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What Works Case Study

WHAT WORKS: FIRST MILE SOLUTIONS' DAKNET TAKES RURAL COMMUNITIES ONLINE

Affordable, asynchronous Internet access for rural users

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EXECUTIVE SUMMARY

Many developing countries continue to face the challenge of how to increase access to information communication technologies (ICTs) in rural and remote areas. Telecommunication companies are usually reluctant to extend their network due to high infrastructure costs, low population density, and limited ability to pay for the services. First Mile Solutions (FMS) counters this problem by providing telecommunications equipment that can cheaply connect rural and remote populations[1] to the Internet through an innovative technology: DakNet. DakNet leverages short-range wireless technology in tandem with traditional telecommunication and physical transportation infrastructures. Local transportation—e.g., public buses, motorcycles, and supply trucks—facilitates data exchanges between rural villages and Internet hubs. This unconventional communication network provides end-users with asynchronous access to e-mail, voice messages, and Internet browsing.

BUSINESS MODEL

First Mile Solutions (FMS), a company based in Cambridge, Massachusetts, is a product of MIT's Annual 50K Entrepreneurial Challenge, and has translated the rural telecommunication problem into a promising market opportunity. FMS is a provider of simple, low-cost, and low-risk telecommunication equipment that is easy to deploy and maintain. The FMS strategy is motivated by studies showing that rural and remote populations are willing to spend three to five percent of their household income on communication related services.[2] While the profit margin from each user may be low, the sheer size of the target population holds potential for high profitability. FMS occupies the market niche between more expensive real-time Internet technologies and cheaper asynchronous alternatives such as transferring data using USB keys or CDs. Its low cost and ease of deployment and use make DakNet the ideal technology for introducing users to the possibilities of ICT services and gauging their demand.

The main clients of FMS can be divided into two categories: 1) non-profit institutions that work in rural areas such as non-governmental organizations (NGO), development organizations, governments, and academic institutions; and 2) for-profit companies such as local Internet Service Providers or corporations that work in rural areas. While FMS may enjoy a greater potential for growth by serving the latter market, for-profit companies are more skeptical of the possibility to serve rural populations profitably. As such, clients of FMS so far have fallen into the first category—NGOs and development organizations that are experimenting with different ICT pilots related to development. To catalyze the formation of an end-user market, the founders of FMS have launched another company, United Villages (UV), with the business purpose of creating for-profit rural Internet Service Provider operating companies in developing countries. United Villages and First Mile Solutions merged in August 2003 to leverage the consolidated benefits of both the vendor and service provider models. United Villages has established an operating company in India in September 2005, United Village Networks Private Limited.

DEVELOPMENT BENEFIT

FMS' most direct benefit stems from providing ICT access to people in rural and remote areas that would otherwise have had to use personal visits, regular mail, or radio communication to accomplish the same purpose. Through appropriate application, having access to ICT can also generate benefits in other areas such as education, health, commerce, and governance. To achieve other development benefits, FMS depends on its clients and strategic partners to use the technology effectively. American Assistance for Cambodia/Japan Relief Fund (AAfC/JRF), an NGO based in Cambodia, was the first organization to experiment with ICT applications of DakNet. After connecting a few schools in rural areas to the Internet via Satellite, AAfC/JRF used these schools as shared access points to experiment with pilots in telemedicine, e-government, and e-commerce. The telemedicine project, which allows doctors in cities to treat patients in more remote clinics and hospitals, has resulted in better health care and has indirectly improved local doctors' skills. The e-government project allows villagers to e-mail the governor directly. The e-commerce project allows weavers to generate extra

[1] Rural areas are characterized by a population density of two hundred and twenty people per square kilometer with an average annual income of $USD 350 a year. Remote areas have population density of one hundred people per square kilometer with an average annual income of $USD 200 a year.
[2] International Seminar on ICT Policy adn Rural Telecommunications, 2004. http://www.ictseminar.org/ICTWorkshop/FAQ.asp?CategoryID=756

income by selling their silk scarves and local handicrafts over the Internet. While the pilots were implemented on a very small scale, they have revealed key insights on the application of DakNet.

CHALLENGES

FMS' main challenge is to penetrate the relatively risky and unknown rural market by combining its ability to provide low-cost Internet access with locally relevant applications, keeping in mind the end-users' limited ICT literacy. Applications are the key to generating end-user demand for DakNet technology. Since FMS itself does not develop these applications, FMS will need to rely on strategic partnerships or its clients. Some organizations have used FMS technology to develop applications but none have moved past small-scale deployments. While the United Villages (UV) model is a more active attempt to engage the end-user, it still needs to work with a network of application developers and service providers in order to create real value for the end-user. Additionally, the regulatory environment may prohibit profitable services such as United Villages' proprietary VoiceMail Over IP technology.[3] The next two years will be crucial in determining the success of both the FMS and UV ventures.

[3] VoiceMail over IP is a way to send and receive voice messages – it is essentially a way to send a static voice message to someone's phone. Voice over IP (VoIP) is a real-time protocol which enables users to talk in real-time. VoIP has come under regulatory pressures as it competes with the traditional PSTN network (i.e. the wireline phone).

WHAT WORKS:
FIRST MILE SOLUTIONS' DAKNET TAKES RURAL COMMUNITIES ONLINE

ICT PROMISE FOR DEVELOPMENT

Information Communication Technologies (ICTs) have been indispensable in helping industrialized economies achieve productivity gains over the last twenty years. ICTs hold as great a promise for the world's poor as tools that can improve living standards and spur growth across economic classes. An expansive telecommunications infrastructure offering services at a low cost helps developing nations to integrate more effectively with the global economy, increase the efficiency of local economic activities, abet democratic governance, and improve the quality of basic social services such as health care and education. Thus ICTs are seen as *overall enablers of development*.[4] The United Nations' influential Millennium Development Goals (MDGs)[5] both target and rely on ICTs. Target number eighteen[6] of the MDGs specifically states to "*make available the benefits of new technologies, especially in information and communication.*" Successful attainment of other MDGs goals and targets will depend on effective use of ICTs.

ADVANTAGE OF DEVELOPING COUNTRIES

Developing countries have the advantage of adopting optimal technologies for their needs without having to invest heavily in R&D themselves. Although ICT implementation costs remain prohibitively high, recent technologies such as wireless ICTs are becoming less and less dependent on expensive physical infrastructure. Some examples of ICTs that have or are quickly gaining traction in developing countries include mobile phone networks, Internet based services, and Voice over IP (VoIP). VoIP in particular, is revolutionizing the telecommunications industry by offering the same rates for international as for local calls.

CHALLENGES TO ADOPTING ICT

Despite the promising benefits of these technologies, developing countries, especially in rural and remote areas, have been slow to change for several reasons. High cost and limited access are the main obstacles to telephone services. The ratio of communications infrastructure costs to income is many times larger in developing countries.[7] Individuals in developing countries must spend a more significant portion of their income than their counterparts in industrialized countries for the same communication service.[8] The high costs are primarily due to inefficient state-owned telecommunication providers. The absence of competition tends to result in higher prices and lower quality of service because operators have less incentive to regularly maintain and repair existing infrastructure. For example, some clients in India have referred to their phone service as "seasonal" because service is highly dependant on when technicians happen to be in the area. In addition, governments often impose restrictions on the use of technologies that can reduce telecommunication costs such as VoIP because it affects the state's monopoly on market share and revenues.[9]

Given the high relative costs in many developing countries, ICT services are typically shared among the users. Instead of having a computer or telephone in every household, people go to telecenters, Internet cafes, or e-kiosks. However, shared phones at telecenters lower the value of real-time one-to-one communication because they require the communicating parties to agree on a meeting time

[4] Accenture, Markle Foundation, UNDP, Creating a Development Dynamic, Final Report of the Digital Opportunity Initiative. http://www.opt-init.org.
[5] http://www.un.org/millenniumgoals/
[6] Included in Millennium Development Goal number 8: Develop a Global Partnership for Development.
[7] In industrialized countries, the original telecommunication infrastructure was also expensive relative to income. Government interventions, through for example state monopolies, were needed to provide the initial funds. The high costs made telecommunications a risky venture for the private sector since many years of strong revenues were needed to eventually recover the initial investment.
[8] Telephone subscription costs 33% GDP per capita in low income countries and 0.8% in high income countries. Total Internet Price (cost of 20 hours of Internet use per month) is $USD 57.28 in low income countries and $USD 23.27 in high income countries. (ITU World Telecommunication Indicators 2003)
[9] ICT in Africa: A Status Report, Chapter 6 World Economic Forum Global Information Technology Report 2002-2003, Mike Jensen http://www.weforum.org/pdf/Global_Competitiveness_Reports/Reports/GITR_2002_2003/ICT_Africa.pdf (accessed January 22nd, 2005).

beforehand. If one wants to call a friend in a rural village, one needs to make sure that this person will be at, or close to, the telecenter when the call is made. Telecenters often overcome this requirement by broadcasting incoming phone calls.

