Toward a Global Rural Network: Strategy and Action Plan

View From Practice

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1. INTRODUCTION

During the last decade, pilot studies and focused projects have established the efficacy of the Internet in developing nations;[1] however, connectivity remains uncommon and it is generally slow and unreliable.[2] The developing nations are too poor to attract sufficient capital to build modern Internet infrastructure.[3]

The activity of the past decade has had positive results. All governments are now aware of the importance of telecommunication infrastructure and the relationship between infrastructure and social planning. Technology has also steadily improved, dramatically lowering infrastructure cost.

We feel it is time to consider a grand challenge infrastructure project: connecting all the villages of the developing nations within 10 years (Press, 2004a). The World Bank estimates that there are 2949 million rural people in low and lower-middle income nations, and the average population of a rural village in India, China, or Bangladesh is 1,060 people. If we assume this population is representative, a global rural network would have to reach nearly 3 million villages (Press, 2004b). This is a daunting challenge, but others, like sending a man to the moon, achieving rural electrification in the United States, building our interstate highway system, or deploying the global positioning system were also ambitious.

This note suggests a strategy for achieving a global rural network, and recommends a plan of action. Bangladesh is considered as the nation for the initial pilot design and implementation.

[1]This effort has been motivated by the hypothesis that the Internet can lead to an improvement in the quality of life in rural areas of developing nations, and perhaps reduce the motivation for urban migration. This hypothesis has been stated frequently, in many forms, by many people (e.g., Press, 1995, 1996a).

[2]Approximately 28% of the world population lives in rural areas of low-income nations, and the figure approaches 50% if we include lower-middle-income nations, and these people essentially have no Internet access (World Bank, 2004).

[3]The cost of 20 hours of low-quality Internet access in a low-income nation is 2.5 times monthly per capita gross national income, whereas 20 hours of high-quality service is 1.6% of the average monthly income in a high-income nation (World Bank, 2004).

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TABLE 1. The Cost of U.S. Government–Funded Network Infrastructure Projects

Project	Cost ($ million)
Morse telegraph	.03
ARPANet	25
CSNet	5
NSFNet backbone	57.9
NSF higher-education connections	30
NSF international connections	6

2. STRATEGY

We advocate a strategy similar to that used by the U.S. Defense Department's Advanced Research Projects Agency (ARPA) and the U.S. National Science Foundation (NSF) in doing the research and development that eventually led to the National Science Foundation Network (NSFNet), the first global Internet backbone. There are three general parallels between the NSFNet and what we are proposing.

Like NSFNet, this should be a highly leveraged infrastructure investment. The NSF subsidized Internet connectivity for research and education institutions during the 1990s. They began by building the NSFNet backbone network, and then began offering grants for connecting 4-year institutions of higher education. Schools could apply for $20,000 in connection assistance, typically a router and a link to a regional NSFNet point of presence (POP). NSF also made grants to connect foreign research and education networks to the NSFNet, eventually linking 28 research and education networks in 26 nations.

Table 1 shows that the NSFNet was a high-return investment. It became the first global Internet backbone, at a cost of less than $100 million to the U.S. taxpayer (Press, 1996b).[4]

The NSF strategy was to build common infrastructure—a backbone network—then offer a subsidy for connection to that infrastructure. It was a heavily leveraged investment. The aggregate cost of staff, equipment, and installation of university local-area networks far exceeded the cost of the NSFNet program.

We would do the same. A village would receive POP equipment (including a power supply) and a link to a backbone (see Figure 1). Networking, buildings, staffing, workstations, and so on within the village would be the responsibility of the local population.

Although they eventually went into production, NSFNet and the ARPANet before it were originally applied research projects, designed by highly qualified researchers. At the time they were being designed, active debates on packet versus circuit switching, OSI versus TCP/IP, the separation of the network and transport layers, and so on, were taking place. Routing algorithms had to be invented and the domain name system was being defined.

Highly qualified researchers from leading universities and research labs were brought in to design and oversee the implementation of these networks. The work was not done by career government employees, but by top scientists on temporary assignment who funded research with grants and oversaw deployment after contracts were awarded by competitive bidding.

[4]Of course NSFNet could not have been built without prior federal procurement, research, and development. For example, valuable lessons were learned and thousands of programmers trained in the development of the $8 billion SAGE system for warning against the approach of bombers.

