Annenberg Research Network on International Communication

Project Proposal

Wireless Networks and Community Development

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I. Introduction

It is widely accepted that new information and communication technologies (ICTs) can be used to alleviate a wide range of obstacles for economic and social progress in the developing world. This is particularly true of the Internet. As a global platform for accessing and sharing information, the Internet offers unique opportunities to overcome a variety of informational deficits that handicap people, businesses, and communities in poor nations (Castells, 1999; Rodriguez and Wilson, 2000; Kirkman, 2001). Analysts have claimed that increased productivity, better health, education, and government services can all result from widespread Internet adoption. However, cost remains a major obstacle for Internet diffusion in the developing world (Norris, 2000; Sarrocco, 2002). A combination of poor telecommunications infrastructure, low population density, inadequate regulation, and high-cost technologies designed for urbanized areas makes Internet connectivity in many parts of the developing world a complex and costly proposition.

As a result, researchers and donors have began to question the cost-benefit rationale of extending Internet access to these high-cost, low-income areas (Hewitt de Alcántara, 2001). For example, Kenny (2002) argues that to address the informational needs of the rural poor, traditional technologies such as broadcast radio provide a more cost-effective alternative. There are abundant small-scale demonstration projects funded by international donors and governments that prove the benefits of Internet connectivity for a variety of development goals. These projects however tend to be designed and deployed by outsiders, rather than fostered internally. As a result, long-term sustainability and wider-scale replication are rarely obtained (James, 2003; Caspary and O'Connor, 2003). A combination of high costs and low usage by the target population frustrates efforts to extend Internet connectivity beyond these heavily-subsidized initiatives.

Recent developments in wireless Internet access technologies are raising new hopes for sustainable Internet diffusion in the developing world. These technologies allow sharp reductions in Internet deployment costs, particularly for last-mile connectivity in low-density areas (where the underprivileged are most likely to live). More importantly, they make possible an infrastructure development model based on community-shared resources, small-scale investments, and user experimentation. While we often think of

Internet deployment as an undertaking for large commercial or government organizations (i.e., in the traditional model of telecommunications development), new wireless technologies allow bottom-up infrastructure build-up more closely tied to community needs. They also open the door for quite different approaches to deployment and use of information infrastructure. For example, low-cost wireless networking may support local information sharing, only later to explore the benefits of connection to remote resources. These technologies are powerful, flexible, and economical. Wireless Internet access technologies therefore hold the potential to redefine the terms of the debate about the sustainability and cost-effectiveness of strategies to promote global Internet diffusion.

II. Project Goals

The project seeks to examine and assess the possibilities created by new wireless Internet access technologies for promoting Internet use and diffusion in developing nations. As Grace et al. (2001) argue, anecdotal evidence is too often used to justify ICT projects, resulting in poor implementation designs and lack of long-term sustainability. We seek to construct and apply rigorous measurement techniques to evaluate the potential benefits of wireless access technologies for development goals. The project will investigate how these technologies are being appropriated and deployed, by whom, and with what results. The goal is to analyze a range of different settings and implementation strategies, from small rural telecenters funded by international donors to larger scale community networks established by local governments or business cooperatives. We plan to contrast these with wireless networks in advanced countries, and expect to find considerable differences in how the technology is deployed and used. Particular attention will be given to the cost-effectiveness of last-mile solutions such as Wi-Fi,[1] and the dynamics of infrastructure development associated with them. Two research questions will guide the project:

1) Can wireless Internet access technologies alleviate the economic constraints that limit Internet connectivity in developing nations?

A number of studies demonstrate that cost remains a major obstacle for Internet adoption in the developing world. Even in absolute terms, Internet access and leased line costs are typically higher in developing than in developed nations (OECD, 2001). When income disparities are factored in, it is clear that traditional Internet connectivity (i.e., via dial-up or broadband wireline technologies) remains out of reach for all but a small privileged minority. The causes are manifold. The preexisting telecommunications infrastructure is typically poor and unevenly distributed. In many nations, regulation discourages competition in the provision of backhaul services and last-mile connectivity (Wallsten, 2003). Access technologies designed for urbanized settings often prove uneconomical in low density areas. Finally, low income and high costs discourage private investments, creating a negative feedback of limited capacity, high prices, and low service demand (Sarrocco, 2002).

[1] Wi-Fi refers to systems employing the IEEE 802.11 protocols for wireless networks.