Even if they can afford the services, ICT access in rural areas is limited because long distances and low population densities result in higher cost-to-number user ratios and rural inhabitants have lower incomes. From a profit perspective, it does not make sense to pay more to reach fewer people who have less to spend. From a development perspective, this is unfortunate since communication technologies can greatly benefit the rural poor. For example, farmers can use telephones or cell phones to check which markets are offering the best prices instead of physically bringing all their goods to market without knowing if he is receiving the optimal price.

Besides access, other obstacles that limit the use of ICT in developing countries include limited human capacity, expensive hardware such as mobile phones or computers, and lack of locally relevant applications. All of this limits actual ICT demand even though people would like to enjoy its benefits.

FIRST MILE SOLUTIONS

First Mile Solutions (FMS) specifically tackles the problems of high cost and limited access through its Village Area Network technology which includes DakNet, a novel, low-cost technology.[10] DakNet integrates inexpensive Customer Off-The-Shelf (COTS) hardware components, open-source software, and FMS's proprietary software to create an asynchronous Internet hub and spoke system. Computers at the hub are connected to the Internet in real time, while computers at the end of the spoke are connected asynchronously. Traditional transport mechanisms such as cars, motorbikes, buses, or even donkeys transport data between the hub and spoke.[11]

COMPANY BACKGROUND

FMS co-founders Richard Fletcher and Amir Alexander Hasson first met in 2001 when they were taking Professor Sandy Pentland's class on Developmental Entrepreneurship at the Massachusetts Institute of Technology (MIT).[12] Inspired by the possibilities of new and affordable wireless technologies, they began to formulate a vision for DakNet as a class project. At the time, available technologies providing Internet access in rural areas were all either too expensive or too risky for telecommunication operators to implement. Traditional wireline infrastructures were too expensive to install and maintain and new technologies such as WIMAX-type systems were too risky to immediately launch on a wide scale. DakNet, they believed, could overcome these deficiencies and provide a glimpse into the market opportunities that exist in serving people living in rural and remote areas. Fletcher and Hasson were inspired by the idea that profits could be made by catering to the poor as customers. This concept, known as the bottom of the pyramid (BOP) business model, was popularized by C.K. Prahalad, Al Hammond (Prahalad, Hammond, 2004), and Stuart Hart. They believed that low-cost, innovative solutions can profitably address the unique needs of the low-income market.

Fletcher and Hasson's ambitions and aspirations led them to take their class project to the next stage and enter MIT's Annual 50K Entrepreneurial Challenge.[13] To support their entry, they deployed a successful proof-of-concept system in rural India. Their idea and pilot brought them to the semi-finals and an opportunity to incubate it at MIT's Media Lab Asia.[14] Hasson moved to India to work with Media Lab Asia for nine months to manage rural WiFi pilots including DakNet. The primary DakNet pilot in India was with Bhoomi, an eGovernance initiative established by the Indian State Government of Karnataka to computerize all land records in Karnataka. Armed with these initial proofs of concept, Hasson returned to Boston and was contacted by Bernie Krisher from American Assistance for Cambodia/Japan Relief Fund (AAfC/JRF) to deploy their solution for rural schools in Cambodia. FMS' first commercial deployment followed shortly thereafter and was launched September 1, 2003. Because FMS was first incubated at the MIT lab and quickly captured AAfC/JRF as its first client, it was able to generate revenue and break-even right from the start, according to Hasson.

The official mission of FMS is to "help public and private organizations in developing nations bridge the digital divide by providing affordable, scalable communications infrastructure and by building internal capacity in wireless networking."[15] As of January 2005, FMS had four full-time staff, including the founders, and had deployed their technology in four countries: India, Cambodia, Costa Rica and Rwanda. A rough calculation shows that their technology has connected 30,000 villagers which, based on the bottom of the pyramid concept, leaves them 3.9 billion more as potential customers.

TECHNOLOGY

The underlying concept of DakNet is simple and has been around for some time. Computer scientists first invented *sneakernets* to transmit data, not by phone lines or wirelessly, but rather by foot or "sneakers." When large quantities of data need to be moved and time lag is not a key consideration, it often makes more sense to transport data on CDs; the resulting bandwidth can actually be very

[10] Dak is hindi for "post" or "postal"
[11] FMS' entry into the MIT 50K entrepreneurial challenge was entitled "*Donkey Net*".
[12] http://web.media.mit.edu/~sandy/
[13] *http://50k.mit.edu*
[14] MIT media lab Asia's main research focus was on technologies for developing countries.
[15] www.firstmilesolutions.com

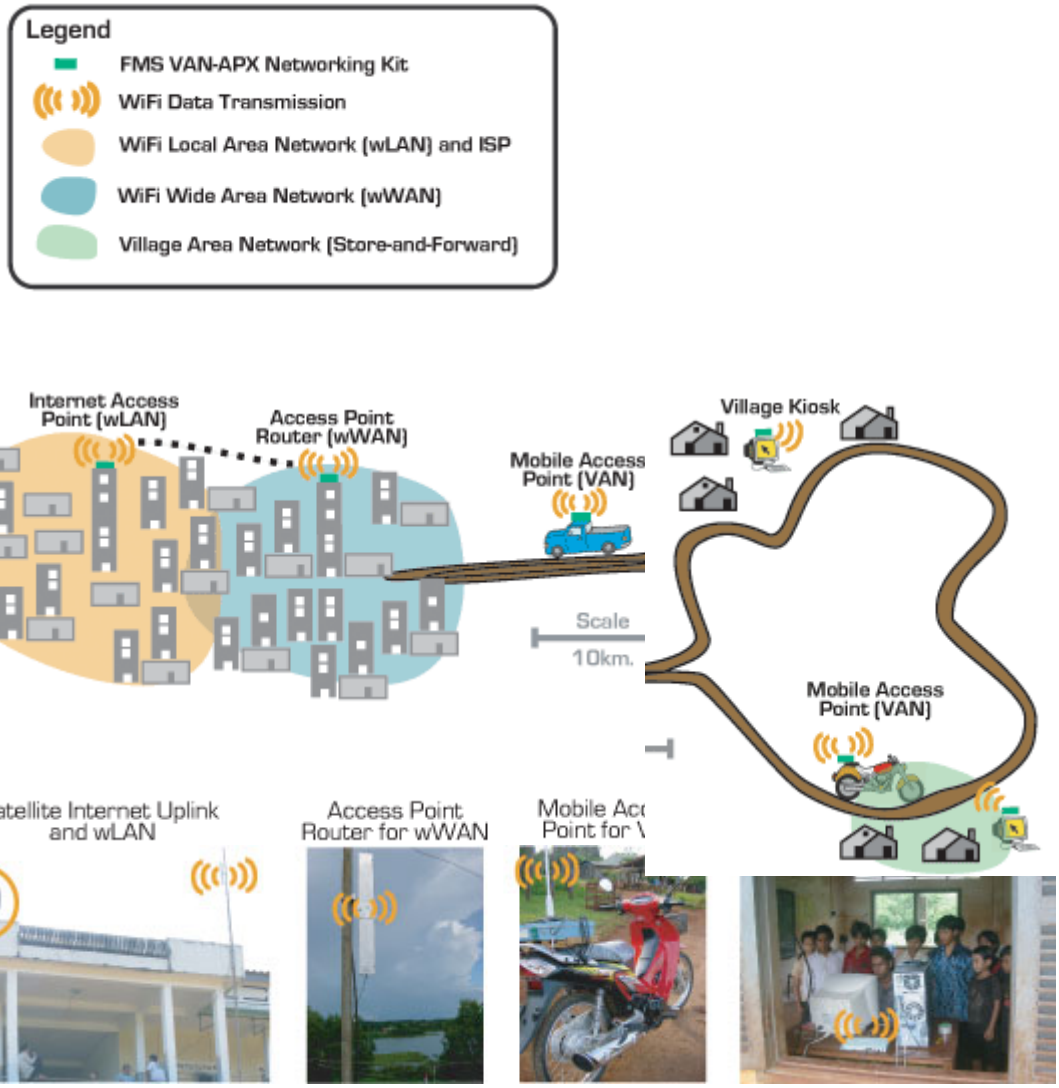
high.[16] The poor quality of phone lines in developing countries is another motivation for using sneakernets and batched or cached data transfers. In fact, Drishtee, a social enterprise in India that provides e-government services, initially used a cached data transfer approach over dial-up for its rural kiosks. Analysis suggests that the scalability of Drishtee's operations may be challenged because of the limited availability and reliability of dial-up connectivity in rural India**.**[17] Other than the fact that data moves more slowly on sneakernets, a major disadvantage is that it requires fairly extensive manual intervention. The sender first has to write the data on a portable storage medium, say a CD; he then hands the CD to someone, referred to as the *e-postman*, who delivers it to an administrator who sends the data on the CD using his Internet connection.

