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An Internet Diffusion Framework

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 [4]. This column describes one such project, the MOSAIC Group (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 [1]. While support for policy makers is our primary motivation, 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 chroniclers 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 (www.nw.com) also produces a very concise representation of the Internet, automatically counting the number of hosts in each top-level domain every six months.

Others compile in-depth information on a limited geographic area. For example, *Boardwatch Magazine* (www.boardwatch.com) concentrates on the U.S., using interviews, questionnaires, and automated techniques to compile data on every ISP and each IP backbone network. The result is a 560-page directory that 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

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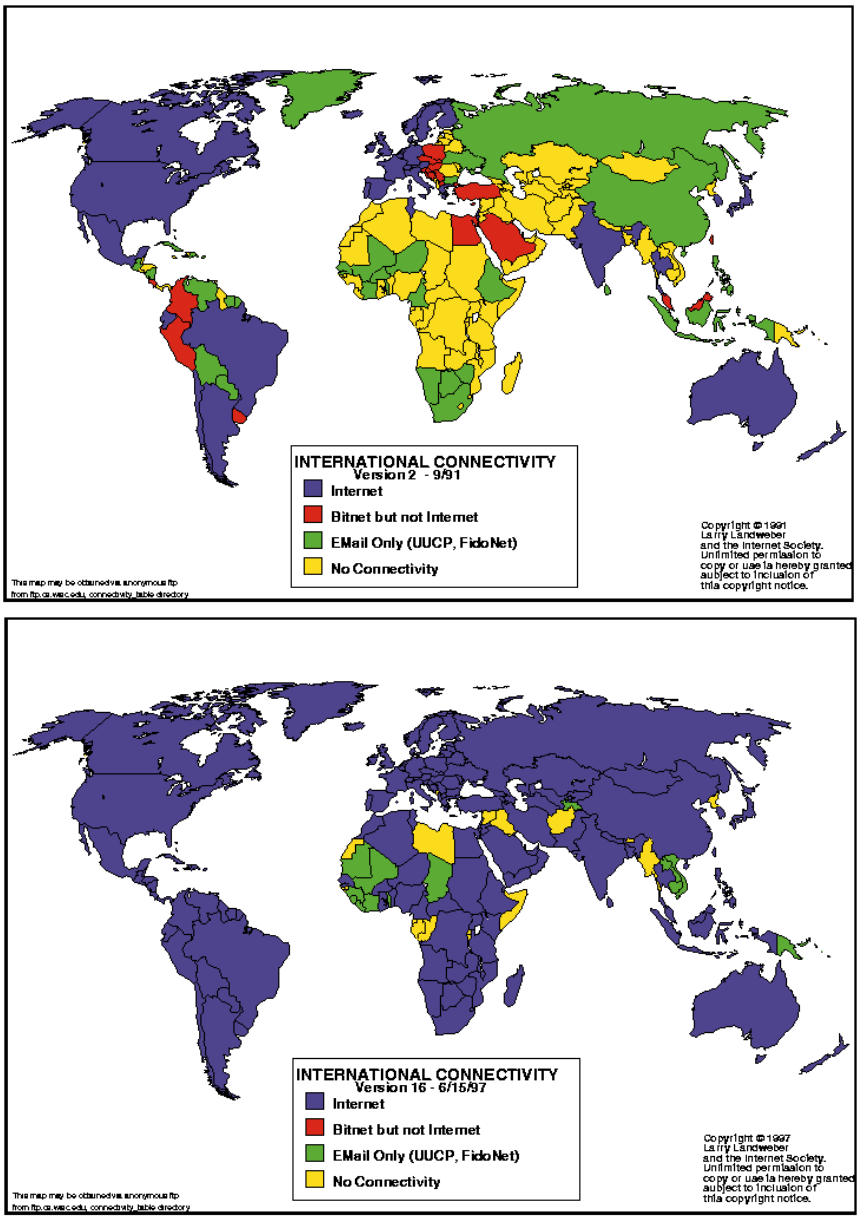

Figure 1a. Network diffusion, February, 1991
(b) Network diffusion, June, 1997

Source: Larry Landweber; ftp.cs.wisc.edu/connectivity_table/

information on the Web site, give feedback to the agency, contact agency officials, and so forth.[1]

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 each nation as a 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.[2] In addition to these dimensions, our framework includes an open-ended list of determinants—factors that influence the development of the Internet (such as the values of the dimensions in a nation).

