Low-end equipment, open-source, and community participation to build rural Information infrastructure

Daryl Martyris
Goa Sudharop Community Development
25 Peabody Terrace #23
Cambridge, MA 02138
Daryl_martyris@ksg04.harvard.edu

ABSTRACT

Several projects exist in India and other developing countries whereby innovative solutions are being developed and applied for building information infrastructure and connectivity. This paper presents an alternate model where for the most part, established technologies (recycled and low end computers and Linux software) have been used to substantially reduce the cost of establishing school-based community Internet centers in the state of Goa. The key to its success has been collaboration between the private sector represented here by Red Hat India, an NGO represented here by Goa Sudharop and the Goa State Education Department, combined with community participation in the implementation process. This project provides an example of how low initial costs of infrastructure and linkages between different stakeholders can result in cost savings of up to 60% over a conventional community Internet center thereby increasing their chances for financial viability. This paper does not seek to provide a detailed description of the GSCP implementation or its efforts towards sustainability or to provide a detailed technical comparison of closed source vs. open source software.

INTRODUCTION

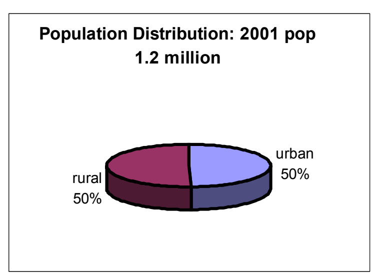
Most developing countries including India suffer from the lack of access to basic communication &information infrastructure. This study will focus on school-based community access centers (as opposed to kiosk-based), each serving a population of 5000-8,000 people or 1-2 villages. Locating community Internet centers in schools has been popular with rural access projects in Southern Africa and is a sound idea in India for the following reasons - 1. To construct a strong foundation for an IT empowered society, it is important to impart computer literacy at the school level. 2. 99% of schools are permanent or "*pucca*" structures [1], and are easily accessible to the bulk of the rural population, regardless of caste and economic status.

However, factors such as the locations of the schools and the investment required for creating the infrastructure pose substantial challenges. In the last few years the Government of India has given extending rural phone access greater priority. The Governments of many Indian states have recently engaged in attempts to provide school based community access. I will provide a brief summary of these efforts which range from outright grants to schools of computers and teaching staff (Goa), the Build, Own, Operate and Transfer (BOOT) model in Andhra Pradesh and Tamil Nadu, and Kerala's IT@Schools project [2].

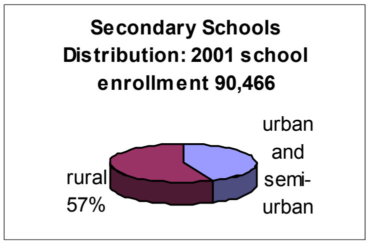
The BOOT model out-sources the setting up and maintaining of facilities of 10 PC's per school computer lab and training teachers to teach Information Technology (IT) as a subject, to private companies like NIIT, which are then permitted to use the facility after hours for revenue generation. Kerala's IT@Schools project places the burden of building the infrastructure and sourcing PC's on the school - either through internal resources, or in collaboration with village-level government bodies. A list of vendors short-listed by the government offers schools equipment at discounted rates. The major difference between the BOOT approach and the IT@Schools approach appears to be that in the former the package includes providing the vendor use of the facility for revenue generation, while in the latter, schools have the choice of paying higher rates for the equipment and not offering use of the facility for after-hours revenue generation. Teacher training is provided by the state.

Background on the Goa Model

Goa is India's smallest state. It is divided into 2 districts, and 11 taluka's, but with a combined area of 3700 sq. km. it is smaller than many districts in India's larger states. It has a population of 1.2 million, distributed evenly between 335 villages and 14 towns, and a literacy rate of 75.5 %.

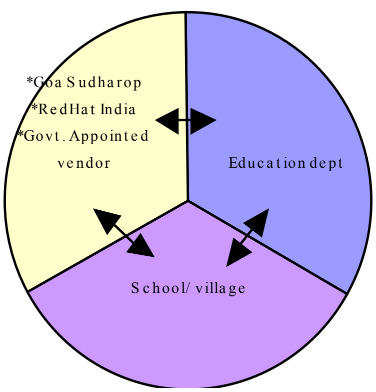


Source: 2001 Indian Census



Source: Goa Department of Education

PC's were first introduced into Goa schools in the early 90's as part of the central government CLASS project. A study in 1995[3] found that upto 45% of schools had at least 1 PC, though very few had more than 1-2. In 2001, the Goa government contracted with a private sector company to provide 1 PC, 1 printer and one computer trained teacher per 108 students for every high and higher secondary school (HSS) [1] in the state. The cost of all maintenance and the supporting infrastructure for the provided PC's is borne by the state for a period of 3 years. While the Goa government is to be lauded for being the first to put computers in every school in the state, this method is likely the most expensive, and is unlikely to work in a larger state or with a student to PC ratio, which is targeted to prevailing norms in other developing countries. For example, in Costa Rica, the reported average was about