DakNet addresses this problem by making use of recent advances in cheap, high bandwidth and easy-to-use wireless technologies. Data is seamlessly transmitted over a wireless link to the e-postman and then to the Internet access point. The e-postman does not need to do anything other than come within range[18] of the different users. For example, the e-postman could simply be a bus driver doing his routes, completely oblivious to the data transfers taking place. For a rural villager to send an e-mail, he composes it with his favorite e-mail program (e.g. MS Outlook, Yahoo mail, etc.) and presses send. The e-mail is stored on the computer until the e-postman comes within range. At this point, the Fixed Access Point (FAP) device connected to the user's machine automatically transmits the e-mail to the e-postman's Mobile Access Point device (MAP). When the e-postman arrives at the hub where a computer is connected to the Internet, the e-mail is transmitted from the MAP to the Internet hub, and then to the Internet. An e-mail sent to a rural villager takes the opposite route. The e-mail is transmitted from the Hub Access Point (HAP) to the e-postman's MAP, then to the recipient's FAP, and finally to the user's mailbox. *DakNet* overcomes the fact that the infrastructure capable of carrying data is severely limited in rural areas by leveraging traditional transport infrastructure such as roads and potentially water and air.

In addition to e-mail, users can surf the web asynchronously by requesting a certain number of web pages to be retrieved at the Internet access point and sent back. Current applications not only download explicitly requested web pages, but also the pages that are linked by the requested page.[19] FMS is currently evaluating the possibility of caching a large number of Internet web pages at each remote location.[20]

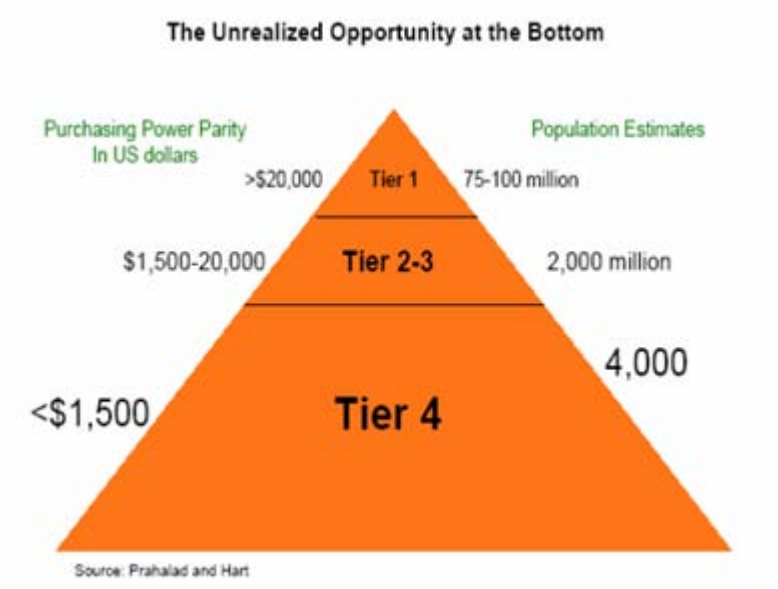
[16] A crate full of CDs can hold huge amounts of data.
[17] Hasson, 2002.
[18] The range can vary depending on the implementation but typically, if the e-postman drives in front of the user's house, there are no problems.
[19] One can download several levels of web pages, i.e., download the pages that linked to the pages initially requested.
[20] Hasson refers to this as Akamai for asynchronous networks.

The diagram below illustrates how the technology works for both real-time point-to-multipoint WiFi links as well as store-and-forward 'drive-by' DakNet links which together constitute a "Village Area Network" as coined by FMS.



BUSINESS MODEL

FMS positions itself as an affordable WiFi solutions provider for rural and remote Internet connectivity. The business model of FMS is consistent with the core concepts of the *base of the pyramid* (BOP) (Prahalad and Hammond, 2002).



The BOP business model views 4 billion people who earn less than $1500 a year as a business opportunity rather than too poor for anything but aid. While people at the BOP have low individual purchasing power, their sheer volume allows providers of goods and services to lower their prices but still earn a profit through high volume. The key is to offer goods and services that are relevant to the BOP's needs because they have limited disposable income. By providing an innovative, low-cost, and easy-to-use telecommunication alternative, FMS hopes to address the communication needs of the BOP market. The following subsections address the issues of revenue sources, customers, competition, and conclude with a real-world cost comparison.

REVENUE SOURCES

FMS generates revenues from both its core technology and accompanying consulting services, including the following:

- **Hardware**: Hardware prices for the core FMS technology and antennas are in Appendix 1. Since the price of the wireless technology that FMS uses should drop significantly over time, we expect that FMS' sourcing costs will be lower in the future. This will allow FMS to increase its profits and/or lower the costs of its products.
- **Software**: FMS recently began to charge for the software it provides with its systems **(**see Appendix 1**)**. FMS offers core applications that allow the network to function properly and increase the value of the system. For example, they provide software that makes asynchronous web-surfing possible and lets individuals create and send voice messages to phones or e-mail accounts. In the near future, they plan on creating new applications that allow more effective interaction with e-commerce web sites such as e-Bay or Amazon, and the creation, storage, and management of large caches of web pages.
- **Installation and Training**: FMS technology requires some expertise to plan, configure, deploy, test, and roll out with training to local support personnel. FMS typically sends its staff on-site to carry out these tasks. Although the amount of time required varies depending on the deployment characteristics, a typical project connecting one HAP (hub) to five FAP (e-kiosks) using a single MAP (e-postman) involves:

Action	Number of days	Number of engineers	Cost (USD)
Design and plan the network	3 days	One engineer (USD 480/day)	1440
Configure the nework and train local system administrators	3 days	Two engineers (USD 260/day)	1560
Deploy and train local users	7 days	Two engineers (USD 260/day)	3640
Train administrators on testing and maintaining the network	3 days	Two engineers (USD 260/day)	1560
Total[21]	**16 days**		**8200**

- **Maintenance**: Clients usually carry out maintenance operations, but FMS intervenes remotely for more complex issues. For these services, FMS charges an ongoing service fee of $USD 25 a year for each connected village. The fee can vary depending on the scale of the deployment.

The following table outlines the price associated with the first year of a hypothetical deployment[22] connecting five schools using one e-postman and one Internet hub. (This is a partial view since some costs, such as per-diems and airfare, are not included.)

Component	Price ($USD)
Hardware	4,305
Software	415
Installation & Training	8,200
Maintenance	125
TOTAL:	**13,045**

Although these figures are useful estimates of costs, FMS usually tailors the pricing and services provided to each client because the local context, quantity of equipment, and usage needs vary widely. Also, total costs depend on whether a project is more or less service-intensive. Hasson estimates that each FAP, MAP, and HAP hardware component costs FMS USD 400, a large part of which is dedicated to supporting network software.

