An Internet Diffusion Framework

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Over the years, we covered the globe with cities then linked them with railroads, highways, telephone lines, power grids, canals, and so forth. We are now deploying the Internet, and several organizations and projects are tracking this global diffusion [6]. This article describes one such project, the Mosaic Group (http://www.agsd.com/mosaicgroup.html) study of the global diffusion of the Internet.

The global diffusion of the Internet is of interest to infrastructure planners and policy makers. As Ithiel de Sola Pool pointed out, telecommunication infrastructure planning is implicit social planning. Policy makers may see the Internet as an opportunity, a threat, or both, but none can ignore it – infrastructure and society are inextricably interdependent. While this is the case for all nations, we are particularly motivated by the hypothesis that a relatively small networking investment may have a significant impact in developing nations (Press [2]). Although support for policy makers is the primary motivation for our work, we must also confess to a degree of unabashed curiosity in tracking the spread of the Internet around the world.

In tracking the diffusion of the Internet, one must choose a balance between breadth and depth. One of the first to chronicle of Internet diffusion was Larry Landweber, who simply noted whether or not a nation had an international IP link. He produced well known maps between 1991 and 1997, graphically showing the Net's progress (see Figure 1). Keeping track of only one variable allowed Landweber to maintain a global perspective at a reasonable cost. Network Wizards, http://www.nw.com, also produces a very concise representation of the Internet, automatically counting the number of hosts in each top-level domain every 6 months.

Others compile in-depth information on a limited geographic area. For example, *Boardwatch* Magazine, http://www.boardwatch.com, concentrates on the United States, using interviews, questionnaires, and automated techniques to compile data on every ISP and each IP backbone network. The result is a 560-page directory which requires a professional staff. Unlike Boardwatch, Chris Demchack and her colleagues at the University of Arizona maintain a global perspective, but focus on one aspect of the Internet -- government Web sites. They have compiled data on the Web sites of national agencies in nearly every nation of the world. Figure 2 shows the average openness of agency Web sites in each nation. Openness is the sum of transparency and accessibility, where transparency is a measure of the amount of data an agency makes available through its Web site and accessibility measures how easy it is for visitors to use the information on the Web site, give feedback to the agency, contact agency officials, and so forth. (For details on the coding scheme and project, see http://w3.arizona.edu/~cyprg/).

We seek a middle ground. Our goal is global coverage, considering a variety of characteristics of Internet diffusion at a reasonable cost. We focus on the nation as our unit of analysis, and characterize the state of the Internet along six dimensions: pervasiveness, geographic dispersion, sectoral absorption, connectivity infrastructure, organizational infrastructure, and sophistication of use.[1] In addition to these dimensions, our framework includes an open-ended list of determinants -- factors which influence the development of the Internet, i. e., the values of the dimensions in a nation.

The Framework

Each dimension has five ordinal values ranging from zero (non-existent) to four (highly developed). Table 1 shows the definition of the levels of the first dimension, *pervasiveness*. As you see, pervasiveness is based on factors like users per capita and the degree to which non-technicians are using the Internet. Note that the explanations of the values are somewhat subjective and imprecise. For example, we do not try to pin down the exact number of users per capita, which would be impractical, but are satisfied with a rough, order-of-magnitude

estimate. Our goal is categories which accommodate a wide range of nations, and yield a high degree of consensus among Internet experts from a nation.

Over 200 nations now have IP connectivity, but in many of these, access is restricted to one or two large cities. As such, we selected *geographic dispersion* as our second variable. This dimension measures the concentration of the Internet within a nation, from none or a single city to nationwide availability with points-of-presence or toll free access in all first-tier political subdivisions and common rural access.

While widespread access is desirable, the payoff is in who uses the Internet in a nation. This is accounted for in our *sectoral absorption* dimension, a measure of the degree of Internet utilization in the education, commercial, health care, and public sectors. These sectors are seen as key to development, and were suggested by the measures used by the United Nations Development Programme Human Development Index [7].

Connectivity infrastructure is our fourth variable. It a measure based on international and intranational backbone bandwidth, exchange points, and last-mile access methods. A highly rated nation will have high speed intranational and international backbone connectivity, public and bilateral exchange points, and a high proportion of homes with last-mile access using CATV, xDSL, or some other technology that is faster than analog modems.

Organizational infrastructure is a measure based on state of the ISP industry and market conditions. A highly rated nation would have many ISPs and a high degree of openness and competition in both the ISP and telecommunication industries. It would also have collaborative organizations and arrangements like public exchanges, ISP industry associations, and emergency response teams.

Our final variable is *sophistication of use*, a measure characterizing usage from conventional to highly sophisticated and driving innovation. A relatively conventional nation would be using the Internet as a straight forward substitute for other communication media like telephone and FAX, whereas in a more advanced nation, applications may result in significant changes in existing processes and practices and may even drive the invention of new technology.

In addition to these six dimensions, our framework considers determinants of Internet diffusion. One view of these determinants is presented in [4], which organizes them into government policies and non-governmental determinants of Internet success, as shown in Table 2. The Internet does well in nations with robust, competitive telecommunication and computer industries, ample financial and human resources and an interested, supportive government [1].

