area to improve the life quality of communities. Furthermore, research and educational capacities of Jimma University academic staff will be extended. The programme has the following projects.
- Zoonotic and animal diseases.
- Child health and nutrition.
- Environmental health and ecology.
- Epidemiology and modeling.
- Soil fertility.
- ICT and library.

In what follows we will report on our experiences of the ICT projects in Mekelle and Jimma. We can do this because there is a high degree of overlap between the needs regarding ICT.

4.2 The ICT infrastructure projects

To appreciate the problems we solved it is necessary to describe the situation in Jimma when the programme started.

The Internet access at JU in 2007 was 4 Mbps. There were a couple of Sun Blade 1000 work stations (512 MB RAM, one UltraSPARC III CPU) running Solaris 8 that were used as proxy server (Squid), DNS server (Bind) and web server (Apache). There were also two Sun Fire v880 machines that weren't even in use! The core network switches were two Cisco Catalyst 6500 devices[15]. What made the situation problematic was that only one person was running the ICT for the whole university. He also didn't really understand how to configure any of the above software.

For example, from time to time 'the Internet broke'. The only solution was to wait for him to fix the problem. He would then fix the problem, till it happened again. Actually, the problem was that there was no log rotation on the Squid log file so it would fill up the partition and make the system stop working. His solution was to delete the log file each time which didn't prevent the problem from happening.

Given the fact that the person in charge was unwilling to share his very limited expertise with junior staff (two bachelors) he was in a very powerful position. He couldn't be replaced, so it seemed, because nobody had the knowledge to keep the system running nor did anybody else have the root passwords. Nobody, except him had the key to the server room.

MU had exactly the same hardware was JU. In fact, all the bigger Ethiopian universities had the same hardware.

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[15]To put this into perspective, Ghent university used in 2007 only a couple of the 3500 series.
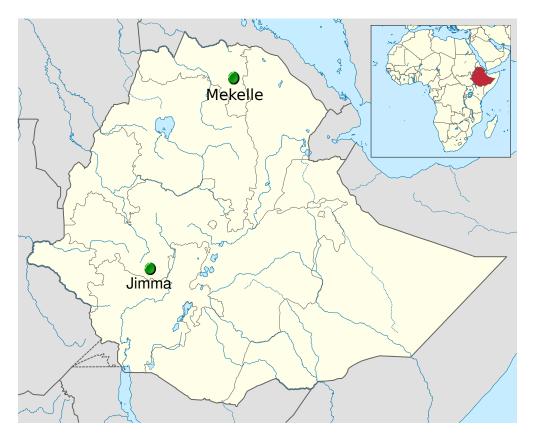
Figure 2: Map of Ethiopia with the location of our programmes in Jimma and Mekelle

This was because the World Bank donated a lot of IT equipment in the beginning of this decade. MUs staff tried very hard to manage their infrastructure, but they also had only one person with some skills.

To summarize the situations; in both universities there was a working small WAN with very limited and unreliable services.

Before we continue with reporting on the ICT projects we remind that the programmes in Ethiopia consist of two phases. Phase one $(2003 - 2007)$ and phase two $(2008 - 2012)$ in Mekelle. Phase one $(2007 - 2011)$ and phase two $(2012 - 2016)$ in Jimma.

4.2.1 Apply bandwidth management and optimization techniques

During the first phase of the JU-IUC programme there was a lot of attention for bandwidth management and optimization. The key objective was to provide reliable and as quick as possible Internet access.

To achieve this the following actions were taken. During the first three years all the Sun hardware was replaced with rack mountable servers running Debian GNU/Linux. This meant that the junior staff needed

to be trained in basic system administration: handling servers, installing Debian, setting up software by following HOWTOs, reading manual pages, using mailing lists and forums, ...During several training sessions in Belgium and Ethiopia the staff was trained in DNS, Squid, Apache, Dansguardian, MRTG, Collectd and Icinga.