CUSTOMERS: FOR-PROFIT VS. NOT-FOR-PROFIT

FMS initially attracted potential customers through the media exposure it received through general press including CNN, the Wall Street Journal, and the Economist.[23] It also participated in several international conferences including the United Nations ICT Task Force Workshop on Open Access in 2003. In fact, media attention generated enough business leads for FMS to avoid spending additional efforts on marketing. To sustain its growth however, FMS is considering hiring a marketing manager.

FMS customers can be classified into two categories: not-for-profit institutions that work in rural areas and for-profit companies. Currently, clients mostly fall under the first category – governments, NGOs, and development organizations willing to carry out ICT projects aimed at improving the lives of the rural poor even if they are not profitable. Instead of using investment returns as the benchmark, these institutions use measures such as improvements in access to information, education, health, and improved governmental processes. As a secondary benefit, pilots using the innovative nature of DakNet create greater visibility and media attention,[24] which in turn helps FMS' not-for-profit customers to secure important funding and public support.

[21] This figure does not include travel, per-diem, and other related costs.
[22] Inspired by the Chulumani, Bolivia pilot proposal.
[23] http://www.firstmilesolutions.com/news.php
[24] The Cambodia DakNet has been featured on CNN and in publications such as Newsweek and The Herald Tribune.

For-profit		Not for profit	
Customer	**Core Need**	**Customer**	**Core Need**
Village kiosk operators/ Internet Service Providers	Generate income from providing Internet services in rural areas.	Governments	Expand ICT coverage; enable data collection
Corporations	Decrease information costs and inefficiencies in the supply chain; find new channels to reach the rural market	NGOs/ Development organizations	Improve people's access to information in rural areas; Communicate between local staff and headquarters.
		Academic institutions	Facilitate research projects in rural areas

FMS can sell its technology to for-profit companies that are either Internet Service Providers (ISPs) or corporations that work or want to work in rural areas. Of the two, its primary business model is to sell to ISPs willing to provide service in rural areas. Surveys in rural India have revealed that on average, people spend between three and five percent of their household income on communications-related expenses, such as news, TV, radio, mail, and phone.[25] Some studies even argue that since an increase in income may result in a larger increase in communications-related expenditures, there is latent demand for ICTs.[26] Recent experiences from kiosk operators such as Drishtee[27] and N-logue in India have shown that rural inhabitants are willing to adopt new technologies that provide cost-savings, especially when they offer lower-cost substitutes for existing expenses as opposed to new costs requiring disposable income. By providing e-government services, they save users both time and money by avoiding a personal trip to the government office.

Assuming that each kiosk or ISP serves 1000 inhabitants, FMS believes that it has the potential to generate USD 1900 – USD 3800 per year at price as low as USD 19 per year for the end user.

Figure: Potential telecommunication revenues per 1,000 inhabitants.[28]

Telecom expenditure/year, per client	Penetration (%)	Revenues/year (USD)
USD 19 (rural)	10	1900
USD 10 (remote)	10	1000
USD 19 (rural)	20	3800
USD 10 (remote)	20	2000

Despite the promising market opportunity, people at the BOP are also the more difficult to reach and people are still very skeptical that serving this segment can be profitable. Thus far FMS has only been able to sell to one telecommunications company, located in Rwanda.

The other type of for-profit company that FMS aims to sell to is corporations that work or want to work in rural areas. For example, it has explored a solution for a sugar company that would like to use Internet access to manage communications with its sugar suppliers in rural areas.

[25] Harvard's Center for International Development, Christopher Blattman, Jensen, Robert, Roman, Raul, "Assessing the Need and Potential of Community Networking for Developing Countries: A Case Study from India", February 2002, Unpublished.
[26] A one percent increase in income resulted in expenditure increases in News (2.33%); Cable-TV (1.26%); Phone (1.11%); and Mail (.81%), or on average a 1.4% increase in total ICT expenditures. (Hasson 2002)
[27] Case Study on Drishtee Telecenter Initiative, Part of the "Empowerment Case Studies" project commissioned by the World Bank Poverty Reduction Group and drafted by the Indian Institute of Management - Ahmedabad. http://poverty.worldbank.org/files/14646_Drishtee-web.pdf (accessed on January 23, 2005).
[28] Based on FMS' models

COMPETITORS: ICT TECHNOLOGY SPACE

As a telecommunications equipment company, FMS mainly competes against other ICT-related technologies. However, the products of its competitors are significantly different from DakNet. Technological alternatives may be separated roughly into four categories: wired, wireless, satellite, and sneakernet-inspired technologies.

Technology	Advantages	Disadvantages
Wired	High bandwidth (fiber optic).	Expensive maintenance Extensive infrastructure
Wireless	Fairly high bandwidth Good coverage	Need to install towers and have decent line of sight
Satellite/VSAT	Minimal infrastructure Ease of installation	High cost of bandwidth High latency[29]
Sneakernet/DakNet	Low cost Ease of installation	Asynchronous

Wired networks provide the best data transfer speeds when fiber optic cable (not copper) is used, but this requires extensive infrastructure. The higher implementation cost is acceptable in areas with heavy traffic, but not in rural areas. In rural areas, wireless technologies are a more cost-effective solution. Maintenance costs and down times are typically higher with wired networks.

Wireless technologies have a large range. CorDect, which has characteristics that are similar to the upcoming WiMax standard, has already been deployed by several rural ISPs. In CorDect deployments, repeaters are typically used to extend the range of the base station to a maximum of twenty-five to thirty-five kilometers. The range however, depends on the geographical terrain of the area. The range can be significantly reduced and more expensive to achieve in mountainous areas. The cost of setting up an access center varies between USD 93,000 and USD 100,000 (Paul, 2004). The local kiosk start-up kit, which includes telecommunications equipment and a PC but not maintenance and repair, costs USD 1,300 (Paul, 2004). CorDect provides telecommunications access to all inhabitants within the access center's range who have appropriate hardware. In remote areas however, having such a wide coverage is not always important. The need is less acute when villages are scattered and individuals share equipment located at specific access points. Certain countries require regulatory approval of this type of technology.

Satellite/VSAT (Very Small Aperture Terminal) technology allows users to connect to the Internet from virtually anywhere on earth with minimal infrastructure. Only a power source and a view to the sky are required. This is the only option for extremely remote communities. Satellite technology deployments can cost as little as USD 2,000 to set up, although they tend to be significantly more expensive. The main disadvantages of this technology are high latency and high network usage fees. Access charges vary between USD 3,000 and USD 6,000 a year. Although these fees are usually too large for FMS' target population, VSATs can be used to connect DakNet's hub to the Internet. The costs of the VSAT are then amortized over more users.

Traditional sneakernets come closest to FMS' technology. The Wizzy Digital Courier project in Cape Town, South Africa achieves access by using milk trucks to physically transport data that schools want to send and receive through a USB key. The software needed to carry out sneakernet data transfers is open source and similar to the software used by FMS. Thus the costs are minimal and mainly pay for the truck drivers to perform manual data transfers. The manual intervention makes the sneakernet approach less scalable than DakNet's seamless data transferring network. Both Wizzy and DakNet have the key advantage of being significantly cheaper and less risky than other technologies. They are also less likely to come under the scrutiny of telecom regulators. Their target market, the 20,000 individuals situated within a radius of five to eight kilometers from the hub,[30] is not profitable for traditional telecom companies but can generate profits for local operators using FMS.

However, when population density is high enough throughout a larger range, CorDect becomes a more competitive proposition. For example, if rural and remote densities are constant throughout a

[29] Latency is the amount of time a message takes to traverse a system.
[30] Assuming 1) rural and remote population densities, 2) one FAP or kiosk per 1,000 individuals, and 3) 20 kiosks per hub.

twenty-five kilometer radius, the covered population is over 400,000 in rural areas and close to 200,000 in remote areas. It may make more sense to deploy a CorDect system with a population of this size especially if demand for the service is high. Taking the one-kiosk-per-1,000-inhabitant ratio, DakNet would require over two hundred fixed-access points and many e-postmen, resources that would be difficult to manage and set up.

Determining which technology is the most appropriate in any given setting is a complex and often imprecise task. The most appropriate technology provides the optimal cost to functionality value proposition.[31] If villagers are unwilling or unable to pay more for real-time services, the deployments are small scale, and the population density is uneven, FMS technology is the best solution. Whether FMS can succeed in a given region depends on many factors, including:

- Frequency licensing fees
- Existing infrastructure
- Bandwidth and latency requirements
- Total number of access points
- Population density
- Geographical terrain
- Maintenance costs (local expertise, availability of replacement parts, etc.)

