A Multi-Disciplinary Approach to Shared Access Village Computing Initiatives: The Case of Akshaya

Joyojeet Pal
Department of City and Regional Planning
University of California Berkeley
joyojeet@berkeley.edu

Sergiu Nedevschi, Rabin K. Patra, Eric A. Brewer
Department of Electrical Engineering and Computer Science
University of California Berkeley
{sergiu,rkpatra,brewer}@cs.berkeley.edu

1 Introduction

Through the Akshaya project in the Malappuram district, the government of Kerala has fashioned the nation's first e-literate district, imparting at least one member of every household with basic computing familiarity. This was not done through a district-wide campaign of barefoot computer professionals – instead, the state undertook a massive project to install over 630 telecenters[1] called e-Centers[2], where individuals were trained in the basic concepts of computing using 15 hours of digital content. About 400 of the telecenters were connected wirelessly through a centrally controlled network.

The project is a state-private partnership, in which the state agency KSITM[3] planned the project, set up the connectivity, marketed the idea, developed an e-literacy program, and facilitated region-specific digital applications. The physical space, equipment, and operations of the telecenters were provided by local entrepreneurs, selected by the state government in conjunction with local village councils. KSITM planned the locations in such a way that no house in the district was more than 3 km from an e-Center.

E-literacy was the first phase of the project, during which each household could nominate one member to the local e-Center to acquire training in the basics of computing. The state paid about 85% of the cost of this training as incurred by the entrepreneurs. Following the e-literacy phase, all e-Centers were free to operate as cybercafés and as training centers for a variety of services for the local areas including online payment and e-government services. The state provided free connectivity for three years, starting 2004.

1.1 Approach to the Study

We approach this study as a group of regional planners and computer scientists who are scrutinizing the project not just with the intention of establishing a research hypothesis, but also of creating recommendations on what can be done differently, or similarly, in future iterations of such projects. Regional studies of Kerala, as part of India, and Malappuram, as part of Kerala, help us examine important factors in the 'case for' public underwriting of services such as e-Governance, computer literacy, and shared internet access. Shared access centers like Akshaya are being set up widely in India, in the Union Budget for 2005 around US$ 25M was set aside for community-based shared

[1] Basically subsidized village cybercafes, also sometimes referred to as kiosks.

[2] Each e-Center had about 5 computers, a printer and scanner.

[3] Kerala State Information Technology Mission (KSITM), headed by the state IT Minister K. Kunhalikutty and IT Secretary Aruna Sundarrajan

internet access by the National Government. We look at specific local characteristics that may contribute to the success of such a project, measured roughly through frequency of usage[4] at the shared access centers. In the case of Kerala, the study identifies human development, sectoral changes in employment structure, and migration, as key elements that could influence the usage of telecenter services. Our hypothesis is that these factors play a critical and under-examined role in the use of shared access computing, especially when seen as utility services.

Secondly, we perform a network traffic analysis of the existing operational network in Malappuram using data obtained by network traffic monitoring. This provides us with insight into the current and projected performance of the e-Centers. By looking at the patterns of favored usage, we discuss an important unresolved problem in telecenter deployments across India and other developing countries: what are the kinds of content people demand, and what would be the kinds of applications and services popular enough to enable such telecenter projects.

2 Project Philosophy and Implementation

By the mid 90s, India found itself in a wave of enthusiasm about computing projects in underserved areas as enablers of regional development. Educating people in the use of computing, and using computing to make citizen access to governance easier were recognized as vital parts of progress in an economy increasingly driven towards the service sector. e-Governance and community telecenter projects were prioritized among development initiatives in India.

In 2000, the state government in Kerala initiated an e-governance transaction enabling mechanism called FRIENDS[5], which offered integrated computerized service/payment counters for citizens at each of the district headquarters.[6] The Kerala government had a stated mission of equipping all its local governing bodies (over 1200 in all) with computing facilities, along with training for users and locally-relevant content and services for their sustenance.[7] The Akshaya project has been a continuation of this.

The seeds of the project were in a demand by the village councils (panchayats) in Malappuram, northern Kerala, to the Information Technology Minister[8] in April 2002 with a proposal of district-wide computer literacy – for which the councils offered a sum of Rs. 6 million[9] from their budget (∼$ 133,000). The state government took the idea forth, and converted it into a telecentre project deciding to use Malappuram as the initial test-bed, with the eventual goal of replicating the project throughout the state of 32 million citizens. The idea of layering the computer training with a state-supported network of public computing points was to give citizens the opportunity of taking their learning to the next level.

All the e-Centers were franchised to private entrepreneurs, but centralized state HQ control over the network and connectivity, branding and outreach of the project, curriculum and logistics. The government facilitated loans for entrepreneurs setting up e-Centers. The e-literacy training for the people was subsidized with the village- and district-level governments paying e-Center franchisees Rs.120 per head (∼$ 2.8) towards the training while each recipient of the training paid Rs.20

[4]Ideally, we would have liked to incorporate frequency of use by individuals, but at this stage, that data was unavailable.

[5]Fast, Reliable, Instant, Efficient Network for Disbursement of Services

[6]A research study showed that citizens saved an average of 42 minutes per month, and at an average spent about a third of what they originally did on paying bills through travel costs and agents, and that 97.4% of users preferred the FRIENDS counters to the original department counters. Madon, Shrin and G.R.Kiran

[7]Project is known as the Information Kerala Mission (IKM)

[8]P. K. Kunhalikutty, the Minister, was also one of the elected representative of the district

[9]The panchayat contribution was subsequently changed to incorporate various levels of village council contribution

(∼$ 0.5). The subsidy was applicable to only one member of each household. The state appointed a high-ranking official, the KSITM chief, M. Sivasankar, as the district collector of Malappuram (the top government post for the district) to oversee the project's implementation.

2.1 Logistics

e-Centers were planned across Malappuram such that each serviced approximately 1000 clients for the e-literacy phase. Each center was assigned a list of households from the local neighborhood, and persons from those lists could get their subsidized e-literacy training only from their assigned e-Center. About 475 e-Centers were new establishments, and their entrepreneurs were selected through a government tender announcement as new e-Centers. About 160 were created by converting existing private cybercafés into Akshaya e-Centers. Each e-Center was created at the cost of approximately Rs. 200,000 to the entrepreneur. The cost of the wireless network was mostly borne by the state.

The Malayalam language e-literacy modules, introducing basic computing concepts and what a computer could be used to do, were played like videos on PCs, to individual viewers over 10 sessions of 90-mins. The viewers took a multiple-choice test at the end of the last module, and all users had to answer correctly to be certified e-literate.[10] The e-literacy phase was completed by February 2004. Students didn't learn to operate any specific applications in the e-literacy phase; the course design did facilitate better decision-making among its graduates on what computers meant to their daily lives, and how these can be used in the future.

The organizers of the project emphasized on training for entrepreneurs for economic sustainability, since the e-literacy was to be only a one-time revenue for entrepreneurs. Each entrepreneur was trained in one of six focus areas – multimedia, data operations, software, hardware, financial services, and community building. The set of e-Centers was geographically broken up into clusters of six (usually one panchayat area) and within each cluster, each entrepreneur got a different type of focus area training. Thus one panchayat had only one hardware e-Center, and so on. This scheme was meant to bring technology services that would otherwise not be available in these regions, and give e-Centers more means of economic sustainability.