At the end of the first phase the JU ICT staff had successfully implemented their own authoritative DNS server[16]. The setup makes use of internal and external zones and uses a couple of slave DNS servers. The staff also implemented a caching Squid proxy server that applies the following bandwidth management and optimization techniques:

- Time based ACLs. E.g. Facebook and Youtube aren't allowed during office hours.
- Limit the bandwidth usage per IP with Squid delay pools.
- Use Dansguardian with ClamAV to do content filtering and anti virus checking for the Windows

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[16]At the time, only Addis Abeba university was the only other Ethiopian university with their own authoritative DNS server. Ethiopian telecom is very reluctant to hand over control. Getting permission from them was more challenging than setting up the DNS itself.

computer labs

To save bandwidth when installing software local mirrors for Debian and Ubuntu were set up.

4.2.2 University e-mail system created

During the first phase of the JU-IUC programme a local e-mail system was set up. As there wasn't any real server hardware available, a desktop PC was installed with Debian GNU/Linux, Postfix, Amavis, Courier IMAP and Sqwebmail. The next year a rack mountable server was installed and the data was migrated to the new system. Over the last five years the number of mailboxes grew from 249 to 2343.

The successful implementation of the local e-mail system prove to be very important for the whole IUC programme. Next to saving bandwidth it made communication between the staff easier. Users enjoyed using the local webmail system, as they were previously waiting many minutes for GMail or Yahoo mail to load. Using the local e-mail system also meant that when Internet access was down people could still send e-mail to each other locally. When Internet access returned, e-mail from abroad would gradually be delivered into their inbox.

Very important for the adoption of the system was that everybody in the JU-IUC programme was "forced" into using the university e-mail system. The coordinators from Belgium and Ethiopia said they would only reply to e-mail messages if sent from the university e-mail system. Having a critical mass proved to be very important. It ensured that the ICT staff was aware of the importance of the system. In the MU-IUC programme management couldn't be convinced of this, which meant a much slower adoption. Because the staff involved in the JU-IUC programme was so happy with their official e-mail accounts, other staff members soon followed.

At the end of the first phase the staff of JU and MU jointly organized an international training course for other VLIR-UOS partners on the installation and administration of an e-mail server. This training built capacity at the other partners, but more importantly it built additional capacity in their own institutions. Other staff members were given the opportunity to learn from their colleagues, who created an official training program that they could follow. It also required the trainers to fully understand their own system, as they were going teach about it.

4.2.3 Creation of a user management system

When the e-mail system was set up the account creation and management needed to be done on the command line. This was error prone and account creation was slow. Only one person was trusted to create the e-mail accounts. When this person was away from the office no accounts were created.

The HR office and the registrar office couldn't provide an up to date list of the staff or students. This meant that importing user information wasn't possible. This made us create a web interface to manage the e-mail accounts.

To create the web interface, a one month training period was organized in Belgium. Two staff from JU and MU undertook training which focused on developing web applications with the Symfony PHP framework. The objective was to learn how to use the framework, and to create a web application for managing their institutions' user accounts. A pre-built web interface could have been used too, but then the capacity to create web applications would not have been built.

As the primary users, the JU and MU staff knew what was important in the design and how it would be used. They also made sure that the interface was available in English and Amharic, their official language. They designed the application interface to reflect Ethiopian practices. For instance the naming practice is totally different. In Ethiopia children get a given name followed by their father's given name and their grandfather's given name.

From the beginning, the system was designed with the future in mind. Instead of focusing on only e-mail accounts, the database model left room to add other types of accounts such as file server and Internet access accounts, ...The idea was that the system would be expended during the following years.

After this training the developed system was ready to be deployed. It could be expected that when the trainees returned to their institution they would get the system up and running in no time. However, this almost never happens. This was foreseen – at the end of the training I went to Ethiopia to help them deploy the web interface.

It was expected that the system would be expanded over the coming years. Unfortunately, this didn't happen straight away. Of the four participants, two started their masters study, one was given other tasks at the university and the last one no longer wanted to program.

This put us in a awkward situation. A lot of money was spent training the four staff. The training produced a web interface that was useful, but it also had some bugs and could not be maintained. We expected that the trainees would train other staff on the framework and application. Given the situation, this wasn't going to happen soon. We needed to build more capacity on using the PHP Symfony framework.

To achieve this a second training course was necessary. However, for the training to take place the four staff who had completed the first training course needed to extend the web application. This demonstrated they still cared and could take ownership. The second training

course was organized in Ethiopia and participants from other IUC programmes (South Africa, Tanzania, Kenya, Mozambique, Zimbabwe) were also invited. As a result of this second training course, more staff of JU and MU were trained, leading to real ownership of the web application.