Our hypothesis is that new wireless Internet access technologies can help overcome many of the obstacles for cheaper connectivity in the developing word, particularly at the last mile. Wireless access solutions do not need reliable wired infrastructure, which is scarce in the developing world. Rather, they take advantage of a resource that is typically underutilized in developing areas: the electromagnetic spectrum. Developing nations thus have the potential to leapfrog the first generation of Internet access technologies (e.g., fixed dial-up access), much like mobile telephony is allowing leapfrogging of traditional wired telephony. Because several of these new technologies operate on unlicensed spectrum bands, there are typically less regulatory obstacles for local deployment and experimentation. In some cases they allow bypassing of high-priced connections offered by monopoly operators. Even where backbone capacity is scarce, wireless local area networks (WLANs) allow users to share the costs of connectivity to regional or international access points, or even simply to establish networks aimed at providing local connectivity. In short, we hypothesize that wireless access technologies make possible the deployment of high-capacity local networks that are independent of traditional wired infrastructure, thus allowing bypassing of several technology and regulatory bottlenecks that make traditional connectivity prohibitively expensive in the developing world.

2) Are wireless access technologies creating new models of infrastructure development that promote sustainable Internet diffusion in the developing world?

The challenge of Internet diffusion in the developing world is not only economic in nature. There are also implementation models linked to wireline technologies that tend to discourage investments outside rich urban centers. Laying wire to provide Internet connectivity is not unlike paving roads. It typically requires large upfront investments, and the architecture of the network (and thus the range of possible uses) has to be carefully planned in advance because resources are not easily redeployed. As a result, centralized planning by large organizations (which are better able to pool and manage large resources) is typically how infrastructure gets deployed. This often involves making many ex ante assumptions about how the infrastructure will be used and by whom. Such assumptions are easier to make in the case of well-understood, single-purpose networks (such as roads and sewage) than in the case of the Internet, where applications and uses often result from "learning by doing" (Bar & Riis, 2000). In many areas of the developing world, demand for connectivity is complex to aggregate and difficult to predict. This not only discourages private investors, but also creates sustainability problems as well-intentioned donors and governments often miscalculate the long-term viability of pilot projects.

Our second hypothesis is that wireless Internet access technologies encourage a different model of infrastructure development better suited to the challenges of extending connectivity in developing nations. Unlike fixed access, wireless access solutions are both flexible and scalable. They can more easily accommodate new users by providing access to anyone within the reach of the radio signal. Because of the cost advantages associated with wireless and the use of unlicensed spectrum bands, infrastructure investments to create WLANs are within the reach of organizations such as local governments and small-scale entrepreneurs. Furthermore, mesh networking allows the

aggregation of capacity between community WLANs, and thus the network is able to grow organically based on experimentation and use by individual or institutional users.[2] The infrastructure therefore expands bottom-up, without a preconceived plan, and linked to the needs and attributes (geographical, demographic, economic) of local communities. Because network growth is driven by user demands, long-term sustainability becomes the norm rather than the exception. Furthermore, wireless networking technology is flexibly reconfigurable, in terms of both its physical layout and its logical architecture. As a result, wireless networks can be adjusted to serve emerging needs, or transformed to reflect the growing familiarity of their users with the technology. This continuous transformation, we believe, can be driven from the inside by the network users themselves. Such a dynamic can play an important role in the network's sustainability.

We will also benefit from a comparison with the deployment and evolution of wireless data networks in developed nations. Other projects undertaken by ourselves and collaborators will examine wireless networks in two contexts. The first studies the emergence of community-based Wi-Fi networks in the US and selected EU countries. The second looks at corporate wireless networks in the US. We expect this comparison to shed light on the dynamics of infrastructure development and the role played by end users in shaping the network in different contexts. Ultimately, our goal will be to understand how different user populations with distinct objectives and needs create different network development trajectories, and the socio-economic implications associated with them.

III. Research Strategy

We propose a multi-step research strategy that utilizes a variety of data collection techniques. The strategy comprises two different stages.

Stage 1: Review of Existing Initiatives

Wireless access technologies have gained much momentum following sharp drops in equipment prices and increased experimentation with unlicensed spectrum bands. Over the last years, a number of pilot projects have been launched to provide low-cost Internet access through wireless networking in several developing nations. Among the better known is a project called DakNet that combines Wi-Fi with a mobile access point mounted on and powered by a public bus to provide email and video message capabilities to rural villages in India.[3] In order to understand how wireless access technologies are being linked with development goals in a variety of different settings, we will compile and review these initiatives based on a number of criteria (see Table 1). These criteria correspond to key dimensions along which wireless networks vary. We expect network deployment and uses to reflect these differences. Following our two research questions, the review will attempt to identify network deployment patterns and establish cost comparisons with initiatives based on traditional access technologies. We will take advantage of secondary data created by several development organizations, which

[2] Under a mesh network configuration each local node can act as a data router, which enables the optimization of Internet backhaul and allows the wireless network to expand as the number of nodes grows.
[3] See www.daknet.net.

maintain databases of pilot projects in the area of ICT for development from around the world.[4] This review will also serve to identify candidate projects for the next research stage.