2.2 Wireless Network Description

The Akshaya wireless network is one of the world's largest wireless Internet Protocol-based (IP) networks and is a unique initiative to provide connectivity throughout Malappuram. The e-Centers in Malappuram needed to reach remote areas in the district to provide VoIP (Voice over IP) telephone and video streaming/teleconferencing facilities. With a large expatriate population, VoIP and e-mail were envisioned as killer applications. KSITM required that the network provide always-on connectivity with reasonable bandwidth and small delay and jitter suitable for VoIP.

Network Logistics

When, during May 2003, the KSITM initiated bids for connectivity solutions, around 75 solution providers proposed a variety of wired and wireless solutions, some of which involved wiring up the full district while others proposed cellular coverage using 3G technology or 802.11 based wireless links. Wireless was the obvious choice since wiring up the 3500 sq.km. district with Nilgiris in the east, the Arabian Sea in the west and evergreen forests, ravines, hills and rivers would have been impractical and expensive.

[10] The test module would ask the user to try again if they got the answers wrong

The short timeline of the project triggered one of the world's largest and fastest wireless IP deployments. Tulip IT Services Ltd was the wireless system integrator for the project.

Solution Overview

Tulip's solution consisted of a high bandwidth wireless backbone network that leads to a subsidiary access network for connecting the individual e-Centers. The wireless backbone, consisting point-to-point directional links connects the Network Operating Center (NOC) to about 40 nodes called POPs (Points of presence). Every POP fed to an access network connecting wirelessly to the e-Centers. The total internet bandwidth available to the network is a leased 2 Mbps fiber optic line.

Backbone network

The tree-shaped backbone connects the POPs using a combination of 802.11a and VINE (developed by WiLAN) point-to-point wireless links. The links range up to 20-30 km, though most of them are less than 10 km.

The 802.11a links are based on the open IEEE 802.11 wireless standards and operate in the 5.3-5.8GHz spectrum, providing throughputs of up to 24 Mbps. Currently, the Akshaya network uses 802.11a radios on the crucial high bandwidth backbone links. However, most of the backbone is connected using VINE (Versatile Intelligent Network Environment) technology, allowing a node to function as both an end-point as well as a relay. The VINE radios from WiLAN are based on direct spread spectrum technology and operate in the ISM band from 2.400GHz to 2.4835 Ghz while supporting operation speeds up to 11 Mbps.

Access Network

While the backbone connects all the POPs to the NOC, individual subscribers connect directly to the nearest POPs. This part of the network is based on Airspan's WipLL technology. WipLL radios are capable of delivering burst data speeds of up to 4 Mbps (3.2Mbps net) to each subscriber.

Each POP acts as a base-station, has a WipLL radio with an omni-directional or sector antenna that connects to a set of subscribers (e-Centers). The e-Centers in turn have subscriber radios with directional antennas pointed towards the nearest POP. These radios are mounted on towers that ranged between 20-30 meters in height, depending on the local vegetation and topography.

3 Regional Analysis

We study the Akshaya network, and its possible courses for the future by looking closer at the district of Malappuram, and contrasting it against the rest of Kerala – to see if the results of the first phase of the project can be used as indicators for future iterations.

3.1 Profile: Kerala

Kerala has attracted academic interest for a number of reasons, key among them being its impressive progress in human development, much ahead of the rest of India. A traditional land of plenty with many rivers and rich soil, Kerala has had a rich agrarian economy, rice and palm near the coastline, and estate-based industries (rubber, coffee etc) in the hinterland.

Due to progressive education policies both by local monarchies and by post-independence communist governments, the local literacy rate is very high – almost at 100% in most urban areas. The

Area	38,863 sq.km
Population	31.8 million
Pop. Density	819 per sq.km
M/F Ratio	1058
Literacy	90.9%
Decadal Growth	9.42%
Household size	4.7%
Urban Pop	25.7%

(a) Kerala (b) India

Figure 1: Kerala Profile and India

state funded healthcare is much more accessible in Kerala than the rest of India. The state has high religious diversity[11] and the nation's best indicators for women at higher levels of college education. The state has one of the best road networks in the nation, high teledensity, and highest foreign exchange remittances from migrant workers. Yet the state also suffers from the nation's highest unemployment rate[12], the highest suicide rate, high indebtedness among farmers, and a diseased industrial sector.[13]

	Sex Ratio	**Male Literacy (%)**	**Female Literacy (%)**	**Total Literacy (%)**	**Decadal Growth in GDP (%)**	**Workers as percent of total pop (%)**	**Non workers (%)**	**Household size**
Kerala	1058	94.20	87.86	90.92	9.42	32.32	67.68	4.7
India	933	75.30	53.70	64.80	21.34	39.26	60.74	5.3

Table 1: Comparison between Kerala and India on Human Development Indicators

[11] Although the three major religious groups of Hindus, Muslims and Christians are spread over the entire state, there is greater concentration of Muslims in the north, of Christians in the central areas, and Hindus in the south.

[12] Except Jammu and Kashmir, on which data is not available, though perceptibly the highest unemployment due to the active insurgency problem.

[13] For all these statistics, only the larger states of India are taken into consideration – this means the capital region of Delhi and the former Union-Territory states of India are left out of the comparison.

3.2 Profile: Malappuram

Area	3350 sq.km
Pop	3.6 million
Pop. Density	1022 per sq.km
M/F Ratio	1063
Literacy	90.9%
Decadal Growth	9.42%
Household size	5.3%
Urban Pop	9.7%

(a) Malappuram

(b) Kerala

Figure 2: Malappuram Profile and Kerala

Malappuram is a district in northern Kerala, known for its thickly forested interiors and its sunny coastline. It is of interest to academics for a number of reasons, key among them being its large number of migrants in foreign countries. Malappuram is the most populous district in the state, and the only Muslim-majority district in Kerala. The district has been functioning as a separate administrative unit since 1969. Malappuram was the traditional military headquarters for coastal kingdoms of northern Kerala because of its thickly forested terrain.

The profile 2 shows the low degree of urbanization and the relatively higher household sizes. The level of industrialization in the state has also been low.

3.3 Relevance of cross-regional comparison extrapolating from Akshaya

In our study of the Akshaya network[14], two things stood out as vital regional characteristics that made the study of Kerala a unique endeavor within India, and one factor that made Malappuram a unique case within Kerala. Thus the key conclusions of this report are largely relevant primarily to unique conditions of these areas.

Kerala has a far higher rate of basic education than the rest of India, which brings up a relevant question of whether it is possible to study the Akshaya network and apply the learning to any other part of India, since the numbers for Malappuram on education are much closer to Kerala than they are to the rest of India, despite being among the lesser developed parts of Kerala.

Secondly, the population density of Kerala is among the highest in India. This is a particularly important skew factor, since even the rural blocks in Kerala tend to have the characteristics of peri-urban towns in the rest of India – the average village size in Kerala is over ten times of the average village size in India. The road networks in Kerala are superior compared to the rest of India, and even the more remote areas studied in Malappuram had good access to paved roads.

[14]Sergiu Nedevschi, Rabin K. Patra, "Akshaya: India's First District-wide E-literacy Infrastructure", 20^{th} Annual South Asia Conference, University of California Berkeley, February 2005

3.4 Human Development

Kerala hasn't been able to galvanize economic growth like some of the more industrially inclined states of western India, or the high-yielding agriculture producers of northern India. Kerala, although much lower than states like Maharashtra and Gujarat in terms of adjusted per capita income, has much better spread of income over the population. The large proportion (63.9%) of the population in the national average middle-income group[15] creates a large potential clientele for e-Centers services (essentially people who are high-school educated or more, and in service sector jobs but cannot afford personal computing devices), which is worth keeping in mind while sizing the market in other states based on Akshaya's performance.