One often hears that the Internet will erode the power of national governments through borderless commerce, entertainment and news. However, we have found governments still play a major role in determining Internet diffusion. One government may encourage the Internet, if swayed by its potential economic and educational opportunities, and another may discourage it because of threats to the political stability of the regime or to the culture. Figure 3 depicts an ordering of several nations on their apparent sensitivity to Internet risks and opportunities as estimated by the MOSAIC Group. As you see, the Finnish government has opted for policies which encourage Internet diffusion while Iraq has judged it too hot to handle.

Our framework focuses on the nation as the unit of analysis, but an understanding of the global diffusion of the Internet requires attention to multinational issues and organizations as well. These include the role of multinational corporations (cable and satellite providers, telecommunication companies, ISPs, and content providers), organizations for the regional and global governance of the Internet, technological improvements, and non-Internet, regional or global networks such as those used in currency trading, banking, international EDI, and by large corporations. (These may move to the Internet when performance and security requirements are satisfied).

Results

Table 3 shows the dimension scores for several nations. In addition to showing dimension values, our reporting format gives brief explanations for the scores, predictions of the scores for the coming year, and a table showing

the relationship between the dimension values and key determinants. Table 4 and Table 5 illustrate these for the case of Cuba, and Figure 4 and Figure 5 illustrate a graphical representation of changes over time (in Finland) and of multiple nations (in the Persian Gulf).

Some of the results in Table 3 were generated during in-depth country studies conducted by the Mosaic Group. These studies are reported in [6], and they require considerable expense -- between one and ten person-weeks visiting the nation and several months of traditional research and writing. While these in-depth studies have value beyond our framework, they are too expensive if we hope to cover all nations on a regular basis.

Another approach is to rely on the opinion of informed Internet observers and participants within each nation. The non-Mosaic results in Table 3 were derived from a questionnaire which took respondents less than one hour to complete. If we have chosen our dimension values well, we would expect two experts from the same nation to arrive at the same values. To the extent that two differ, it should be fairly simple to resolve the disagreement by asking what assumptions they were making about the definitions of the values and the actual situation in the nation. As such, this approach has the possibility of scaling up, and we would like to apply our framework globally. If you are familiar with the state of the Internet in your nation, and would be willing to complete our questionnaire, please visit http://som.csudh.edu/fac/lpress/gdiff/ where you will find a questionnaire.

Footnote

1. These dimensions were modeled on [8] with input from [3].

References

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Tables

Table 1: The five levels of the *pervasiveness* dimension.

Level 0 *Non-existent*	The Internet does not exist in a viable form in this country. No computers with international IP connections are located within the country. There may be some Internet users in the country; however, they obtain a connection via an international telephone call to a foreign ISP.
Level 1	The ratio of users per capita is on the order of magnitude of less than one in a thousand. There is limited availability, and use of the

Experimental	Internet is embryonic. Only one or a few networks are connected to the international IP network. The user community comprises principally networking technicians.
Level 2 *Established*	The ratio of Internet users per capita is on the order of magnitude of at least one in a thousand. The user community has been expanded beyond networking technicians.
Level 3 *Common*	The ratio of Internet users per capita is on the order of magnitude of at least one in a hundred. The infrastructure of supporting and related goods and services has become well-established, although is not necessarily extensive.
Level 4 *Pervasive*	The Internet is pervasive. The ratio of Internet users per capita is on the order of magnitude of at least one in ten. Internet access is available as a commodity service.

Table 2: Factors and policies influencing Internet success within a nation.

Internet Success Determinants

- Telecommunication infrastructure
- Personal computing and software
- Financial resources
- Human capital
- Sectoral demand and awareness
- Competitive environment

Government Policies

- Markets and choice
- Investment policy
- National security
- Cultural concerns
- Social equity

Table 3: Internet-diffusion ratings

Nation	P	GD	SA	CI	OI	SU	Rating Date	Evaluator
Armenia	2	2	2	1	2	2	Sep-98	Tigran Nazarian
Bahrain	2	1	2	1	1	2	Mar-98	MOSAIC Group
Bangladesh	1	1	1	1	2	2	Jul-98	MOSAIC Group
Benin	1	1	1	1	2	1	Sep-98	Ken Lohento
Bosnia	1	1	1	1	2	1	Mar-98	MOSAIC Group
Burkina Faso	1	2	1	2	2	1	Sep-98	Kiswendsida Kisito Kabore
Cameroon	1	1	1	1	2	2	Sep-98	Derek Ajesam Asoh
Chile	3	2	2	2	3	2	Aug-98	Claudio Araya