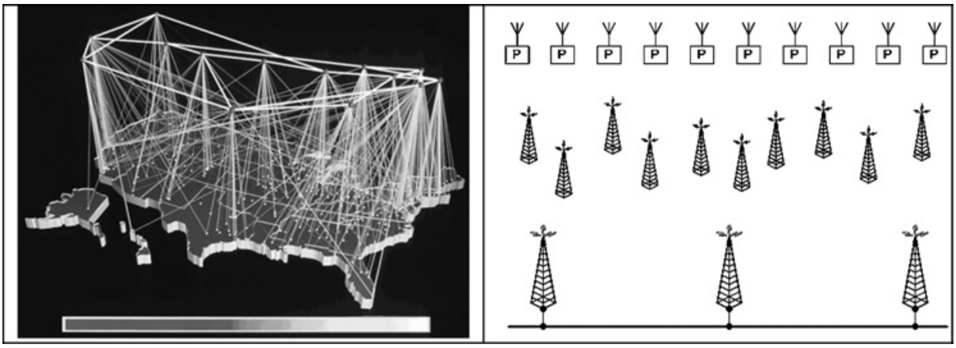

Figure 1 The National Science Foundation built a backbone and subsidized the connection of a single point of presence at each university. We would build a backbone and subsidize the connection of a single point of presence at each village.

We would follow a similar procedure in this case. A variety of skills would be necessary to design a cable/wireless backbone and village point-of-presence equipment. A technical team of experts in several fields should be assembled to jointly design the network and components and plan for deployment and operation. Disciplines include

- Geographic information systems with data on current and planned fiber networks; the rail, pipeline, power distribution, and road systems; village coordinates and populations; topography; vegetation; and climate
- Terrestrial wireless radio design and tuning
- Mesh networking and routing algorithms
- Fiber-optic network design and installation
- Design and operation of network operation centers for monitoring and maintaining a large, unreliable network
- Network design—both practical and using mathematical modeling and optimization
- Antenna design and modeling
- Mechanical design for radio towers
- Design of solar and other power systems
- Satellite communication research and practice
- High-altitude platform research and practice
- Design of village POP configuration
- Training for POP operation
- Experience with village telecommunication center operations and applications
- Spectrum politics and policy
- Local government and university relations

NSFNet was a "dumb," "end-to-end" network. We have seen that the NSF funded only the Internet backbone, and left the bulk of the funding to connecting networks. Application development was also left to the users. The IP protocol was developed to route packets of data from one computer to another, nothing else. The network was "dumb," because it ignored the content of those packets. They were treated the same if they contained music or pictures, e-mail messages, or images from Mars. The data were interpreted and acted upon

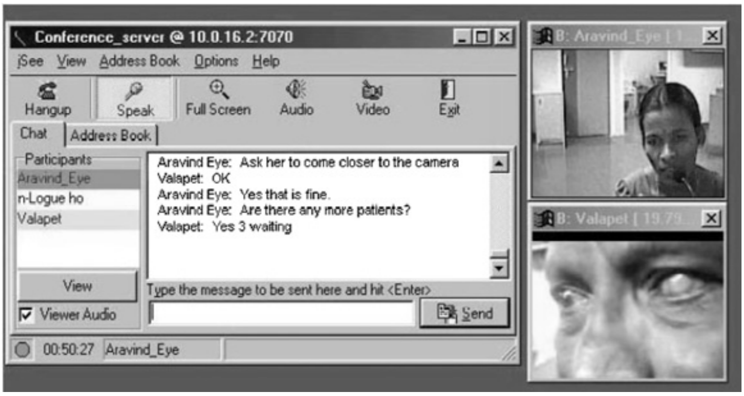

Figure 2 A remote eye examination using video and text chat (Jhunjhunwala, Sujatha, & Anuradha, 2004).

by application programs running on the computers connected to the network. Applications and application protocols, from e-mail to the Web to file sharing, blogs and wikis, were invented by users at the network ends, not by the operators of the network. Every user was a potential application inventor and developer. Every user was a content provider.