	Proportion of 6-14 year olds currently enrolled				**Proportion of 15-19 year olds who have completed grade 8**			
	All	**Poorest 40%**	**Richest 20%**	**Enrollment gap by wealth**	**All**	**Poorest 40%**	**Richest 20%**	**Enrollment gap by wealth**
Kerala	0.949	**0.887**	0.975	0.088	0.749	**0.531**	0.923	0.392
All India	**0.677**	**0.5**	**0.942**	**0.442**	**0.447**	**0.204**	**0.824**	**0.62**

Table 2: State-wise proportions of enrollment and completion of the 8th grade (1993)
Source: Deon Filmer, Lant Pritchett, 1998, cited in Nedevschi, Pal, Patra 2004

E-Center projects are deeply tied to education systems in the areas they operate in for two reasons – first, cybercafés as they are currently structured create a prerequisite of basic written literacy, most often in the English language. Second, school students are a major audience for e-Centers, and the level of existing computing education in schools affects the demand for projects like Akshaya.

The data on school education in India is an indicator of the scope for technology adopters within each state for two reasons – first, government schools are increasingly establishing computer labs (and there isn't much scope for home Internet usage for children trained in schools). Secondly, the percentage of population having completed secondary school is an indicator of English-language prevalence, which is a major push factor for e-Centers projects.

Although the data in table 2 is old, it still shows the massive difference between the rest of India and Kerala in terms of the potential number of users. The figures show a contrast between enrollment and completion of middle school among the poor in the rest of India as against Kerala. This skew is one factor that creates a significant case for Akshaya-like ubiquitous telecenter services across rural areas, since it is highly perceivable that a relatively well-literate population exists even in the poorer rural areas.

The level of economic-class related equity is much higher for Kerala, and the actual enrollment and attainment does not start dropping off till the 7^{th} grade (Figure 3). In contrast, for the rest of India, the inequity exists right at the starting point, and gets progressively worse. These statistics present very challenging tasks for human development projects, which face great odds in working even with the middle 40% of the population, reaching the bottom 40% being much more difficult. Again, this skews the validity of a comparison between Kerala and the rest of the country.

e-Centers are generally expected to effect gender development. For this, it is important to study statistically if the conditions are favorable to the inclusion of women in projects of this kind. Due

[15]Sources: NFHS, 1992/93 and Haque, Lanjouw and Ravallion.

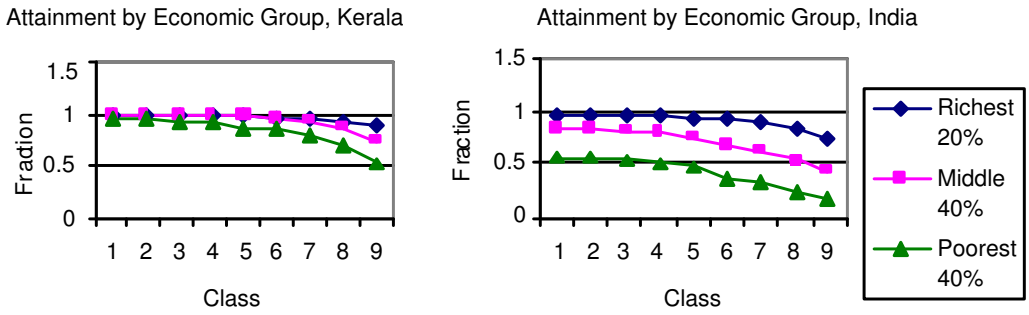


Figure 3: Class-wise Attainment by Economic Group in Kerala (1998-99)
Source: Selected Educational Statistics 2000-01, Department of Secondary & Higher Education, Ministry of Human Resource Development, Govt.of India.

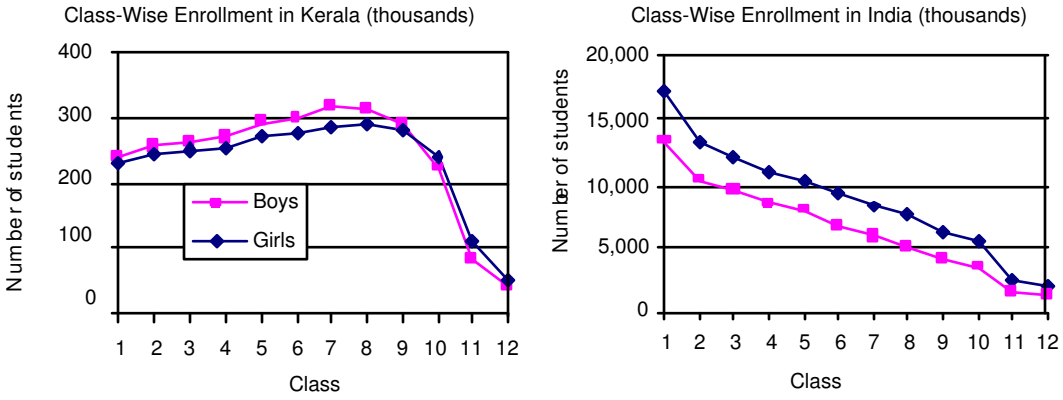


Figure 4: Class-Wise Enrollment in Kerala of Male and Female Students
Source: Selected Educational Statistics 2000-01, Department of Secondary & Higher Education, Ministry of Human Resource Development, Govt. of India.

to the high threshold of using computers, the lower the women's education, the poorer are the odds of any real human development – thus completing a vicious cycle.

In Kerala the enrollment actually increases from class 1 to class 7 (Figure 4), due to the increase in population and to the fact that higher classes are more difficult to graduate, with higher repetition rates. On the other hand, we see an abrupt drop in enrollment during the transition into high-school. More boys are enrolled in primary and secondary education, while more girls are enrolled in high school. The picture for the whole of India, on the other hand, looks quite different. The enrollment drops continuously and uniformly. As opposed to Kerala in every class there are more boys enrolled than there are girls.

The statistics for rural education in Kerala confirm the existence of a much more equitable attainment situation for males and females as well as urban and rural populations in terms of their ability to process language (Figure 5). While these educational gaps are negligible across urban and rural regions for Kerala, the disparities are enormous for the rest of India – especially disadvantageous to rural females. This case for Kerala is especially important in justifying the presence of state funding, as opposed to other parts of the country, where it is perceivable that the

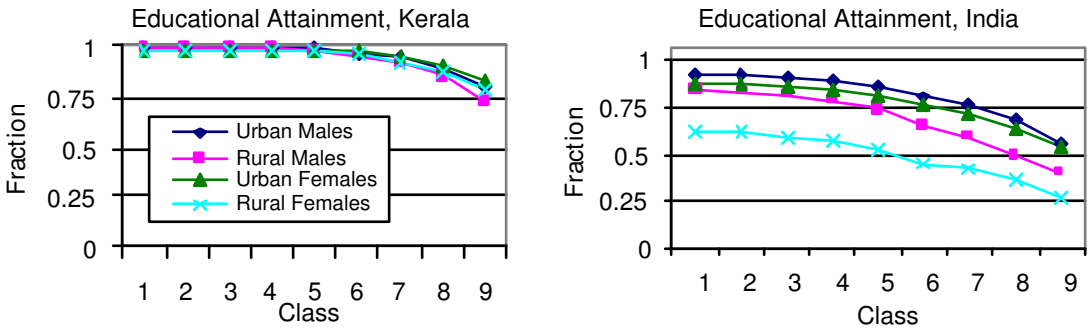


Figure 5: Class-Wise Enrollment in rural Kerala and rural India
Source: Selected Educational Statistics 2000-01, Department of Secondary & Higher Education, Ministry of Human Resource Development, Govt. of India.

benefits of technologies such as shared access e-Centers, as beneficial to the entire community, as close to uniformly as possible, is a much harder sell. A detailed study of the district-wise percentage of enrolled students through all of Kerala[16] showed limited variation between districts within Kerala. Thus if younger populations are to be either the present day or near-future patrons of the e-Centers, there is reasonable expectation for universally constant demand base. The expectation of universal access being equally useful, based on level of education as the key qualifier for people to use computers, can be more or less constant in the state. Malappuram district shows the highest ratio of students among all other districts in Kerala, with 22% of the total population being enrolled in schools, partly due to the district's young population.[17]

The existence of IT resources can be used to fill in some gaps in education system, and conversely, can draw more clientele from a widespread network of schools. At certain levels of learning, shared knowledge resources over the net can improve the quality of education, by making up for the lack of training in teachers, by bringing education in remote areas, and familiarize young children with technology. The fact that Kerala has a good basic education system, network of teachers, and commitment to education means that such IT services have a good base from which to serve in several complementary roles in a variety of human development goals.