Cuba	1	1	1	1	2	1	Mar-98	MOSAIC Group
Cuba	1	2	1	1	2	2	Aug-98	Marta Ruiz
Czech Republic	3	3	2	3	3	2	May-98	Ryan McCulley, Mike Leinen
Democratic Rep. of the Congo	1	1	1	1	1	1	Sep-98	Eric Nzita
Dominican Republic	2	3	1	1	3	2	Jul-98	Daniel Pimenta
Finland	4	3	3	3	4	4	Mar-98	MOSAIC Group
Guinea	1	2	1	1	3	1	Sep-98	Hadja Binta Keita
Guyana	2	1	1	1	2	2	Sep-98	Andrew Mancey
India	1	3	1	1	1	2	Sep-98	MOSAIC Group
Iran	1	2	1	1	2	1	Mar-98	MOSAIC Group
Iraq	0	0	0	0	0	0	Mar-98	MOSAIC Group
Kuwait	3	1	2	2	1	2	Mar-98	MOSAIC Group
Mauritius	1	1	2	1	1	2	Sep-98	Yann Kwok
Oman	3	1	2	1	1	2	Mar-98	MOSAIC Group
Pakistan	1	3	1	1	2	1	Sep-98	Fasih Ahmed Masood Sindhu
Pakistan	1	3	1	1	2	1	Sep-98	Naseem A. Bhatti
People's Republic of China	2	3	2	2	2	2	Sep-98	MOSAIC Group
Peru	2	4	3	1	2	3	Jul-98	Jose Soriano
Qatar	3	1	1	1	1	2	Mar-98	MOSAIC Group
Saudi Arabia	1	1	1	1	1	1	Mar-98	MOSAIC Group
Slovak Republic	3	3	2	2	3	2	May-98	Ryan McCulley, Mike Leinen
Solomon Islands	1	1	1	1	1	2	Sep-98	Samuelu Taufao
Sri Lanka	1	2	2	1	3	3	Sep-98	Priyantha Pushpa Kumara
Tunisia	1	2	2	1	3	3	Sep-98	Lamia Chaffai Sghaier
United Arab Emirates	4	3	2	1	1	2	Mar-98	MOSAIC Group
Uganda	1	1	1	1	-	2	Sep-98	Michael Sserunjoji
Uganda	1	1	1	1	-	2	Sep-98	Dorothy Okello
Uruguay	3	3	3	2	2	3	Jul-98	Ida Holz
Venezuela	2	3	1	1	3	2	May-98	Luis German Rodriguez
Yemen	1	1	1	1	1	1	Mar-98	MOSAIC Group
Zimbabwe	2	3	3	1	3	2	Sep-98	Joyce Chidora

Table 4: The relationship between key determinants and the dimensions they affect, Cuba, 1998.

Determining Factor	**Dimensions most directly affected**
Poor telephone infrastructure	*Pervasiveness, geographic dispersion, connectivity infrastructure,* and *sophistication of use* are all inhibited due to the difficulty in connecting end users and networks.
Difficulty attracting capital	*Connectivity infrastructure* cannot be improved without capital.
Cultural values stressing health, education and equality	Health and educational *sectoral absorption* is emphasized as is *geographic dispersion* outside the capital.
Centralized planning	

	Pervasiveness is reduced by planning delays, and the Inter-ministerial Commission was formulated) is an element of increased *organizational infrastructure*.
Concern for national security given US hostility	*Pervasiveness* is reduced by access restriction.
Protection of embargoed business activity	*Pervasiveness* is reduced by content restriction.
Propaganda to and from US	*Pervasiveness* is reduced by content and access restriction.
Fear of use by subversive organizations	*Pervasiveness* is reduced by access restriction.
Non-commercial economy	Commercial *sectoral absorption* is inhibited as resources are shifted elsewhere.
Populist history	In seeking to server rural areas and small towns, *geographic dispersion* is increased and *connectivity infrastructure* extended outside the capital.
Emphasis on human capital	Education *sector absorption* is increased.

Table 5: Explanations of dimension values, Cuba, 1998.

Pervasiveness: Cuban IP connectivity is minimal, with perhaps as few as 100 users. Even if we were to include UUCP email accounts, there are less than 1/1,000 population, therefore Cuba is at the *experimental* level. However, it is noteworthy that email use extends well beyond the network technician community.

Geographic Dispersion: The only IP point of presence offering network connectivity in Cuba is at CENIAI in Havana. If; however, we were to consider email connectivity, we would find access in every province and nearly every municipality. So, while Cuba must be rated at the *single location* level because of limited IP, they are clearly interested in geographic dispersion.

Sectoral Absorption: IP connectivity is *rare* in the health and government sectors, and *nonexistent* in education and commerce, giving Cuba a *rare* overall ranking. On the other hand, UUCP-based email is used in the health sector throughout the nation, more than 10% of the ministries have email accounts, and the YCCs (education sector) are nationwide.

Connectivity Infrastructure: While Cuba has an international IP link, they have no domestic backbone and barely any leased line access, placing them at the low end of level 1 on this dimension. They are severely hampered here by poor telephone infrastructure and their historical concentration on X.25.

Organizational Infrastructure: While not independent businesses, CENIAI and Teledatos are both in the business of providing connectivity to organizations with networks, and there is some degree of competition between them (either by design or historical development). There is also a degree of coordination provided by the *Inter-ministerial Commission* for Networking. On this basis, we can rank Cuba at the *controlled* level.

Sophistication of Use: As there is little IP connectivity, Cuba must be ranked at the *minimal* level here; however, email and information retrieval from email-driven servers have reached the *conventional* level in the health care and biotechnology communities.

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