53 – 73[4] students per computer and in Turkey the ratio is 40 to 1. However, when viewed as just one part in the cost-lowering linkages, alluded to earlier, such an action by a state government has clear benefits. The other components in the linkage are the role of the NGO Goa Sudharop [5] in recycling used equipment to augment the number of computers per center, and teacher training, the role of the private sector (Red Hat-India [6]) in training and helping to build a pool of manpower skilled in Linux maintenance, and the role of the village community in raising funds for the additional infrastructure required for the additional computers. The linkages are shown in the figure above.

[1] This averages 2 PC's per school. Additionally several urban schools had purchased PC's with internal funds. The government provided PC's were all Pentium 3's

Each of these roles is explained in detail in providing a solution encompassing the following elements:

INFRASTRUCTURE

Wiring, furniture, phone line for connectivity and Uninterruptible Power Supply (UPS) are required for each school-based center. The Electricity supply in Goa is inconsistent with lots of spikes capable of damaging PC's.. While UPS were provided free of charge for the 2 Government provided PC's, the school management and village communities had to raise the funds to provide the above items for the PC's provided by Goa Sudharop. On average each school raised $100 from the community, per PC provided.

EQUIPMENT

It was apparent to the project planners that low-cost solutions are a must for rapid penetration of community Internet centers in rural villages. Goa Sudharop decided that the most efficient solution to providing large numbers of low cost computers was to use donated recycled computers, some of which were sourced locally and some shipped from the US[2]. The experiences of Computer Aid in shipping computers to Southern Africa [8] and those of Tamil Nadu Science Foundation (TNSF) of importing small amounts of used equipment from the US to S. India were studied. The primary drawback, were the issues of customs duty waivers, and difficulty in getting spares for these PC's. The duty waiver problem was resolved by working with the State Department of Education, and the spares issue was resolved by designating about 10% of the recycled PC's as spares. Between 2000 to 2002, 450 recycled PC's were distributed to 100 of Goa's 420 HSS schools, in collaboration with the State department of Education, augmenting the numbers of Government-issued PC's. This resulted in 30 rural schools reaching the targeted threshold of 10 PC's with many more schools moving into the 5-6 PC range. The average all-school student to PC ratio changed from the prevailing 95:1 to 60:1. The cost of sourcing and moving the equipment from the US to its location was $35 per PC. Other equipment costs were $115 per center. The labor cost of installing the computers is included in the unit price per PC.

Operating System and lab configuration

The choice of Linux as the operating system was motivated by the fact that Linux is an Open-source [9] and stable operating system and free of licensing costs. In addition Red Hat-India partnered with Goa Sudharop to train teachers in Linux, free of charge. Red Hat India also franchised a local computer science institute to offer the Red Hat professional certification, thus laying the groundwork for increased commercial availability of Linux maintenance and support and creating a potential employment opportunity for people familiar with Linux. It was decided to implement Linux Terminal Server Project

[2] PC's were sourced from World Computer Exchange [7]

(LTSP) [10] networks of diskless nodes connected to a central server to support further scalability, since additional nodes can be added as they become available. LTSP as a solution requires less in the way of memory, processing power than 10 standalone PC's. The solution had to be rugged to sustain the vagaries of the weather (high humidity and salinity and ant infestations) and rough handling by users. Since it was felt that the most common cause of failure of older computers is hard-disk failure, diskless nodes were the perfect solution. LTSP also allowed compatibility with existing windows based systems. This was important because the government's 3 year maintenance contract with the vendor supplying PC's to schools does not allow schools to replace the Original Equipment Manufacturer (OEM) installed Windows software with Linux. Goa Sudharop provided computers are, however networked to the Government provided ones to enable file sharing and Internet access. Finally, LTSP was found to be easy to operate by teachers and the Internet center operators.