3.5 Sectoral Development

A quick look at Kerala's sectoral development is also important in establishing whether there is a trend towards service sector jobs. Though the case for public access e-Centers need not be justified by the expected future growth of service sector jobs, the demand for computer access tends to be spurred by training services, with the eventual goal of tertiary sector employment.[18]

A shift share analysis of the state's labor force, as compared to that of India as a whole is useful in better understanding the growth and decline areas.[19]

When compared to the rest of India, Kerala shows greater economic concentration in the service sector areas, while the manufacturing sector is deficient, facing systemic problems. Related to the

[16]Pal, J., Nedevschi, S., Patra, R.K., Kerala Compendium (unpublished 2004) `http://www.cs.berkeley.edu/~rkpatra/cp225/kerala_compendium.doc`

[17]ibid

[18]Ferraz C., Fonseca R., Pal J., Shah M., Computing for Social Inclusion in Brazil: A Study of CDI and Other Initiatives in *Bridging the Divide 2004*, Berkeley, CA: Management of Technology and UNIDO Program, 2005

[19]Due to lack of complete data sets, we had to use the two best years we got data on.

	India 2001-02 (%)	India 2002-03 (%)	Kerala 2001-02 (%)	Kerala 2002-03 (%)
Agriculture, Forestry and Fishing	25.0	23.0	19.0	17.3
Mining & Quarrying	2.2	2.2	0.3	0.3
Total Primary Sector	**27.2**	**25.2**	**19.3**	**17.6**
Manufacturing	15.3	15.5	9.3	8.2
Electricity, Gas & Water Supply	2.4	2.4	2.6	3.5
Construction	6.0	6.2	11.7	12.5
Secondary Sector	**23.7**	**24.1**	**23.6**	**24.2**
Trade, Hotels, Transport and Communication	21.8	22.5	31.7	32.4
Financing, Real Estate & Business Services	12.7	13.1	10.8	10.7
Community, Social and Personal Services	14.6	15.1	14.6	15.1
Tertiary Sector	**49.1**	**50.7**	**57.1**	**58.2**
GDP	100.0	100.0	100.0	100.0

Table 3: Sectoral Comparison between India and Kerala (GDP) 2001-2003

	Shift-Share Analysis: 1996-2000				**Interpretation**			
Industrial Sector	**Econ Growth**	**Prop. Shift**	**Diff Shift**	**Total % Change**	**Competitive**	**Opportunity**	**Strong**	**Stable/ Declining**
Agriculture & Hunting	0.072%	-3.49%	4.74%	1.32%		Yes		
Mining and Quarrying	0.072%	-9.16%	6.23%	-2.86%		Yes		
Manufacturing	0.072%	-2.72%	-1.00%	-3.66%				Yes
Electricity, Gas and Water	0.072%	-0.07%	18.68%	18.69%		Yes		
Construction	0.072%	-5.03%	0.82%	-4.13%		Yes		
Whole sale, Retail Trade	0.072%	2.01%	1.46%	3.55%	**Yes**	**Yes**	**Yes**	
Transport, Storage, Comm.	0.072%	-0.07%	5.48%	5.48%		Yes		
Finance, Insur. & Real Estate	0.072%	4.33%	-5.62%	-1.22%			Yes	
Community, Social & Personal Servicess.	0.072%	2.70%	6.17%	8.95%	**Yes**	**Yes**	**Yes**	
Total Employment	**0.072%**	**0.0%**	**3.43%**	**3.50%**				

Table 4: Shift-Share Analysis of Kerala (labor) 1996-2000

manufacturing sector, the growth in the tertiary sector is evident. The strength of the construction industry is indicative of the infrastructure building tendency,[20] and tourism is also growing every year. This is reflected in the large share of the economy being taken by Trade, Hotels and Communication. Anecdotal evidence from the Akshaya e-Centers also informs us that there is a very significant demand for computer training among outward-bound migrants.

[20]Home-building, using cash resources from international remittances is also a large chunk of the construction industry.

	Share Primary Sector (%)	**Growth Primary Sector (%)**	**Share Secondary Sector (%)**	**Growth Secondary Sector (%)**	**Share Tertiary Sector (%)**	**Growth Tertiary Sector (%)**
Thiruvananthapuram	11.2	3.4	24.4	20.4	64.4	17.2
Kollam	21.1	5.1	25.2	15.7	53.7	17.0
Pathanamthitta	28.4	7.9	17.8	22.8	53.8	16.7
Alappuzha	10.1	2.8	29.7	14.3	60.1	16.9
Kottayam	16.6	1.2	21.0	20.9	62.4	16.9
Idukki	51.2	6.7	14.7	31.1	34.1	16.7
Ernakulam	11.8	3.2	30.9	17.7	57.3	16.8
Thrissur	12.6	5.9	27.0	15.4	60.4	16.8
Palakkad	18.7	6.2	21.4	16.3	60.0	16.8
Malappuram	17.9	6.0	19.9	17.3	62.2	17.0
Kozhikode	15.4	4.9	24.5	18.2	60.2	17.0
Wayanad	39.2	5.0	9.1	19.1	51.7	16.9
Kannur	15.3	4.4	25.6	14.4	59.1	16.9
Kasaragod	20.8	2.4	26.2	10.9	53.0	16.7
All-Kerala	**17.6**	**4.9**	**24.2**	**17.3**	**58.2**	**16.9**

Table 5: Sectoral Comparison within Districts of Kerala (GDP) 2002-2003
Source: For tables 3.5, 3.5 and 3.5: GDP and sectoral share of income, India and Kerala, Directorate of Economics & Statistics, Kerala and Ministry of Labor, Govt. of India

We find a reasonable degree of uniformity, though there is more variation than in the case of educational statistics. The only exception districts are Ernakulam, with higher manufacturing, and two districts, namely Idukki and Wayanad, with disproportionately large agricultural sectors. Interestingly, it is the secondary sector that has shown the most volatile growth within Kerala, whereas the tertiary sector shows much more uniform growth patterns.

Though this sectoral changes analysis is superficial, it does help in predicting that the demand for telecenter services is similar in most of the districts within Kerala, assuming that tertiary sector workers are the major factor in generating this demand. Consequently, we expect that the results obtained by Akshaya in Malappuram to be replicable in the other districts of Kerala.

We found anecdotal evidence that a number of people visiting Akshaya e-Centers were either students, or young persons looking to get service sector jobs, often breaking away from traditional family occupations in the primary sector. The data for Kerala supports this observation.