ANALYSIS OF ASYNCHRONOUS COMMUNICATIONS IN DEVELOPING COUNTRIES

The major drawback of DakNet technology is that it provides asynchronous and not real-time Internet access. The speed of the network is dependent on the frequency of visits from the e-postman. Asynchronous communication has the following disadvantages:

- The network cannot support potentially important applications such as VoIP.
- The context-aware, customized web pages found on advanced web sites cannot be viewed optimally.[32]
- It is difficult and cumbersome to make use of e-commerce web sites and fill out forms.[33]
- Asynchronous web surfing is not as effective nor enjoyable.

These drawbacks however, are not as serious a limitation as they might initially appear. In fact, a recent quantitative study done by graduate students at the University of California - Berkeley (Guerraz et al., 2003) recommends the use of asynchronous communication infrastructure in developing countries. Based on the output of their cost calculator and other considerations such as power sources, scarce bandwidth, and unreliable infrastructure, they argue that asynchronous communication in general leads to the most efficient use of scarce resources in developing countries. For example, since low access speeds and network congestion[34] are common in developing countries, real-time services can be costly and ineffective. In these situations, asynchronous communication makes sense because it spreads out data transfers more evenly over time, using the communication medium more effectively.[35]

Besides being able to use resources effectively, pilot projects have shown that asynchronous communications can adequately meet the needs of individuals in the target market. Analysis of the 2001 SARI pilot project[36] that brought ICTs to parts of rural India (65 kiosks) indicates that 94% of information exchanges were asynchronous. The relevant applications did not require real-time communications. McKinsey, a management consulting firm, concluded in its report on SARI that in the short term, only e-mail, scan-mail, voice-over-e-mail, and chat were likely to generate revenues. This implies that the primary value added of real-time communications is only chatting. It is unlikely that the revenues and increased utility from chatting warrant the additional expenses required to build real-time infrastructure. Furthermore, since the rural poor typically share ICT access, coordinating with

[31] Note that we assume all technologies support voice and data services.
[32] The web server does not have access to the cookies stored on the user's computer that are needed to customize the displayed web page.
[33] FMS wishes to develop software that will help users fill out web forms more effectively.
[34] Congestion can be due to low capacity pipes linking the country to the Internet backbone or simply the low capacity of certain channels such as satellite uplinks.
[35] Note that the most popular Internet protocol (TCP) is real-time are badly suited to this type of environment. This leads to low effective utilization rates.
[36] C.f. SARI web site http://edevelopment.media.mit.edu/SARI/mainsari.html (accessed March 9, 2005)

friends to simultaneously be near the access centers can be a complex task. Until key applications requiring real-time connectivity are introduced and adopted, the demand for more expensive real-time systems is likely to be limited. In light of these observations, asynchronous communications should be able to meet most of the connectivity demands of poor rural areas in the short- to medium-term.

DAKNET'S COST ADVANTAGE: A REAL WORLD EXAMPLE

FMS' first major client was American Assistance for Cambodia/Japan Relief Fund (AAfC/JRF), an NGO based in Cambodia that has built over 250 schools. AAfC/JRF first approached First Mile Solutions in 2001 to connect its schools to the Internet. Many schools were already equipped with computers and printers powered by solar panels. However, only one school,[37] using a donated satellite, was connected to the Internet. Satellite technology was the only way to connect schools without telephone lines. Needless to say, it was too expensive to purchase a satellite for every school. AAfC/JRF was interested in FMS' technology as a much cheaper alternative. DakNet infrastructure was also more difficult to steal and vandalize than satellites and wireless base stations. If all fifteen schools had been connected to the Internet via satellite, it would have cost[38] USD 260,376 for the first year.[39] Using FMS only cost USD 39,979 (at that time, FMS did not charge for its software). FMS used the school that was already connected to the Internet as a central hub. The other fourteen schools were divided into five routes, each of them serviced by a "motorman." Motormen are the e-postmen hired locally that ride their motorbikes between the central hub and surrounding schools. Information from the schools would automatically be downloaded from the FAP to the MAP when the motorman passed by, and uploaded to the hub when the motorcycle returned. A hub operator trained by FMS managed the hub. Altogether, the DakNet solution was cost effective.

Satellite		**First Mile Solutions**	
Satellite	$ 49,500	Satellite	$ 3,300
Usage fee	$ 54,000	Usage fee	$ 3,600
Electric Generator	$ 25,500	Electric Generator	$ 1,700
Gas	$ 77,376	Gas for Generator	$ 5,158
Hub Master	$ 54,000	Hub	$ 699
		Hub Master	$ 3,600
		MAP	$ 2,995
		FAP	$ 7,485
		Motor man	$ 6,000
		Antennas	$ 3,000
		Gas for Motorcycle	$ 2,418
		Motorcycle Maintenance	$ 24
Total Cost	**$ 260,376**		**$ 39,979**

As of December 2004, AAfC/JRF had purchased equipment for 3 HAPs, 7 MAPs, and 33 FAPs. AAfC was so pleased with the results that they had already made plans to connect 10 schools in Robib, 9 schools in Koh Kong, and 10 schools in Preah Vihear in the near future. The introduction of basic telecommunications services in these places has been revolutionary, as many of these places did not even have a regular postman. The solution offered by FMS and AAfC/JRF is currently the only viable option for connecting to the Internet. This successful deployment of DakNet technology proved that it can function under difficult conditions, be it poor infrastructure, challenging climate conditions, or limited capacity of local staff. This proof-of-concept has paved the way to more opportunities.

[37] School #1 in Robib was the first to be connected to the Internet. The satellite and monthly service fees were donated by ThaiCom.
[38] Installation and maintenance fees not tabulated.
[39] Deploying wireless technologies to connect the rural schools to the Internet would have been as expensive as using a satellite. The schools were barely within the range of CorDect which costs around $USD 200,000.

STRATEGY FOR THE FUTURE

In order to play a more important part in its ecosystem and to help bootstrap the end-user market, FMS founders launched a separate venture, United Villages. In March 2004, an early-stage venture capital firm, Cambridge Light Partners, decided to invest in Hasson and Fletcher's vision. However, they were not interested in supporting a technology equipment company, but were excited about the potential of a service company for rural ISPs. They believed a company focused on bootstrapping and penetrating the rural ISP market represented a more attractive investment opportunity. Hasson thus created United Villages (UV) to fulfill this role. The relationship between UV and FMS is equivalent to the relationship between Verizon and Cisco. Verizon delivers services to end-users and actualizes deployments, whereas Cisco provides the networking equipment that supports Verizon's activities. Although UV is technology-blind and free to deploy the most appropriate technology for its clients, FMS is its primary equipment provider.

UV's business model is to fund start-up rural ISP operators while keeping a fifteen to twenty percent stake in them. In addition to providing initial capital, UV also manages value added services such as e-mail and voice-message-over-Internet Protocol (VMoIP). These additional services give UV an entry into the end-user market of the rural poor. Managing end-user identities through e-mail addresses provides business opportunities for other activities. For example, UV aims to launch a new private Internet currency.[40] UV envisions a scenario that involved an individual in the US buying DakNet credits for his relative in his homeland to purchase local products and services. This could be an entrance point to the lucrative remittance market since relatives in industrialized countries are already communicating with their friends and family in poor areas using DakNet.

Adoption of DakNet technology will depend heavily on the usefulness and relevance of related applications and the villagers' ability to use them despite low levels of education and literacy. Since FMS and UV have made a conscious decision to focus on creating a small set of core tools instead of creating many different applications, they must indirectly support application developers or form strategic partnerships with existing application developers that have an interest in entering the market. Securing locally relevant applications will be important because different countries have different needs and use different languages. In their initial stages, FMS and UV are considering running pilot projects with established e-kiosk operators running successful applications.[41] Such a partnership will need to be carefully crafted to strike a balance between UV and their partner's objectives.

[40] They have a patent pending technology/business model for this.
[41] Note that most of the established e-kiosk operators are in India; to our knowledge there are none in Cambodia.

CHALLENGES AND LESSONS LEARNED

FMS' initial deployments have revealed many challenges, from actual deployment of the technology to penetrating the BOP market. The following section highlights several of those challenges.