Software Applications

The applications which a school based center requires are academic, for school use, and non-academic, for community use. Purely academic applications include subject specific software such as Kemistry or Tuxtype[11]. Dual-use (community and school) applications include word-processing and spreadsheet applications like Star-office, email, HTML (Hyper Text Markup Language) browser like Mozilla and an editor like Bluefish. Community specific applications include small business accounting software, and Internet telephony (VOIP). While many of these are freely available, they are usually not as user friendly as MS products, and require some customization. There are upward of 14 Linux User Groups (LUG's) in all the major Indian cities which are contributing to the development of vernacular open-source software

TRAINING

Curriculum development and teacher training

While Red Hat initially trained Goa teachers in Linux use at no cost, GSCP has continued to invest in teacher training. Revenue generation through community access provides one solution to raising the funds required for this. The state prescribed computer syllabus was framed assuming use of a Microsoft Windows environment, and had to be adapted for use in a Linux environment. Finally providing teacher training addressing more complex topics such as computer integrated teaching will be a major expense, and low cost approaches to delivering this need to be considered.

Vernacular Language support

Vernacular language support for software is critical. Few Linux applications have versions in vernacular languages, but attempts are being made to develop these by groups such as Tenet[12]

CONNECTIVITY

Goa has telephone service in all its villages and an Internet Point of Presence (POP) with 2 competing Internet Service Providers (ISP's). LTSP allows sharing a single 33-56Kbps dial-up connection with multiple PC's. Low band-width solutions, like using email for web searches are being investigated [13], and as far as possible all HTML content is cached locally (offline) to protect against disruptions in phone service, which are frequent.

COST PER SCHOOL BASED CENTER

All one time cost components in setting up a school-based community Internet center have been included in this analysis – infrastructure, hardware and software, maintenance[3], training and connectivity. Replacing the equipment when it ages is discussed in sustainability

Goa Model

Includes the contributed shares of all stakeholders

Costs could be further reduced if sharing of the Government and Goa Sudharop provided equipment could have been optimized. However contractual restrictions between the Government and the hardware vendor who supplied the government PC's under the scheme prevented this. Training costs would be higher by about $ 75 per school if Red Hat did not provide initial free training.

Cost category	Cost	Share of cost
Hardware	$2,170	40%
Software	$200	4%
Teachers salary and training	$948	18%
Maintenance (@ 3 years)	$1,000	19%
Infrastructure	$1,000	19%
Connectivity infrastructure (phone line)	$50	1%
Total	$5,368	100%

Conventional Model

Below is the cost structure of implementing a conventional school based center using non-open-source licensed software and new equipment.

Cost category	Cost	Share of cost
Hardware	$7,750	58%
Software	$1,000	8%
Teachers salary and training	$933	7%
Maintenance (@ 3 years)	$2,624	19%
Infrastructure	$1,000	8%
Connectivity infrastructure (phone line)	$25	1%
Total	$13,332	100%

[3] Though maintenance is not a one time cost but is spread over 3 years, to be able to fairly compare the costs of using recycled vs. new equipment, 3 years of maintenance costs have been included in the initial set-up costs

The costs for the conventional center are based on data from published reports of the government implementation in Goa schools[4] extrapolated for a lab of 10 PC's. It is consistent with costs citied in studies of similar implementation in other developing countries. These costs are likely identical to costs incurred in a BOOT type or the IT@Schools implementation[5]. Comparing the 2 sets of costing information, we see that the cost savings per school-based center is $7990 or 60% per center, with most of the savings being in hardware (72%), software (100%) and maintenance (62% in absolute terms).

Alternate Models

New equipment with open-source

Realizing that sourcing used hardware might not be possible in every instance, new diskless nodes can be purchased for less than $300 each. The savings on hardware for a lab of 10 PC's with an LTSP configuration would 45%, with total cost savings also of 45% per center.

Used Equipment with Closed-source

Realizing that the technical resources to set up and maintain Linux labs might not be available in every instance, used equipment might be used in a traditional networked windows environment. In this event, the hardware cost would be approximately the same as that for an LTSP lab (GSCP Model), but maintenance and software costs would be comparable to the conventional model. The total cost savings in this case would be 40% per center. Overall cost savings would, however, decline if large investments were made in licensed open-source software beyond the $100 per license for Windows and MS Office that are included in the cost.

SUSTAINABILITY AND COMMUNITY INVOLVEMENT

Involvement of the community is critical to proper utilization of the lab by both the school as well as the general community. Initial resistance was encountered from school managements to keeping the school facilities open, after-hours for community access. The formation of IT committees with representation from the Parent Teachers Association (PTA), school management and village leadership was crucial to ensure that none of these stakeholders feels threatened by the introduction of IT enabled education and services. The following services are offered to the village communities for 3-4 hours daily after regular school hours, on a usage fee basis to generate revenue for sustainability of these centers.