3.6 Migration

Nearly 1.5 million Keralites live outside India and they send home more than US $785 million a year by way of remittances[21]. The high percentage of migrant laborers has an important role for Akshaya, because migrants are an influencing factor in the demand for communications services and e-literacy training programs. While this is especially important in Malappuram, the district with the highest number of outward-bound migrants, understanding migration at the state level is useful in predicting possible demand for such services in future deployments.

Economically, there have been stages when almost a fourth of the entire state's domestic product was comprised of international remittances. Kerala has had an active workforce of 12.2 million out

[21] Zachariah et al (1998)

Country	**Percentage (%)**	**Migrants (000s)**
Saudi Arabia	38.1	519
United Arab Emirates	29.7	405
Oman	10.4	142
Bahrain	5.7	77
Kuwait	5.1	69
Qatar	4.7	64
USA	2.2	30
Others	4.1	57
Total	100	1,363

Table 6: Locations of International Migrants from Kerala (1998)
Source: Department of Health Services Report on Migration, Kerala

of a total population of around 31.8 million in 2000. Of the 1.36 million Kerala international emigrants in 1998 (Table 6, 90 percent (1.22 million) were employed[22]. Thus, about a tenth of the entire workforce was working abroad. In the same year, the organized sector[23] accounted for around 1.22 million jobs; effectively, the total number of international migrant workers equaled the total in-state organized sector employees.[24]

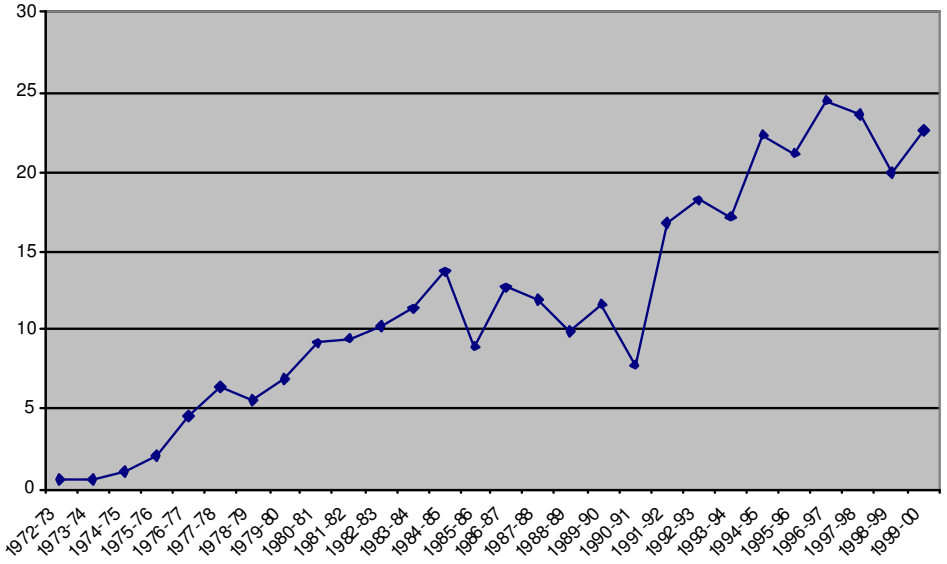


Figure 6: Emigrant Remittances' contribution to Kerala GDP, 1973-2000 (%)
Source: Kannan, Hari (2002)

Since the 1970s, there has been a rise in the number of migrants in the oil producing nations due to shortage of internal labor, and India has been among the major senders of laborers to the Persian

[22]Zachariah, K.C., Mathew E.T., and S. Irudaya Rajan, Dynamics of Migration in Kerala: Dimensions, Determinants and Consequences, CDS Working Paper, 2001

[23]Comprising of those areas that are reported to the government and included in the tax base, thus excluding self-employed non-reporting individuals, agricultural laborers, part-time employees etc.

[24]Kannan, KP, and KS Hari, Kerala's Gulf Connection: Emigration, Remittances and their Macroeconomic Impact 1972-2000, CDS Working Paper, March 2002

Gulf region. The existence of networks among laborers has led to ethnic clusters of laborers and even within Kerala, there are some areas with very high concentrations of international emigrants, the most significant of that being some of the towns in the Malappuram district. Although many of the international migrants tend to be manual laborers with limited schooling, communication between them and their families in the state is an important business, especially since the liberalization of telecommunications in India.

A key goal of the Akshaya project was to generate revenues relying on the connections between local Keralites and their expatriate family members, through international calling facilitated at e-Centers. Figure 6 presents the magnitude of outward migration's effect on Kerala's economy.

	International emigrants				**Local out-migrants**			
	%male	**%female**	**%total**	**female as % of total**	**%male**	**%female**	**%total**	**female as % of total**
SC/ST	1.4	2.1	1.5	12.9	4.9	4.5	4.8	22.6
Ezhawas	7.5	9.7	7.7	11.7	21.2	18.1	20.4	21.4
Nairs	14.0	8.2	13.4	5.7	24.2	14.3	21.8	15.9
Syrian Chrst.	10.6	21.2	12.1	20.8	17.1	32.8	20.9	38.0
Roman Catholic	7.4	19.0	8.4	20.9	8.9	17.7	11.0	38.8
Muslim	52.0	25.1	49.5	4.7	15.6	1.5	12.2	3.0
Others (mainly Hindu)	7.1	8.7	7.3	11.1	8.2	10.9	8.8	29.9
Total	100	100	100	9.3	100	100	100	24.2

Table 7: Kerala caste, religion, and gender profiles of migrants (1998)

This further illustrates the importance of remittances in the Kerala economy, rising from a small fraction of the net state product in the 70s to more than 20 percent by the late 90s. Interviews with entrepreneurs in Malappuram, pointed to significant international communications with migrants at e-Centers, and also the use of remittance incomes to purchase computers, considered valuable fixed assets locally.

Caste and religion play an important role in migratory patterns – this is an important factor in looking at demand from other districts. Incidence of international labor-related migration among Muslim laborers from the districts of Kozhikode and Malappuram was high, especially to Saudi Arabia, where several companies openly preferred Muslim laborers.

In spite of being 23% of the state's population, almost 50% of its international migrants are Muslim (Table 7). In contrast, the share of Hindu migrants is much higher among emigrants within India. In general, the Christian community has the largest share of migrants compared to the size of the community.

The percentage of the migrant female workforce is seen as much higher among Syrian Christians and Roman Catholics. The local migrants are also higher educated than the international emigrants. We see higher educational attainment for Christian and Hindu women, thus the greater percentage of males in manual labor positions, as opposed to women who tended to work more in the private sector. This has consequences for gender implications of computer education demand, in an atmosphere of already high demand for computer education in Kerala.

That there are religious patterns to the migration implies that usage of one or the other of e-Center services can differ based on the structure of the community, mainly what type of migrants are

more frequent within the community. Also, the migration of male migrants leads to concentration patterns of single female left behind by the migrants.[25] All of these are important factors in influencing both the use, and the types of typical telecenter users.