After five years, several other web applications were developed and used. At each university there are a now a number of staff who really understand the framework, and are able to maintain and develop applications using agile software development techniques. The biggest challenge that still remains is how to further distribute the knowledge of the framework to the new staff.

4.2.4 Capacity building in Free Software technologies

As a consequence of the previous activities, a lot of capacity was built in the use of Free Software technologies. At programme inception, the ICT staff weren't even aware of what Free Software was available, and how it could be used. The introduction to software that could be freely shared, modified and used was very important for the programme. The time lost looking for cracked software and passwords could now be invested in studying how to actually use the software. Free Software also made it possible to share the software legally with other universities in Ethiopia.

The projects built serious capacity in using and applying Free Software to solve problems. Staff members were confident to use additional software. For instance one staff member set up a VOIP system with Asterisk. Another staff member set up NeDi as an alternative to Cisco Works, to aid in the management of the network. The ICT helpdesk started using the OTRS ticketing system. Currently they are in working on implementing OpenLDAP and Samba4.

5 A sustainable model to build capacity in ICT

The experiences in the above case studies are only some of the stories that can be shared. More important are the things that I learned the last six years when I was member and leader of several ICT projects in Cuba and Ethiopia. Below is a model to do development cooperation in ICT. Development organizations or volunteers willing to implement ICTs can use the model when developing their programmes.

5.1 Bandwidth is limited, manage it!

When doing projects in developing countries you should be aware of the limited bandwidth. The only sustainable

way to handle this problem is to implement bandwidth management and optimization (BMO) techniques.

Increasing the bandwidth by paying for a faster Internet connection will ease the pain in short term. There will come a day that your partner will have to pay for the bandwidth themselves. If they haven't got the funds they will fall back into their initial situation, that of a slow and unmanaged Internet connection. On the other hand, if they are able to increase the available bandwidth they will use it more cost effectively.

The most common BMO technique is the implementation of a local caching proxy server. The proxy server can then enforce certain policies of who can download what and when. Next to that, the implementation of local services is very important. By offering local services you can save bandwidth and decrease the page loading time. Local DNS, e-mail and websites are the basic Internet services that should be run on the local network.

Unfortunately, what can be cached or offered locally is limited. Social network sites and streaming video sites consume large amounts of bandwidth. Here it is important to define the policies on what is allowed and when. For instance, blocking Youtube and Facebook access during office hours is a fair thing to implement.

Setting up local software mirrors can save bandwidth too. It's very easy to set up a mirror of a GNU/Linux distribution. In situations where the initial sync takes too long or is impossible, bringing a USB hard disk with the mirror on is almost always faster. Another possible solution is to provide a service similar to Youtube on the local network.

Focusing on technical aspects is important, but it should not be the only objective of your project. In the next subsection we describe the importance of building human capacity.

5.2 Capacity building is more important than infrastructure building

It's very easy to go in overdrive and buy a lot of expensive equipment when doing ICT projects. Many times this is done in good faith, but unfortunately this doesn't lead to the best results. In a worst case scenario, the equipment isn't even used. To prevent this, it is crucial to start building human capacity from the beginning. Organizing training that leads to actual implementation will create awareness for the deployed solution. At the same time, this training can be used to identify the most motivated and more expert staff.

In development cooperation it's common to use the *train the trainer* principle. This is a great way of creating capacity, but it's not easy. Many projects succeed in training the trainer, but then fall short of getting the trainers to successfully deliver training. Expecting that

trainers will take the initiative to train others, has only a small success rate. A successful way of overcoming this is to organize the initial training, coupled with followup training *given by the new trainers*. If the trainers know in advance that they will be training others soon after their own training, they will be more motivated. It will also give their own project more visibility and establish them as leaders amongst their peers.

When selecting topics for capacity building it's important to work demand driven. Enforcing certain solutions will not lead to success. It's necessary to identify the problems and to work on fixing them. You create owner ownership of the solution this way. In the end, this is a formula for success.