Email

Civic and consumer information

Document typing and printing

"Buy and Sell" classifieds

Computer training and programming classes

The lab operator is required to offer discounts to parents of the school's students and to make available, at no charge, one PC to all local NGO's to help them in their work. These enforced discounts do not affect profitability since at a given time 5 of the PC's can be used for Internet access, and the other 5 for other purposes. After deducting the operating costs (monthly phone charge, local metered phone time[6], ISP charge[7], electricity, maintenance), the balance forms the lab operator's salary. A percentage of the profits go to the school to reimburse it for expenses on infrastructure, to send the teacher for continuing computer training and to replace obsolete or defective PC's (mainly the LTSP server). Computer training classes currently focus on word-processing and spreadsheet applications. It is hoped that in due course, the training courses might be "branded" to improve employment potential of training program graduates. This could be along the lines of the "Titulado en Informatica" offered by the SEE program in the Dominican Republic (15).

Goa Sudharop does not in any way attempt to recover the cost of the equipment provided to schools, and in fact, all equipment imported into India duty-free must strictly be donated. However, in a commercial operation, using locally sourced recycled equipment, part of the profit could also be used to defray capital equipment costs, similar to the BOOT model. No data yet exists to contrast the time to attain sustainability for Internet centers using the Goa model to either the BOOT model or the Kerala model

SCALABILITY

The project in Goa has out computers in 120 of the 430 (or above 25%) schools in the state. Most of these have Linux as the operating system. India has over 107500 HSS facilities that could be mobilized as community information centers using this model. While primary schools are more widespread, they generally lack the infrastructural readiness of secondary schools. Given that the cost of wiring, furniture and UPS can come to $100 per PC, community involvement in fund-raising is a must, and the number of PC's might need to be scaled back. Used equipment is available from Software Technology Parks (STP) or may be imported after thorough inspection to avoid the problem of "dumping" of obsolete equipment.

Commercially availably Linux technical support will continue to be a problem in the medium term, and hence any implementation will need a dedicated technical staff of

[4] Though details of the costs for training, teacher salary or maintenance were not available, costs could be approximated based on local wage rates and costs of local Annual Maintenance Contracts (AMC).

[5] The composition of the Government, private sector vendor and community contributions differ

[6] Monthly phone charge is $4. Metered phone time is approx $0.020 for 3 minutes or $0.40 per hour.

[7] $25 per year –BSTN[14]

Linux specialists. This needs to be factored into project costs.

POLICY RECOMMENDATIONS

The following policy recommendations are made based on the experience of the GSCP in Goa.

- State Governments should consider involving the private sector and NGO's in the development of the state IT visions so that low cost alternative solutions to improving access and connectivity can be considered and incorporated
- Rather than investing in new access points for e-governance service delivery, existing access points such as the after-hours school computer labs described in this paper might be leveraged
- In cases where state governments consider entering into a BOOT type agreement with the private sector, local communities might be allowed to choose from a "menu" of services, similar to the Kerala IT@friends model, rather than using a one-size-fit-all approach. Thus, while the private sector firm might provide and maintain the hardware in exchange for commercial use of the facility after-hours, a local community might be allowed to pay for the cost of the lab infrastructure (wiring etc) in exchange for free access to the facility.
- The Curriculum committees of the State Education Boards might consider making the state prescribed computer syllabus operating system neutral, rather than basing the syllabus on proprietary software. This will substantially reduce costs by giving schools the choice of using open-source software

CONCLUSION

This study demonstrates how extremely low cost school based community information centers can be established in rural communities by leveraging collaborative efforts among a variety of stakeholders, using recycled equipment and open-source software. Cost savings can also be achieved either by using new low-end hardware and open-source software or closed-source software with recycled equipment. These centers allow the use of information technology tools to promote developmental goals like literacy, employment generation and civic and consumer awareness. This model has its limitations in that if locally available Linux open-source expertise is unavailable, there is an additional cost to develop or provide it, and the full cost savings will not be realized. Also, in areas where electricity is not available for long enough to even charge UPS, alternate arrangements will need to be made, further increasing costs.

Future plans include conducting studies for evaluating the usage and sustainability of offering community access at these centers, and if proven successful expanding the program to cover all 420 schools in Goa to get a better idea of district-wide scale effects on costs of support and hardware maintenance.

While sustainability for a "BOOT" facility costing $13,300 might take longer to achieve than for a $5300 facility using recycled or low end equipment and open-source, this would also depend on the income potential of these centers, specifically the difference in potential income from training in Microsoft products vs. Linux products. In the short to medium term it is possible that Microsoft might be perceived as more valuable. In terms of scalability, this model has potential to be replicated in many of the approximately 107500 HSS facilities across India.

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