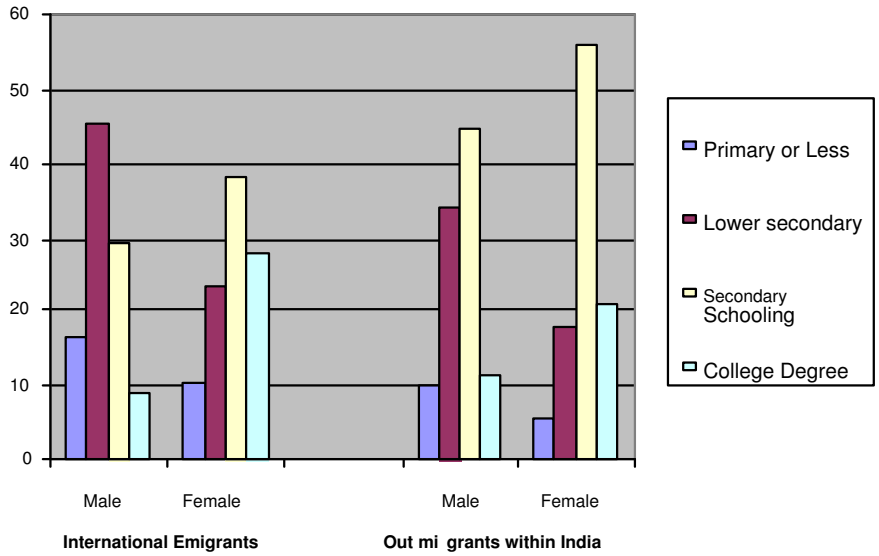


Figure 7: Educational attainment of Emigrants and Local Migrants, Kerala 2001
Source: Survey on Gender Dimensions of Migrants in Kerala (Zacharia et al).[27]

We see that the highest median educational attainment is among female migrants working within India, whereas the lowest is among male emigrants working abroad. Figure 7 shows the high percentage of male workers with school level or lower education. Over 90% of the male emigrant population does not have a college degree; for many of these, getting a short course in computer use or internet access just prior to leaving for the Gulf is very common. The figures for domestic migrants indicate higher levels of education and participation of females in the migrant workforce, underlining the lack of jobs for skilled workers in the state, and reinforcing the previous argument regarding sectoral changes. Unemployment among the educated has been a major problem in Kerala, and many of the state's residents move to metropolitan areas within the country for service sector jobs. Based on the number of secondary school graduates, it can also be inferred that in the range of 40% of emigrants, and in the range of 60% of all out-migrants in India have some English competency (the curriculum for secondary school in Kerala contains English language script and usage), and can potentially use the mainly English language-based Internet e-Centers.

Studies of migrants' job profiles before and after migration show some useful patterns for study[28] – first, we find that migrants tend to set up businesses and self-support after returning from their migrant labor positions. Secondly, we find that that unemployment is significantly higher among migrants within India than it is among international emigrants, even though local emigrants seem to be headed to comparatively more 'white collar' jobs. These have important consequences for

[25] Nedevschi, Pal, Patra (2004)

[27] Based on random sample by authors of 10,000 households from 200 panchayats selected at random from all the 14 districts of Kerala. Zachariah, K.C. and S. Irudaya Rajan, Gender Dimensions of Migration in Kerala: Macro and Micro Evidence - Asia-Pacific Population Journal, September 2001, UNESCAP.

[28] Kannan and Hari (2002)

projects such as Akshaya, since the out-migrants within India are probably at a stage of gathering more employable skills, and are potential users of shared access and computing training.

In general, migration is going to be an essential area of study for any kind of telecenter analysis, both because of the important effect on local communications demand, as well as on the labor mobility front, where the existence of migrant labor networks can lead to greater demand for service sector jobs. The unique case of Kerala, and the consequent demand for training and access services may therefore be a skew factor if used to make predictions for India in general

4 Network Traffic Analysis and E-Center Profiling

In this section, we use a technical approach to gain some insight in the way the network connectivity is currently used in Akshaya. We look at what are the trends seen in the last months, and we examine what are the kinds of content and applications predominantly utilized by Akshaya users. In order to perform this analysis, with the assistance of the Akshaya officials and Tulip network administrators, we log the network traffic for several months, and examine the resulting dataset.

Ideally, such data should be analyzed as a complement to data obtained through extensive surveying of users and entrepreneurs, and we are in the process of performing such a survey. We find network data analysis an objective measure of usage, as opposed to user surveys because of a common problem of stated preferences. Network data at different levels of granularity can be used to study what are the major uses of the network, alongside what people spend most computing time on.

Data Collection

We examine the log of the Akshaya HTTP (World Wide Web) traffic starting with October 14^{th}, 2004. This data includes, for each computer in the Akshaya network, all the Web connections initiated by users, the amount of time spent at a site and the number of bytes transferred.

4.1 Analysis of Internet Traffic by Volume

We begin by analyzing the total volume of Web traffic in the Akshaya network, and its evolution in 5 months previous to March 2005. Figure 8 plots the amount of daily traffic, starting from October 14^{th}, 2004, until March 8^{th}, 2005.

We can notice a sharp traffic increase until December 2004, with a peak of almost 14GB a day. However, the initial increase is not maintained; in fact, the average daily traffic level decreases slightly after December. We also notice high variations in the amount of traffic, with several whole days of complete network disconnections. These variations can most probably be attributed to the variations in network performance and frequent disconnections, on top of the periodic variations due to the weekly cycle.[29]

The traffic seems to be limited by the 2Mbps maximum bandwidth achievable in the network, which corresponds to a total daily traffic of around 10GBytes.[30] However, the slight decrease in the last months might also indicate an overall decrease in demand. We will further investigate this matter in the following section.

[29] The utilization in the weekends is lower, most Akshaya e-Centers being closed.

[30] This computation also considers the fact that the network is only used half the time, being almost inactive at night.

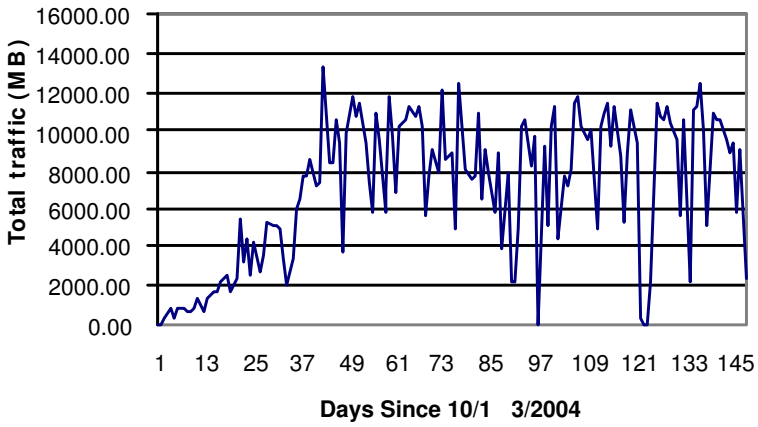
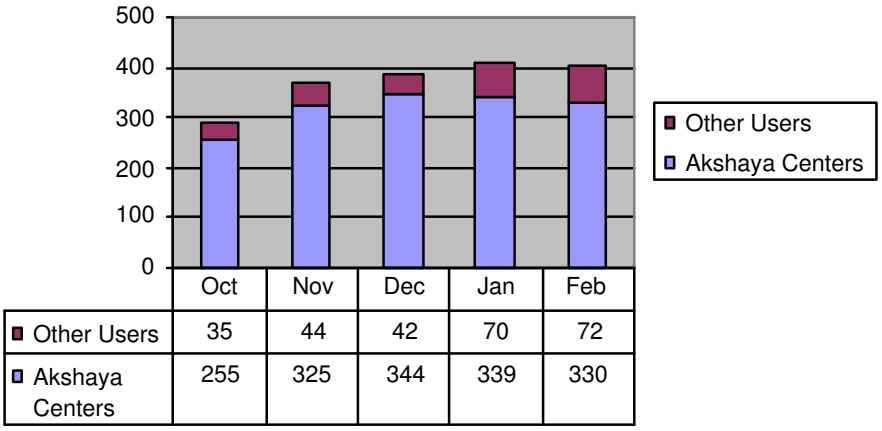


Figure 8: Evolution in the Akshaya daily Web traffic

4.1.1 Number of Centers Using the Web

Throughout the lifetime of the project, a total of 682 e-Centers (613 rural and 69 urban) have been officially registered with Akshaya. About 375 of them, have ever accessed the Web since October 2004. Besides these 375 active e-Centers, there are 87 other users (network administrators, police stations also connected to Akshaya, etc.) that have used the Internet connection at least once.