Training can be delivered locally or abroad; the choice of location depends on a number of factors. Local training, that is, in the countries where aid is being provided, allows you to teach more people. This is primarily due to cost – international airfares are expensive! However you need to be prepared for frequent power cuts, trainees arriving late or not at all, slow Internet connection, old computers, and more. You need to be prepared for everything; a good start is making sure the training can be given off-line. Delivering training abroad gives the trainees the chance to break out of their normal environment and get exposure to technologies that are difficult to demonstrate "at home". This gives trainees the opportunity to see what they are working towards. For instance, you can repeat endlessly how things are organized in a modern data center, but it's more effective to take someone to a modern data center to see how it operates.

When organizing training, it's important to consider that not all participants will actually implement what they learned. There are many reasons for this; the selection of the participants is not always done correctly, for instance you can end up with a network technician following a software engineering training; or participants don't always get the permission to implement when they return to their institution. Another reason why learned skills aren't implemented is the high staff turnover. People easily change jobs. It is very demotivating when you've just trained several people to find out they they left the institution. It also happens that they go back to school for their masters study. Some staff will abuse the gathered knowledge. They will explicitly not share their knowledge, because they see it as an advantage over their colleagues. When doing projects and training people it's something you can only live with. The only real chance you have is to put your eggs in many baskets.

Our experience over multiple training courses is that capacity building can be successfully achieved as follows:

- Train a broad group of staff in a certain topic.
- Identify those who grasped the topic.

- Let the identified people implement the solution.
- Organize a second training where you retrain them, they now become experts, together with other staff.
- Let the experts give training to people outside of the project so they get very confident and know the topic very thoroughly.

In the next subsection we go into detail why building this capacity isn't easy, but is very rewarding.

5.3 The level of knowledge is limited, but the people aren't!

Working together with local people will be challenging. Many of the people in IT weren't computer users when they grew up. In fact, they could have grown up without access to electricity or clean water. Most of the young people will have a Bachelor degree. Unfortunately you can not compare their bachelor, or master, degree with a European or US degree. For instance, it's very normal to finish a programming course without writing code on a computer! This isn't uncommon, particularly if there aren't enough computers at the university. The education system is still heavily based on reproducing theory and less on practice. Basic computing skills, such as touch-typing, are poor because users have had much less exposure to computing systems.

Sometimes it is necessary to explain things many times, each time a bit differently. The language barrier definitely causes problems, even in countries where English is the official teaching language.

It is also important to adapt to the local culture. Sometimes failures aren't admitted or the truth is not told because individuals fear punishment, or their pride is hurt.

The previous examples are only a few of the issues that will arise. Even given their sometimes-limited knowledge, the people you will work with are capable of doing big things. When given the chance they will certainly try to take it. But due to external circumstances not everything leads to success. Which makes it very important to have a good project management.

5.4 Management

In developing countries the awareness of ICT is very low. Therefor it's important that the management supports your project. You need to make sure they give the good example by using the ICT systems you implement.

Beware not to be used as a the milch cow. Even bigger organizations in developing countries can afford to buy computers and other office materials. If project money is used to buy flash memory and ink toners priorities aren't defined right. An exception would be Cuba, where even buying paper sheets is difficult.

When working with the local people it's crucial to build up a team of honest and hard working people. Because you are the foreigner you automatically attract people who will want to take advantage of you. For example, when a training course is organized there will be a lot of candidates. It's then important you can trust your partner to select the right attendees. If your partner can't make the right selection you could end up with a room of participants attending the training solely to obtain a certificate, with no intention of using their new knowledge. If your partner puts himself always between the selected participants, it's time to look for a new partner or modify the selection process.

Development cooperation is big business. It happens that donors are working next to each other. Or even worse, knowingly implementing different or similar technologies. Local partners don't always inform the parties concerned as they are worried one donor would withdraw their cooperation. Another consequence of the "too-many-donors-syndrome" is staff attend multiple courses, hopping from training to training, without implementing anything. If you can establish a good relationship based on mutual respect, your local partner will surely inform you about other activities going on and assign people to do specific tasks.

It is necessary to have continuous leadership. In Mekelle there were six different local project leaders and four different Flemish project leaders. This lead to loss of long term vision and made follow up almost impossible. In Jimma the first six years the leadership was constant. Only in phase two the Flemish project leader was changed. Continuous leadership makes it possible to keep the objectives of the project aligned with the objectives of the local partner.