Table 1: Criteria for the analysis of existing wireless access initiatives

Criteria	Key Questions
Economic Model	How is the project funded?
	Are charges levied on users?
	Are deployment costs being assessed against benefits?
Services	Which services are provided?
	Are specific applications/content being deployed?
	Is training provided to users?
Technology	How is the network configured?
	Off-the-shelf or adapted technologies?
	Does it operate on unlicensed spectrum bands?
Scale	What is the scale of the initiative?
	Are these micro, meso, or macro-level efforts?
Deployment Pattern	Is the network scalable?
	Are network architecture decisions centralized?
	Is the network growing bottom-up?
Local Environment	Rural or urban?
	Principal economic activities?
	Demographic characteristics?

Stage 2: In-depth Cost and Deployment Evaluation

As noted, the evaluation of ICT for development projects often relies on anecdotal evidence gathered by those involved in implementation. In this project we seek to contribute to a more rigorous understanding of how ICTs contribute to alleviate the informational deficits that impede the economic and social progress of communities in the developing world. To accomplish this task we will construct and apply several measurement instruments to a carefully selected sample of ICT projects (the exact number of projects will depend on available funding and logistical issues). These measurements will serve to validate or reject our hypotheses about the cost benefits and new deployment patterns associated with wireless access technologies.

The first step will be the selection of target projects. We seek to create a small sample of projects that vary along the dimensions presented in Table 1. The sample is intended to be representative of different settings and implementation models to enable both qualitative and quantitative comparisons across the projects studied.[5] We will then

[4] Among these organizations are the World Resources Institute, the World Bank's infoDev, and the Development Gateway Foundation.

[5] For a discussion of the comparative case-study method see Ragin (1981).

establish contact with the organization responsible for the project and volunteer to conduct the evaluation. In order to minimize research expenditures, we will privilege partnerships with organizations that are willing to assist in the administration of the evaluation.

Once the sample is defined, the following instruments will be applied:

1. Cost evaluation. We will work with the partner organization to assess the implementation and recurring costs associated with the project. Our focus will be on the cost of connectivity at the last mile, where wireless networking solutions such as Wi-Fi offer particular benefits. The main goal will be to measure the cost benefits associated with different wireless network configurations in the delivery of a range of Internet services (email, web browsing, e-commerce, locally-developed applications, etc.). This will also be used to estimate the long-term sustainability of the project.

2. Infrastructure evolution measurement. Among the advantages of wireless networking is the possibility of decentralized infrastructure growth based on mesh network configurations. We seek to measure infrastructure deployment over time by tracking the growth of the wireless network "cloud" (i.e., the area covered by the wireless network signal). Samples of the size, density, and architecture of the wireless network will be taken at regular time intervals through unobtrusive measurements such as the number of network nodes, the coverage of the radio signal, and network traffic analysis. This quantitative measures will be complemented with structured interviews with key project leaders (e.g., community network administrators, telecenter managers, etc.) to collect qualitative data about the patterns of network expansion or contraction.

3. Impact evaluation. We will construct and administer a survey instrument to evaluate the impact of the project against a variety of development goals. Because snapshot measurements are generally inadequate to evaluate the long-term benefits associated with ICTs, we propose a longitudinal survey design to track usage patterns and assess the project's contribution to close informational gaps. The questionnaire will collect data on ICT availability, use, and expenditure within the target community. Ideally, the first measurement will be taken before or shortly after the start of the project, in order to create a baseline of indicators against which to assess the contribution of the initiative (this baseline will also be checked against available data from other sources such as government census). The initial sample will be selected through random household sampling. This panel will form the basis for tracking trends through subsequent administrations of the survey.

4. Network transformation. In our measurement of the infrastructure's evolution and impact (items 2 and 3 above), we will explicitly seek to document interaction between the two. We expect the infrastructure's evolution to affect how it used, with what impact and, conversely, we anticipate that network use will affect

subsequent network evolution. Our goal is therefore to establish measures that can be monitored over time, to track these feedback processes.

III. Conclusion

Extending Internet connectivity to communities in the developing world involves a delicate cost-benefit balance. The price of Internet access has to be low enough to be affordable in low-income communities. At the same time, the gains derived from connectivity must be high enough to enable long-term sustainability. The costs and deployment models associated with fixed access solutions have often proved inadequate to address this problem. New wireless technologies, on the other hand, offer new opportunities for low-cost access and bottom-up network deployment led by community needs. This project seeks to rigorously assess these opportunities and provide both theoretical insights and practical guidance for the diffusion of new ICTs in the developing world.

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