We expect the same. As Figure 2 illustrates, over a decade of trials and studies have demonstrated rural Internet applications in government, health care, veterinary medicine, education, entertainment, business, agriculture, news, personal communication, and so on, and the rural people in developing nations will invent others.[5]

The new users will surprise us. Necessity truly is the mother of invention, and rural people in developing nations will develop network applications to solve their own problems using their resources and knowledge of those problems. Once completed, the network will become a platform for deploying and testing such applications, regardless of where they are developed. It will be a resource for the global development community.

As we have seen, the NSFNet was a research project, not intended for long-term production. As planned, it was phased down, then decommissioned in April 1995. Many competing private enterprises in the United States and other developed nations were available to take up the slack, and commercial backbones quickly replaced and surpassed NSFNet.

While we would use the NSFNet as a design and deployment model, we would not advocate decommissioning developing-nation backbones once their viability was established. Capital is not easily attracted to developing nations and multiple competing backbones would not be deployed. As such, we would continue operation of these developing-nation backbones as public infrastructure.

3. PLAN OF ACTION

The ultimate goal of this project should be the grand challenge of a high-speed Internet link to a POP in every rural village in the world. We would pursue this goal in four stages.

[5]Descriptions of many example applications abound: International Development Research Centre, at http://www.idrc.ca/, Information for Development Program, Infodev, at http://www.infodev.org/, Development Gateway, at http://www.developmentgateway.org/, and Sustainable Development Networking Program, at http://www.sdnp.undp.org/.

TABLE 2. Backbone and POP Elements that Would Be Designed

Item	Comment
POP equipment and installation	Router, server, peripherals, and software
POP power	Various power sources
POP building	Best left to local people
POP radio, tower and antenna	Should radios be homogenous?
Backbone radio, tower, antenna	Should radios be homogenous?
Backbone maintenance and security	Private firm?
Optical backbone upgrade	After assessment
Network operation center	Key to maintenance

First we would conduct a feasibility study and preliminary network design for a pilot nation. This would be the seed project. A team with the network skills listed previously would be recruited for this project. They would engage in independent research, field experimentation, and periodic meetings to design standards-based network and POP equipment, as shown in Table 2.

Next the network would be deployed in a pilot nation. The initial research consortium would retain responsibility for contracting for and evaluation of this trial. The deployment phase would be costly. For example, if Bangladesh were the selected nation, we would require POP equipment for 86,000 villages plus backbone equipment, a network operation center, and staff. Like other large infrastructure projects, this would require international support and funding from donor agencies and industry.

This would be followed by planning for implementation in other nations, which would proceed in parallel with deployment in the pilot nation. Selection of the pilot nation and the deployment ordering of the other nations would be based on criteria such as

1. Strong government support of telecommunication in general and this project in particular.
2. Open, competitive telecommunication market.
3. Open, competitive business practices and laws.
4. High level of poverty.
5. High level of literacy.
6. Dense population relative to current fiber, roads, pipelines, and so on.
7. High-speed international fiber links.
8. Strong university programs in computer science, geography, GIS, and so on.
9. Varied climate and topography.

We may briefly summarize the position of Bangladesh on each of these criteria.

1. A strong champion would have to be found within the government.
2. There are two potential fiber backbone providers, the telephone and railroad companies.
3. Grameen Bank brings long experience with microcredit and a culture of village entrepreneurship[6].

[6]http://www.grameen-info.org/

4. The nation is poor, so a relatively large marginal impact could be expected. This can also be defended ethically.
5. The literacy level is low, working to the disadvantage of Bangladesh.
6. The population density is very high, placing villages relatively near the fiber backbones on average.
7. There will be an international undersea cable soon.
8. There is an incipient GIS capability associated with Nepal's ICIMOD[7] and university computer science programs are growing.
9. The topography is not particularly varied, but much would be learned about network capacity and stability during rain.

The order of implementation would be determined using criteria similar to the above. As this will take many years, technological change should be anticipated and planned for during deployment. For example, although a terrestrial wireless mesh would seem to be the appropriate technology for the backbone linking a nation's fiber with its villages today, developments in alternative technologies like high-altitude platforms and low-earth-orbit satellite constellations should be continuously assessed (Press, 2003).

During the last decade, we have gathered considerable evidence in support of the hypothesis that networks can improve the quality of life in developing nations—which nation should we begin with?

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[7]http://www.bangladesh-gis.net/

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