5.5 Purchase of IT equipment is difficult

The implementation of ICT requires buying computers and servers. In most developing countries you can forget about next business day support. Many vendors have local resellers but they can't be used for support. From experience, we can say that the resellers have very limited knowledge of the equipment they sell. Desktop computers are easily available in most developing countries, except Cuba. Servers and networking gear are also available, but not the high end ranges and the choice in specifications are limited. When you place an order you can't be sure that you will get it. The main advantage of purchasing locally is that your partner should know how to order. If he doesn't, the process can be tried to see how it works. This creates the local procurement capacity that is necessary for ongoing sustainability.

Another option is to buy through European or American resellers and to ship the goods internationally. However, it's important to take into account delays when importing the goods. Without proper preparation this could easily take several months. Many countries have a very high import tax that can easily double or triple the price. So it's important to know that some countries lift the import tax if you can prove that your project is donating for relief aid purposes.

When purchasing IT equipment it's also good to purchase several items at once. Buy five or ten servers at the same time. Once the project gets going you can't afford to wait another half year (or longer) for your next server to arrive. By buying more hardware than you need the local staff can experiment with the extra hardware. The extra servers can also be used as spare parts.

If licensed software is necessary, think on the long term. Will your partner be able to pay the renewal of the license when the project stops? Even with funding, will your partner actually be able to make the purchase? The chances are very slim that they will have a credit card to make the purchase online. It's very important that the software can be bought locally and that the purchasing process is tested.

Also check the requirements to operate the equipment you buy. For instance, when purchasing a high end UPS make sure the data center actually has a three phase power circuit. Another example is when expending the network make sure your partner has the necessary interface converters so he can use the new equipment immediately.

Once the equipment arrives on site it's important to follow up on the usage. It happens that the equipment is put in *the store* for bureaucratic reasons and then is left in the store forever and forgotten about. Frequently equipment isn't installed correctly: rail kits aren't used, only one power supply connected, ... By personally checking and training the local people to mind these details will eventually pay off.

To achieve maximum ownership it is important your partner pays and orders the equipment as soon as possible. It will put the ownership with your partner very early in the project. Otherwise your partner may abandon the deployed setup. He could wait for the next donor to take over, or to implement something different.

5.6 Small is beautiful

A mistake made frequently is to over-engineer solutions. It is better to start with a small and easy solution that can grow gradually. When implementing you must make that your partner can follow what you are doing. Once implemented, you must be able to step back and honestly say if your partner is able to maintain the solution. Of course, it's better if your partner can do the setup himself.

When starting with smaller and easier projects you can

involve less trained staff and build their capacity. You should value these people the most. They will take every chance they get and will stay longer in the project. In developing countries it's not uncommon that only the senior people are given training, you must take initiative to prevent this.

In bigger projects it can be necessary to rely on a third party for certain aspects of the project. When going down this road it's important that your partner is trained by the third party too. Be aware that consultants will abandon the project when their contracts finishes. If all knowledge is still with the consultant and none has transferred to your partner no progress was made.

5.7   How to handle project follow up

During the lifespan of the project it's important to constantly follow up on the progress of the project. This can be done by requesting reports. However, initially don't expect to get reports voluntarily. It's better to request reports and install a culture of reporting. Far more better than requesting reports is to visit the project in person. Personal relationships are more appreciated than impersonal e-mails. It also gives the staff more opportunity to raise questions and get guidance. With one visit a year you can't achieve much, two visits are the bare minimum.

Another way of following up is to use social networks. Become friends with everybody in the project. Sure, you will have to ignore a lot of uninteresting messages, but you will at least know when something happened. Creating a Google group after a training that connects all the participants is a great way to create a support channel for the participants.

6   Conclusion

Our experiences in supporting ICT projects in Cuba and Ethiopia lets us present a sustainable model for ICT-for-development. To be able to build a sustainable ICT project it is necessary to take into account the following points:

- The available bandwidth in developing worlds is limited. Implementing a caching proxy and other bandwidth optimization techniques is necessary.

- An ICT project in the developing world should focus on creating human capacity. A project that only invests in hardware and software will fail. Frequent ongoing training is the way to handle high staff turnover. This training should be hands-on and should lead to actually implementing a learned technology. The training and implementation should be given equal attention.