By plotting the change in the number of active e-Centers, we see how many e-Centers have accessed the net at least once (over a period of one month), for each of the 5 months for which we logged the traffic. The graph below shows Akshaya e-Centers, or other users such as police stations connected to the same network.



	Oct	Nov	Dec	Jan	Feb
Other Users	35	44	42	70	72
Akshaya Centers	255	325	344	339	330

Figure 9: Change in the number of e-Centers accessing the Web

The number of active Akshaya e-Centers increased from 255 in Oct. 2004, to peak at 344 e-Centers in Dec. 2004, reaching a plateau in the range of the 300s by Feb. 2005 (Table 9). This suggests that the level of usage (measured in number of e-Centers) is likely to remain stable or increase at a very small rate, unless there is either a significant demographic shift in the areas where e-Centers are located, or some new technology which catches on substantially among the

current users (increased videoconferencing or file-sharing are examples of possibilities), or finally, new sets of applications introduced to increase the pool of services offered by the e-Centers. The third is a likely possibility, given that the Akshaya team at the state capital has been working on extending their e-Pay services, networked education, and other applications across all active e-Centers. This latter case would increase in demand for traffic due to the incorporation of new regular users as opposed to more bandwidth intensive usage from existing users.

This brings us to another important question: what are the high network traffic e-Centers and how are they distributed? This is an important issue in studying the case for underwriting Akshaya as a public service utility – the higher the network traffic usage (assuming greater number of users as being partly represented in higher usage) the more 'successful' the project is from the government's point of view.

4.1.2 Analysis of Traffic per E-Center

Here, we analyze the total amount of traffic generated by various e-Centers as a rough measure of e-Center performance. The measure is not holistic, since it ignores non-network uses such as e-training programs. This also overlooks non-HTTP network traffic, though that is typically much smaller in volume than HTTP traffic, and does not dilute the credibility of the analysis.

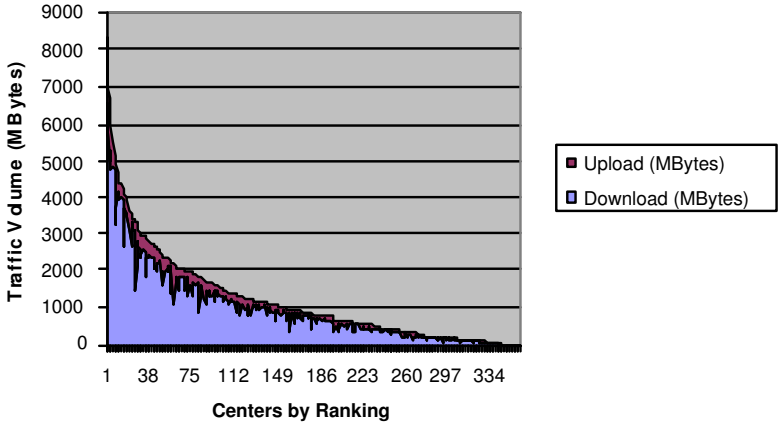


Figure 10: Download and upload by telecenter

Figure 10 presents the traffic volume, both download and upload, at each active Akshaya center, in the period January 8^{th} 2005 to March 8^{th} 2005. The e-Centers are ranked by the total number of bytes transferred in this period. We notice that a few e-Centers score very high, being very active, while a very large number of them are largely inactive, thus making limited gains from network-dependent services.

One explanation for the variation could be differences in entrepreneur skills and level of involvement, though factors specific to the e-Center's location are also influences. Yet, a surprising finding is that, the distribution of high- and low-traffic e-Centers is very similar for urban and rural e-Centers. The average amount of traffic generated in two months by an urban center is 1.71GB, close to the same average of 1.15GB for a rural center. The medians are also very close: 0.98GB versus 0.79GB. While the most 3 active e-Centers were indeed urban, 6 rural e-Centers were in top 10, and 43 rural e-Centers were in top 50 in terms of center activity.

This result is perhaps influenced by the relative homogeneity of population density and level

Application Domain	Share of Traffic (%)
Chat	17.99
Software	16.03
Portals	11.62
News	10.17
Spyware	8.78
Entertainment	8.31
Email	3.94
Search	3.57
Education	2.75
Government	2.26
General Information	2.03
Adult Content	1.81
Matrimonials	1.25
Job Search	0.74

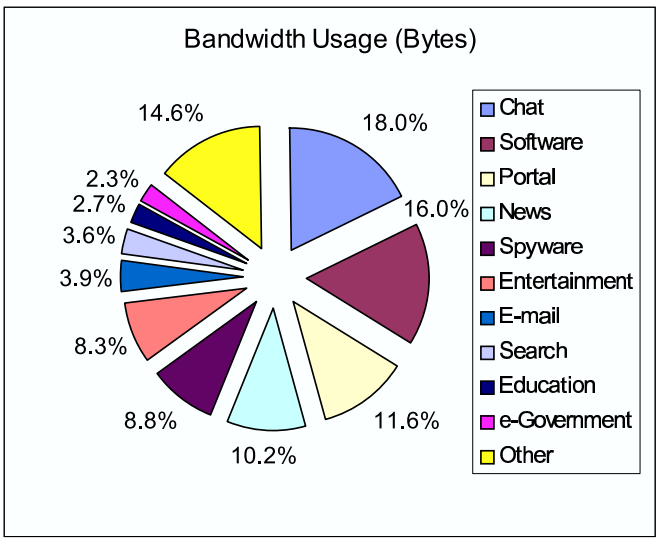


Figure 11: Classification of bandwidth usage by application domain

of income across urban and rural areas. This is further evidence that success may depend on the entrepreneur's skill and ability to attract customers through personal initiative.

4.2 Analysis of Internet Traffic by Content Category

Network traffic data was collected for 16 days in October, 2004. We aggregated daily results and sorted the accessed Internet sites by the network bandwidth used for accessing the websites, then manually classifying the top 400 sites (which account for the large majority of traffic) by the type of content served by each site, the language used in each of the sites and the country hosting it (Figure 11).

We see that chat-related content is the most popular, accounting for about 17% of traffic. Software downloads (including Windows Automatic Updates) account for 16% of the traffic, while portal sites (e.g. Yahoo) that offer everything from news, matrimonials, chat and email accounts account for about 12% of the traffic, news sites clock 10% of the traffic. Though spyware (parasitic applications, pop-ups etc.) is also well represented, it should be discounted from our analysis, since it does not represent voluntary traffic. This last factor, interestingly, makes a case for either using Linux, or getting commercial products that can stop this kind of load on the network.