- Determining actual ICT demand from the end-user market

Entering the BOP market is risky because very little is known about this market segment. Even if it is true that, as some studies suggest, people in rural areas spend three to five percent of their income on communications, FMS will still need to take market share away from traditional incumbents such as personal visits, radio, phone communications, television, and newspapers. This transition in spending patterns will not occur overnight. In addition, it is difficult to determine the optimal pricing strategy and - more fundamentally - whether the trend showing the rural poor as a potential market for telecom is reliable.

- Developing locally relevant applications to generate demand for DakNet

End-users do not have the disposable income to use the Internet for non-essential activities. The client's willingness to pay for DakNet services is directly related to whether the applications replace an existing activity or satisfy an important need. Merely having Internet access is not enough. Application drives the demand for the technology.

- Building a strong ecosystem of partnerships

FMS positions itself as a provider of infrastructure and standard services such as e-mail, asynchronous web-surfing, and Voice Message over IP. Since it does not directly interact with the end-user market, it needs to build local partners. Successful bottom of the pyramid ecosystems are typically decentralized and leverage the expertise and entrepreneurial spirit at the local level. Local partners have both a deeper knowledge of the population's needs and the capacity to manage local operations. In addition to running access points, local partners must also make sure that MAPs are treated with care and reach all access points in a timely manner. This can be a significant challenge. In Costa Rica, when FMS partnered with a local coffee supplier, the project took a long time to start up because the supplier was not maintaining the system as had been agreed upon. Moreover, FMS needs to partner with companies that can develop locally-relevant applications.

- Managing relationships with clients and partners

A major risk to revenues is that rogue clients and partners will cut FMS and UV out of the loop. For example, FMS could be cheated out of maintenance fees and UV's agreements with local rural ISPs could be violated. The technology is designed to make clients and partners dependent on FMS and UV. If they cease to cooperate, FMS and UV have the capacity to bring the network down. In addition to this technical solution, UV needs to detail carefully the agreements it makes with its partners. This is an extremely complex task, especially when dealing with non-US partners.

- Infrastructure, transportation, and weather-related barriers

Ideally, FMS installs the MAP onto an existing transportation method, such as the public bus in India or the coffee delivery truck in Costa Rica. Doing so keeps costs to a minimum.[42] Unfortunately, buses and even ordinary postmen are not always present in remote areas and hiring dedicated e-postmen is an additional cost the client would have to bear. This was the case for AAfC/JRC, which had to subsidize the cost of local motor-taxi men to transport the data daily. In either case, the transport mechanism needs to be able to endure difficult climates. In Cambodia, for example, the motormen have a difficult time during the rainy season. Motormen have taken falls and broken antennas, and covering the same routes can take two to three times longer, raising the price of gas by 150%.

- Limited demand from institutional clients

All of FMS' clients have been institutions such as NGOs and governments. Since these clients do not use FMS equipment for profitable ventures, their demand does not depend on the poor people's ability to pay for the service. Rather, they are at the mercy of donor funding.

- End-users having limited ICT literacy

Demand for the Internet is dependent on having basic computer skills and, in many cases, the ability to speak and understand English. Many rural areas use languages that software companies do not

[42] Interestingly, social costs can be a bit larger than expected since bus drivers will lose passengers as local villagers increasingly use DakNet to communicate instead of taking the bus and meeting face to face.

support and websites in cyberspace are mostly in English. In Cambodia for example, only 86,400 hits show up under the .kh domain on Google, and not all are actually in Khmer, the principal Cambodian language.[43] Part of the challenge is that a Khmer font has not yet been standardized in Unicode, so users must download a separate program for characters to be properly displayed. This creates a huge obstacle for most people in rural areas who do not have basic English and computer skills. This obstacle may lead to a slower adoption of the Internet, thus decreasing demand for FMS technology.

- Regulatory restrictions for certain Internet applications

ICT in most countries is highly regulated industry. The use of the VoIP protocol, for example, is restricted in many countries. FMS' Voice-Message-over-IP technology was not adopted in Cambodia partly because of potential conflict with government regulations. To overcome the regulatory hurdle in Costa Rica, FMS had to package its product very carefully, as a "UPS for data" so that at least on the surface, it did not compete with traditional telecom companies.

The payment system UV hopes to launch shortly will also undoubtedly come under legal scrutiny. Legal expertise will be needed to design the system carefully to avoid infringing on local and international laws.

- Achieving scale is crucial in a lower margin market

For FMS, and even more importantly for UV, penetrating large markets is a key to generating profit. FMS will need to amortize its fixed costs over more sales. This could create a virtuous cycle by lowering costs and increasing demand. However, it has not been able to deploy its technology at a large scale yet. Only its partnership with AAfC/JRF has expanded beyond the initial pilot stage.

- Competitive advantage will diminish as other technologies emerge

As cheaper and more powerful technologies emerge, DakNet's competitive advantage will undoubtedly diminish. While FMS can enjoy a first-mover advantage, FMS will need to adapt and propose new technologies if it is to stay relevant.

[43] The Secretary General of the National Information Communications Technology Development (NiDA) approximated that only 500 websites are in Khmer.

SOCIAL BENEFITS: EXPERIENCES FROM CAMBODIA

FMS' first client was American Assistance for Cambodia/Japan Relief Fund (AAfC/JRF).[44] AAfC/JRF is the only client so far that has experimented with innovative applications of DakNet technology in the areas of education, telemedicine, e-commerce, and e-government. The following section highlights the need for FMS technology under the country context and the development of locally relevant applications. Although the applications are still pilots in the process of overcoming implementation challenges, they do shed light on key issues and reveal potential social benefits in the future.

COUNTRY CONTEXT

Cambodia is one of the poorest countries in the world, having experienced genocide in 1975-1979 during the Khmer Rouge period and political instability until recently. Its population of 12.3 million[45] has a GDP per capita of only USD 280.[46] Over 45% of children under the age of 5 suffered from malnutrition[47] in 2001. While external assistance has been pouring in[48] via official aid, NGOs, and international development programs, Cambodia is still in the process of building basic infrastructure.

The ICT infrastructure penetration in Cambodia is very weak. Since 82.6% of the population still lives in rural areas, expanding infrastructure is very expensive. There are only 0.27 telephone lines, 0.08 Internet cafes, and 0.05 Internet users per 100 inhabitants.[49] Those who do have access to phone lines pay some of the highest prices in the world. Internet costs are 245.8% of GNI per capita and costs for fixed lines are 33% of GDP per capita. In 2002, only 3.6% of households had a telephone line, and public phones were distributed at a low ratio of only 0.03 per 1000 inhabitants.[50] Because there are so few telephone lines, many people use cell phones as their main method of communication. In 2001, the ratio of wired phones to cell phones was about 1:8, the highest ratio in the world.[51] Only recently has the government installed a fiber optic line through Cambodia from the border of Thailand to the border of Vietnam as the backbone of telecommunications infrastructure. There are currently five Internet Service Providers, but coverage is limited. Most areas still do not have Internet, and outside of the capital city of Phnom Penh, those that do are expensive and mainly serve tourists rather than local residents. In Banlung, a city in the province of Ratanakiri, Internet costs $USD 5/hour.

In rural areas where people cannot afford cell phones and infrastructure is not present, villagers mainly communicate through ICOM, a radio system present in each province. (See Appendix 2.) ICOMs are generally located in the center of town and operated by a local entrepreneur. The operator leases the equipment from the government for USD 20 per month. For each call, the operator charges 75 cents. The operator can earn USD 150 per month on average, which is a substantial amount considering that most villagers are farmers who earn only a dollar a day. While ICOM does provide a mode of communication, its functionality is limited. When the operator receives a call, he broadcasts the name of the receiver through an intercom. If the receiver cannot come within a few minutes, he misses the call. In addition, since only one person can use an ICOM at a given time and the whole town and all surrounding areas share only one ICOM, there is a lot of pent up demand. More ICOMs cannot be added because the number of communications channels is limited.