- The local people are very eager to learn. Their educational background is not perfect but they make up with enthusiasm and dedication. If possible, let your partners get a degree in a ICT-related field.

- It's important to have a good relationship with the local management. They know the 'ins and outs' of the system. You should be able to rely on them to select candidates for training. It is necessary to get your project's objectives aligned with your partner institutions' objectives. This way you will work together and the local people will take ownership of the solution.

- The purchase of hardware or software is not easy. Purchasing abroad or locally each have their own advantages and disadvantages. In either case, provide the necessary spare parts as vendor support is very difficult to arrange. Near the end of the project, make sure your partner can purchase the necessary hardware or software without your involvement. This will enable them to continue providing services when your programme has completed. Choosing Free Software over proprietary software makes it easier for your partner to continue, and permits sharing of solutions.

- Do not make solutions overly complicated; keep solutions simple so the local people can implement without your ongoing input. Your help shouldn't be necessary to set up and manage any solutions.

- Project follow up is very important. Two visits per year are the minimum. By personally visiting the project you will get a feeling for the problems and burdens of deploying ICT the in developing world. This makes it possible to adjust the project's objectives.

For the three ICT projects, we can also make several conclusions.

The ICT-infrastructure project in Cuba is very successful. The services offered and their quality resemble very well what we expect from ICTs in the "more developed world". The university has it own storage system, they make use of a central identity management system, several websites are online, the staff is using a reliable e-mail system, the network and system services are monitored, . . .

The ICT programme in MU was not very successful. Lack of continuous leadership in Belgium and Ethiopia is the main reason. Next to that, MU didn't have a clear vision on how to use ICT in their institution. Because of this, when the staff implemented a service it was not given the necessary attention and credit. This made the staff unmotivated. It is only in the last three years that

we have seen a real improvement. This is primarily because of continuous leadership on the Flemish side of the ICT project. In MU there are now a couple of motivated staff that were able to create some small but important changes: BMO best practices were implemented and a local e-mail system was set up. Unfortunately they will soon leave the university to get their masters degree which will again leave a knowledge gap in the ICT office.

Although the programme in JU is not yet finished and phase two has just started, we can already see its accomplishments and impact in the country. The necessary capacity was created to manage the network and systems. A big shift was made to Free Software to offer several services: a local e-mail system, several Drupal websites, web application development in the PHP Symfony framework, Samba fileservers, knowledge of Debian GNU/Linux... A direct effect of this is that JU won in 2010 and 2011 the countries ICT-cup which acknowledges the superiority of the university ICT office in the country. Outside the university the ICT office of JU was contracted to establish the ICT infrastructure in Semera University[17]. The ICT office has also provided training to other governmental bodies throughout the country. One of the most important reasons for this success was the synergy that is in place between the Flemish project leaders and the management of Jimma university. They fully understand they need to work together on a basis of mutual respect and as peers.

For myself I can also make several conclusions. Doing development cooperation in ICT has changed me in many ways. First of all, I have learned to handle unforeseen situations — *Don't Panic* — more easily and to make the best of it. Secondly, I've been exposed to different cultures which made me more tolerable. The best technical solution isn't the most sustainable solution. I've learned to give attention to the personal feelings of the team members and to be more compassionate. Thirdly, I've experienced that gentle diplomacy can accomplish more than enforcing solutions.

7   What's next?

Given the great success of the IUC programme in Cuba VLIR-UOS will start a new programme in 2013. The objective is to multiply the built capacity in other big institutions. For the programme with MU in Ethiopia there are no plans regarding ICT. The programme with JU will continue for another five years. In that programme we will focus on making the ICT services high available, the design and construction of a data center and the set up of a university wide storage system.

The biggest challenge in Cuba will be on how to collaborate effectively with the other institutions. It's easy to talk about collaboration, but effectively doing so is something very different. Another issue we will hope to solve is the limited bandwidth between the institutions. In Ethiopia the biggest challenge for MU will be to stand on their own feet. JU will be facing the difficulty that many of their senior staff will leave the university to start their masters study. It's now up to the university and the JU-IUC programme to attract new staff and to train them. While concurrently increasing the offered services and their availability.

8   Acknowledgments

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[17]Semera University is a new university which is located in the northeast of Ethiopia. `http://www.su.edu.et/`