Interestingly, 'local content' like e-governance, local product information, generally considered in developing region kiosks do not constitute a substantial fraction of the total traffic. This is a single analysis and as a raw measure in traffic does account for the actual benefits of the information to individuals, but does imply that entrepreneurs may find it difficult to rely on them to sustain revenues. The lack of interest in these categories might be explained by the current lack of e-governance content and infrastructure (and other content such on agriculture, fishing, healthcare) – though a future scenario of e-governance being the norm may lead to entirely different usage patterns in kiosks. With services such as these, there is a chicken-and-egg problem of getting a critical mass of vendors (including the government) to invest in online transactions, in the expectation that more people will become users of shared access e-Centers once there are tangible benefits to be gained from using them. Chat-type applications, including video-conferencing and other types of communications, are popular especially due to the large migrant population. VoIP services are

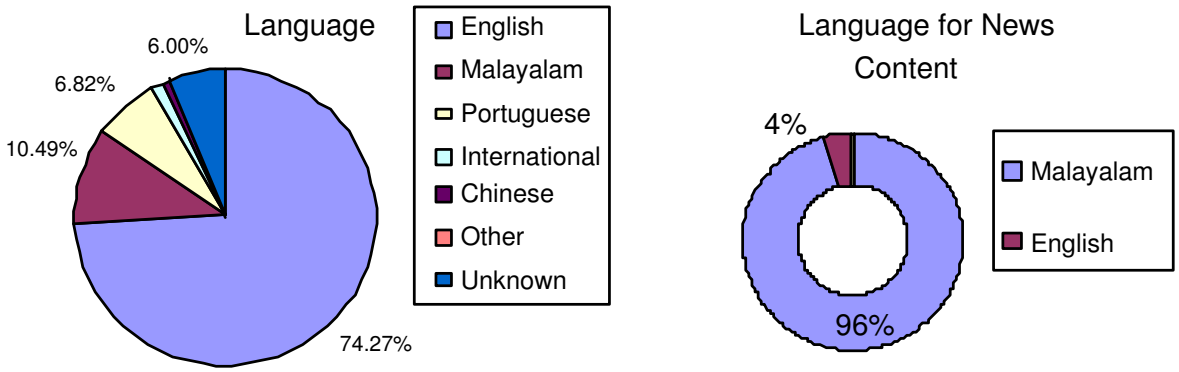


Figure 12: Languages used in Web Traffic

already gaining speed in several other parts of the country, but the expansion of bandwidth to the internet further from the present 2 Mbps will be essential in enabling this.

Traffic categories for Akshaya and their shares of the total traffic are fairly alike traffic patterns around the world: in American public access terminals we would find very similar patterns. This implies that, when considering the economic and usage sustainability of such enterprises, general purpose applications such as communication, email, web search and entertainment may indeed be killer applications, just as they are in more developed regions.

4.2.1 Language of Content

Looking at the languages of the web content accessed in the Akshaya network (Figure 12), we find that English content constitutes $3/4^{th}$ of the traffic, while Malayalam content represents only 10% of the accesses. This is because Malayalam content is poorly (or not) represented in a lot of application domains. The international language content from the figures does not represent a sudden increase in foreign language usage in Kerala, it turns out that the spyware on the computers in the network seems originate from Brazil.

While English content represents the majority of traffic, there is an overwhelming preference for Malayalam in news related content, where it accounts for 96% of the accessed content. This indicates a high possibility of Malayalam content being popular, were it available in other domains as well.

5 Conclusions

After the e-literacy phase, during which around 560,000 people were officially trained, the Akshaya e-Centers have been functioning mainly as cybercafés, though a sizeable number of them earn through training courses. The state continues to underwrite the wireless network, and is expected to do so till 2007.

E-literacy differentiates Akshaya from other e-Centers initiatives, in which villagers often have a very limited conception of what a computer can do. Even though the e-literacy course, if conducted uniformly and universally, does not train a person to become a proficient computer user, it does ensure that each household has one person who has some concept of what a computer is and what it can be used for, and perceivably this is an impetus factor for younger generations to learn computing down the line.

Additionally, the creation of permanent e-Centers plays a supportive role to the e-literacy training itself. For e-literacy, there is no need for permanent e-Centers, but as the Akshaya planners saw it, e-literacy had limited uses if there were no computers to be used once the initial training was done. That being said, there is sufficient concern regarding the sustainability of the e-Centers.

Our technical analysis and field work show that about half of the e-Centers have ever used the network in the last five months: over 200 e-Centers closed shop after the e-literacy, partly due to initial connectivity problems. The level of network utilization has currently reached a plateau, improving the quality of the network by increasing the maximum bandwidth, and introducing new applications will play an important role in the network utilization.

Communication (chat, voice over IP, video-conferencing) continues to be the major money-spinner, aided by the international connections. Services such as e-payment will be important going forth as they generate a periodic usage pattern. In contrast, e-government, health education, agricultural content are represented in a very small way. Tailor-made information for 'farmers and fishermen' isn't creating much impact, though the overwhelming preference for Malayalam language news indicates the long-term potential of local-language content. Initiatives creating fishing and agricultural information for rural villagers bear an important assumption – that people are willing to adopt new technologies in areas that are critical to their livelihoods. Unfortunately, while the impact of such endeavors could in theory produce positive disruptive societal changes, in practice there have been few successful examples. Akshaya is no exception in this respect.

The Akshaya planners have been excellent in incorporating many of the lessons from their testbed in Malappuram in their future layout plan for the rest of Kerala. The e-Centers to population ratio will be much smaller, possibly in the range of a third of the current ratio in Malappuram. In Malappuram, the local district collector, M. Sivasankar, played a vital role in getting the project off the ground, and continuing the project in its first year. Sivasankar's appointment to Malappuram is an interesting intersection of politics and operational efficiency. The collector's is the single highest political appointment in any district. This special appointment indicates the state government's placing the network over other developmental objectives for the district for that particular appointment period. This raises a crucial question - whether a similar "champion" is needed every time a project of this kind is implemented.

Idea of e-literacy came from the grassroots - village councils. It is not clear that other districts within Kerala will voice a demand for e-literacy with equal intensity, and what role such active demand (or lack thereof) will play. But even without e-literacy, it is evident from the regional analysis, as well as the high network usage in a number of e-Centers that there is a strong case for public e-Centers throughout Kerala. The e-literacy also had some interesting gender-related outcomes. About 65% of the people who came to study were women, however, on a less encouraging note, only 11.7% of the entrepreneurs are women. This is partly attributable to the conservatism of most of Malappuram.

Entrepreneurial skills have been vital in innovatively keeping e-Centers sustainable with a clever mix of online and offline services. The role of the entrepreneur was also more central than in other e-Centers projects since the entrepreneur had to go door to door, selling the idea of the e-literacy to get all the households in their assigned localities to participate. This has been an excellent way of selling the concept to the entire community, because in addition to the entrepreneurs' visits, the 'government' branding, alongside the village councils' stamp of approval created excellent credibility for the project.[31] The transference of the publicizing work to entrepreneurs was an excellent way of maximizing the word-spreading within the areas where reaching advertising the concept would

[31] Several entrepreneurs, at the end of the e-literacy, were considering entering public life because of the valuable technocratic influence on the entire community which had got to know them personally

have been difficult and expensive. Careful selection of entrepreneurs, done in some rush due to the political exigencies of the first iteration, will be vital in the future.

Malappuram and Kerala show regional characteristics that make them better suited for e-Centers than other states. Even so, we find the need to reduce the number of e-Centers from the current standard of 3 km. walk per household – moving the number higher certainly implies trading off universal accessibility. This is an important concern for governments which need to strike a reasonable balance between market and sustainabilitiy oriented arguments for computing services, and the logarithmic scale of expenditure on universal access.

Our evidence shows that people tend to use Akshaya e-Centers for things such as communications, entertainment, and file transfer – none of which are mission critical to livelihoods. Meeting with people actively involved in rural e-Centers projects across all of India suggests the similar frustrations faced by people trying to come up with appropriate types of information for farmers. While it is clear that ICT can be successfully employed to provide training and communication services, it is still unclear how and if applications seeking to improve local livelihoods can be successful, especially in short term.