Both the government and NGOs have taken steps to increase ICT access. John Ty, Under Secretary of State of Ministry of Posts and Telecommunications, emphasizes that the main impetus behind the push for ICT development in Cambodia is to catch up with its neighbors as well as the rest of the world. In 2003, the Asia Foundation, in cooperation with USAID, established 22 Community Information Centers (CIC) in the major population centers of Cambodia[52] to provide Internet access and basic computer training classes.[53] In most places, CICs are connected to the Internet via a satellite dish to overcome the infrastructure barrier. While the initial project was targeted towards

[44] More information on AAfC can be found at www.villageleap.com
[45] 2001
[46] $280 is equivalent to $1590 when adjusted for PPP. Data taken from World Development Report, 2004.
[47] 2001 data from World Development Report, 2004
[48] In 2001, Cambodia received $409million in aid and development assistance.
[49] Digital Review for Asia Pacific <http://www.apdip.net/projects/dig-rev/info/kh>
[50] International Telecommunications Indicators. ITU, 2003.
[51] Digital Review for Asia Pacific <http://www.apdip.net/projects/dig-rev/info/kh>
[52] http://www.asiafoundation.org/ICT/overview.html
[53] Until recently, Internet access was free. Now local residents pay $1/hr and foreigners pay $2/hr.

government and NGO staff during the previous elections, students now take great advantage of this resource. Between October 1, 2003 and September 30, 2004, close to three hundred thousand visitors visited the CICs (see Appendix 3). The popularity of the service reflects the latent demand for ICT in Cambodia.

APPLICATIONS AND LOCAL PARTNERSHIP

AAfC/JRF, which was founded by Bernard Krisher in 1990, first approached FMS to use its technology to connect rural schools to the Internet. Its operations in Cambodia are extensive. In Phnom Penh, Cambodia's capital city, AAfC publishes the *Cambodia Daily*, the only independent Cambodian newspaper; manages the Sihanouk Hospital Center of Hope, which provides medical services free of charge; and is partners with Future Light Orphanage (FLO), which houses over two-hundred orphans. In rural and even remote areas, it has built over 250 primary schools financed by various donors with matching funds from the World Bank and Asia Development Bank. Besides building the schools, AAfC supplements the government-mandated curriculum with additional teachers that teach English and computer classes to the most gifted students. AAfC/JRF was FMS' first client to experiment with the innovative applications of the DakNet technology. The following applications and analysis of DakNet's potential social benefits reflect AAfC/JRF's experience. While Internet access has been reliable, each application must overcome specific challenges. Since applications complement the technology, these challenges directly affect demand for DakNet.

EDUCATION

Use of DakNet	AAfC/JRF's original use of the DakNet infrastructure was to connect rural schools to the Internet. One school is connected to the Internet through a satellite, and 14 others schools are connected through the e-postman system. Data is transported by five *motormen*, each of whom covers a different route. The motormen are paid for by AafC/JRF because the routes are not regularly covered by existing transportation options.
Application Context	Internet accessibility complements the computer classes students were already taking. The teachers, some of whom were orphans from the Future Light Orphanage, are first trained in Phnom Penh then sent to rural villages. Originally, students only learned how to type and use Microsoft Word and Excel. Connecting schools to the Internet allows students to learn how to use e-mail and conduct web searches. Many schools have established a pen-pal system with other schools, which motivates students to practice writing and e-mailing in English. Many donors also communicate to the students through e-mail. Some schools are so remote that they do not receive daily newspapers or even mail, so the *Cambodia Daily* (an English-language newspaper owned by AAfC/JRF) sends daily issues to the schools as an Adobe PDF file. The teachers print and post them on the community bulletin board. (See Appendix 4.)
Challenges	The schools have experienced few technical problems with the hardware. The main challenge comes on the content side. Most software and web pages are not available in the Khmer language. Having relevant applications is critical to increasing demand for the technology. Additionally, since each class of twenty students is equipped with only one computer, hands-on time to explore and practice is limited.
Social Benefit	Providing rural communities with Internet access is a baby step in bridging the digital divide. Learning how to use the Internet at the primary school level helps students to overcome the intimidation of using new technology. It also decreases the negative impacts of physical isolation, as they are now able to receive daily Cambodian news and explore the world outside their village through web searches. A less tangible benefit is that, by allowing children to communicate across village boundaries, DakNet helps rebuild social networks largely destroyed during the genocide from the Khmer Rouge period.
Scale-Up Potential	DakNet can easily be scaled up for use in all 250 schools. Given the proper software, AAfC/JRF can also leverage Internet access to introduce e-learning to both teachers and students. The main challenge to scaling up is training enough teachers who can teach computer classes and effectively use the technology.

TELEMEDICINE

Use of DakNet	AAfC/JRF uses the DakNet infrastructure established through the rural schools to implement telemedicine. Villagers can ask the computer teacher to e-mail their symptoms to a medical clinic instead of paying an actual visit. Doctors at the clinic then choose the most urgent cases to treat. Close to seventy percent of the patients that are referred to the telemedicine clinic utilize DakNet.
Application Context	The pilot is implemented through a partnership with Partners Telemedicine,[54] an organization based in Boston, the Sihanouk Hospital Center of Hope in Phnom Penh, and Massachusetts General Hospital (MGH) in Boston. AAfC/JRF initiated the telemedicine pilot because rural villagers in these areas have had scarce medical resources in these areas for more than twenty years. When patients arrive at the telemedicine clinic, local doctors provide foreign doctors with precise descriptions of patients' illnesses. These descriptions contain written explanations, digital pictures, or even digitized X-rays. Any useful information that can be transferred electronically is added to a patient's profile (see Appendix 6 for a sample write-up). The first pilot was established in Robib and the second in Banlung. The two pilots conduct telemedicine similarly, with the exception that the pilot in Ratanakiri also has a capacity-building component. When doctors from Center of Hope visit, they also teach local doctors how to write the reports themselves and treat patients accordingly.
Challenges	The main challenge with the pilot is to have doctors commit to the project over a longer time period. Because they are poorly paid by the government, doctors usually run private clinics to earn extra income. Participating in the project takes time away from their practices. There are also the challenges of properly writing up the symptoms, translating technical jargon between languages, and overcoming cultural barriers related to medical treatment.
Social Benefit	Many patients had long-term illnesses that were successfully treated through the pilot. Additionally, the overall quality of health care in Banlung improved significantly due to the capacity-building component. Local doctors, through their interactions with the telemedicine project, have improved their ability to diagnose and treat common illnesses such as diabetes and thyroid-related problems.
Scale-Up Potential	The goal is that in the future, local doctors will be able to conduct the telemedicine clinics themselves without monthly visits from doctors in Phnom Penh. If the pilot can overcome the key obstacles, then rolling out such clinics in other rural areas can increase the quality of health care in rural areas.

[54] www.telemedicine.partners.org

E-GOVERNMENT

Use of DakNet	AAfC/JRF gave the local Governor of Banlung a computer connected to DakNet. Villagers who live near connected rural schools can ask the computer teacher to write e-mails on their behalf directly to the Governor to voice their needs and concerns.
Application Context	Most of the e-mail exchanges are either about state teachers (different from computer teachers) not showing up at school or land disputes, a common problem in Cambodia. In one case of land disputes, the Governor took the case to the Provincial Land Resolution Conflict Committee and then had representatives visit those involved to present a solution.
Challenges	Villagers have to go through a computer teacher to write e-mail because they were either illiterate or did not know how to use the technology. This can lead to privacy issues and agency problems. For example, the teacher sometimes forgot to inform the villager when they received a response to their e-mail. Since the pilot was only implemented at one village, experiments with other e-government applications were limited.
Social Benefit	Both the governor and villagers liked the new method of communication. Many of these villages are so remote that in the past, the Governor seldom visited them and had little idea of their needs. E-mail brought their needs to the Governor's attention for the first time. Even this basic form of e-government was empowering, democratizing, and led to increased accountability.
Scale Up Potential	For this to reach a greater scale and have a considerable development impact, more sophisticated e-government systems need to be developed and implemented at more locations. In the broader context of Cambodia, the National Information Community Technology Development Authority (NiDA), which promotes IT development and implementation in Cambodia, has begun to offer e-government services in Phnom Penh such as vehicle registration.[55] The service is not only convenient but also a revenue-generator. NiDA can use FMS technology to roll out nationwide e-government applications, especially in rural areas.

E-COMMERCE

Use of DakNet	AAfC/JRF uses the DakNet hub as a communications center to run two e-commerce pilots that sell traditional Cambodian handicrafts.
Application Context	Two workshops were set up to produce traditional Cambodian scarves and blankets (see Appendix 7). The project aims to stimulate the local economy by bringing in extra revenue and preserve Khmer hill-tribe culture and art.
Challenges	The project has not been profitable for AAfC/JRF so far because the raw materials are expensive and the client base is mainly limited by word-of-mouth advertisement and those affiliated with AAfC/JRF. The project can only reach sustainability if AAfC/JRF can expand the client base.
Social Benefit	This project had a positive impact on the weavers' lives, all of whom were women, because it enabled them to generate more income for their family. Prior to the project, the women did not generate any income. Depending on customer demand, they now can earn on average an extra USD 14 per month (To put this amount into perspective, the government pays school teachers a salary of USD 20 a month).
Scale-Up Potential	The pilot has the potential to expand but will need to overcome obstacles, including transporting the raw materials and final products to and from the villages. The founder of AAfC/JRF hopes to have profitable pilots in order to make Internet connectivity self-sustainable instead of dependant on donor funds. Local people are more likely to engage in the new technology if they see the commercial advantages of doing so.

[55] Citizens in Phnom Penh can now register vehicles and real estate information online. Mr. Pho Leewood, Secretary General of NIDA, emphasizes that one of the main goals of NIDA is to generate more revenue for the government. This is a national priority since the Cambodian government is currently highly dependant on foreign aid.

CONCLUSION

The low-cost proposition of First Mile Solutions can bring ICT access to rural and remote areas sooner and more affordably than would be possible with other technologies. ICT access provides direct benefits of increasing access to information. In addition, through complementary applications, ICT can serve as an enabler of other development efforts in areas such as education, health, and commerce. The revenues of FMS so far have primarily come from non-for profit institutions. While it aims to sell to rural ISPs, the market is still very young. The untapped market is a double edged sword—while there is huge potential, very little information is known about it. The transformation of the business model from purely FMS to a partnership between FMS and UV is a key strategic step. UV has stronger revenue-generating potential because it taps into end-users at the bottom of the pyramid more directly and can manage partnerships more effectively. FMS/UV will need to form strong partnerships with local organizations and application developers that have a deep knowledge of the market's needs and budget. End-users will only start to demand FMS technology will come only if they find the ICT applications useful and relevant to their needs. Looking ahead, FMS will need to stay abreast of trends in low-cost telecommunication equipment and be willing to adopt new schemes if they are superior to DakNet. The next two to three years will be critical and will determine the success or failure of the model.

BIBLIOGRAPHY

S. Guerraz, S. Kim, A. Ludwin, H. Qu, T. Tran, A Survey of Data Network Options for Rural Areas: A Business Model for Asynchronous Messaging. www.eecs.berkeley.edu/~binetude/course/cs294_12/paper.pdf (accessed March 9, 2003)

Amir Hasson, Store and Forward Wireless Networking For Sustainable Access in Rural India, M.Sc. thesis, MIT, June 2002.

John Paul, Digital Dividend What Works Case Study: n-logue's Rural Connectivity Model, http://www.digitaldividend.org/case/case.htm (accessed March 11, 2005)

C.K. Prahalad, Allen Hammond, *Serving the World's Poor, Profitably*, Harvard Business Review, R0209C, September 2002.

ACRONYMS

AAfC/JRF	American Assistance for Cambodia/Japan Relief Fund
BOP	Base or Bottom of the Pyramid
CIC	Community Information Center
COTS	Customer Off The Shelf
FAP	Fixed Access Point
FMS	First Mile Solutions
GAIS	Government Administration Information System
HAP	Hub Access Point
ICT	Information Communication Technology
ISP	Internet Service Provider
MAP	Mobile Access Point
NIDA	National Information Communications Technology Development
USAID	United States Agency of International Development
UV	United Villages
VOIP	Voice Over IP

APPENDIX 1: FMS Software and Hardware costs

FMS Equipment	Price (USD)
HAP – hardware	699
HAP – software	150
HAP – antenna	329
MAP – hardware	599
MAP – software	75
MAP – antenna	143
FAP – hardware	499
FAP – software	38
FAP – antenna	128

APPENDIX 2: ICOM Wireless Radio

APPENDIX 3: Breakdown of users of CIC Centers between September 30, 2003, and October 1st, 2004[56]

NGOs staff:	29,912	Students:	147,735
Business and Private Sectors:	14,472	Other people:	61,862
Government Agencies:	34,221	Number of women users:	79,557
Political Parties:	4,601	Number of new users (first time visitors):	21,946

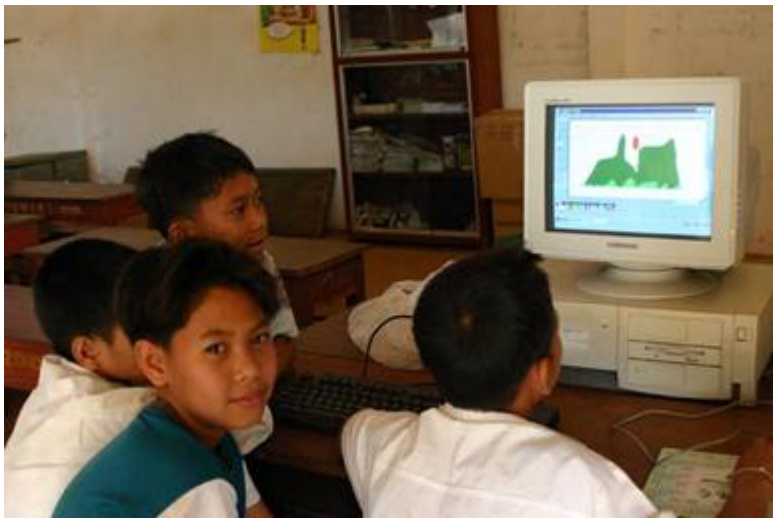
[56] Hutchinson, Kelly and Seng, Chhay. "Cambodia Country Report - Harnessing the Potential of ICT for Rural Development in Cambodia." Prepared for ADBI/UNESCAP Regional Workshop, December 2004.

APPENDIX 4: Motorman Technology

MAP equipment to be secured on motorbike

Motorcade

APPENDIX 5: Schools



Top: Bulletin board posting the daily paper

Upper Right: Children learning paint program on solar panel-powered computer.

Bottom: Primary school building

APPENDIX 6: Telemedicine Sample Report[57]

Patient: HK#00095, 22M, Village 7

Chief Complaint: LBP for nearly 2 years and epigastric pain for 3 months

HPI: His complaints of burning LBP radiated to both lateral and anterior thighs and radiated to right knee and also to suprapubic area; worse with ROM around waist and increase movement; epigastric pain with intermittent trace bright red blood in stool. He was treated with unknown drugs for LBP , but his symptoms can not resolving .no belching , no nausea, no vomiting ,no fever .

PMH/SH: Malaria & typhoid fever 1 month ago treated and recovered **Social Hx:** none / **Allergies:** none / **Family Hx:** brother has hernia / R**OS:** unremarkable

PE:

Vital Signs: **BP110/70** **P65** **R** **T36.5**

Wt 49

General: alerted and oriented, not pale /
HEENT: unremarkable

Chest: Chest :clear both sides , no crackle ./Heart: no murmur , HRRR

Abdomen: soft ,no mass , no organomegaly active BS . no tenderness

Musculoskeletal: no joint pain on body except lower back and knee pain

Neuro: sensory and motor are intact / **GU:** none/ **Rectal:** no mass, no tenderness, colocheck negative

Previous Lab/Studies: none /**Lab/Studies Requests:** x-ray lumbargo.

Assessment: 1.Lower back pain 2. PUD?? 3 Parasitis (Amoebia)

Plan:
1.Paracetamol 500mg 1-2tab po q6h for 10days
2.B-complex 1 tab bid for 1 month
3.omeprazol 20mg 1tab bid for 14 days
4.Metronidazol 250mg 2 tab po bid for 14 days
5. Amox 500mg 2 po bid for 14d
6. Mebendazole 100mg 1 po bid x 3d

Examined by: Dr San **Date: 28/10/04**

[57] Information is public posted on www.villageleap.com

APPENDIX 7: Weavers

Silk weavers in Robib

Traditional weavers of the Ta Gnach Kreung Ethnic Group