The Framework

Each dimension has five ordinal values ranging from 0 (nonexistent) to 4 (highly developed). Table 1 shows the definition of the levels of the first dimension, *pervasiveness*. Pervasiveness is based on such factors as users per capita and the degree to which nontechnicians use the Internet. Note the explanations of the values are somewhat subjective and imprecise. For example, we do not wish to pin down the exact number of users per capital, doing so is impractical. We are satisfied to have a rough order of magnitude estimate. Our goal is categories that 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

[1]For details on the coding scheme and project, see w3.arizona.edu/~cyprg

[2]This form of analysis was modeled on [6] and preceded by [2].

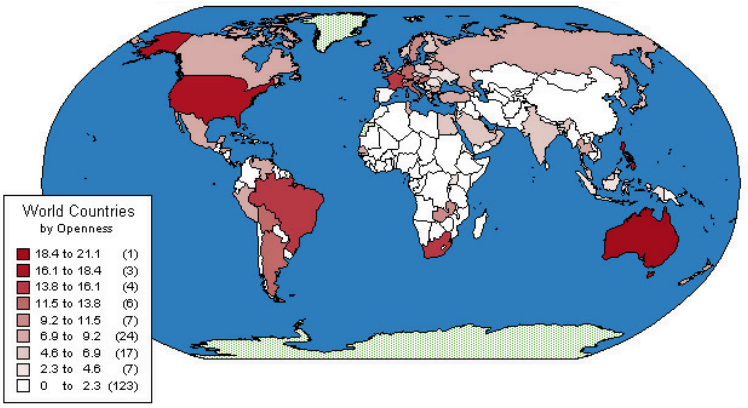

Figure 2. Openness of agency Web sites in each nation
Source: The Cyberspace Policy Research Group; w3.arizona.edu/~cyprg/

Table 1. Levels and definitions of "pervasiveness"

Level 0 Nonexistent	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 Experimental	The ratio of users per capita is on the order of magnitude of less than one in 1,000. There is limited availability, and use of the 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 1,000. 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 100. 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 10. Internet access is available as a commodity service.

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 Program Human Development Index [6].

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 the state of the ISP industry and market conditions. A highly rated nation has many ISPs and a high degree of openness and competition in both the ISP and telecommunication industries. It also has 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 uses the Internet as a straightforward 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

Table 2. Determinants of Internet success and government policies of interest

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

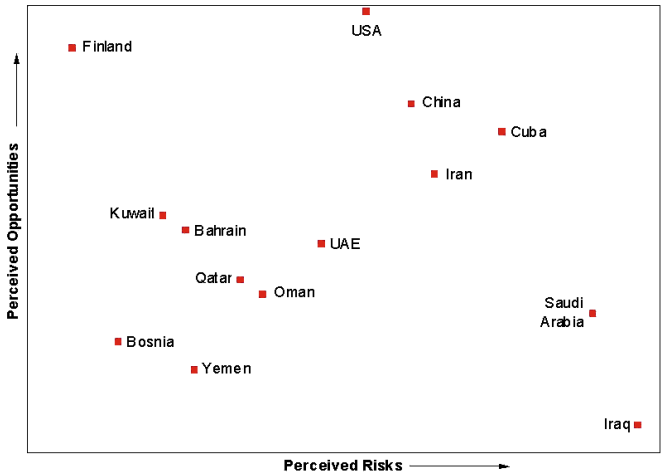

Figure 3. Estimated orderings of government perception of Internet risk and opportunity
Source: MOSAIC Group [5]

Table 3. Dimension values for various nations

Nation	Per.	G.D.	S.A.	C.I.	O.I.	S.U.	Rating Date
Bahrain	2	1	2	1	1	2	Mar. '98
Bangladesh	1	1	1	1	2	2	July '98
Bosnia	1	1	1	1	2	1	Mar. '98
Cuba	1	1	1	1	2	1	Mar. '98
Czech Republic	3	3	2	3	3	2	May '98
Dominican Republic	2	3	1	1	3	2	July '98
Finland	4	3	3	3	4	4	Mar. '98
India	1	3	1	1	1	2	July '98
Iran	1	2	1	1	2	1	Mar. '98
Iraq	0	0	0	0	0	0	Mar. '98
Kuwait	3	1	2	2	1	2	Mar. '98
Oman	3	1	2	1	1	2	Mar. '98
Peru	2	4	3	1	2	3	July '98
PRC	2	3	2	2	2	2	Mar. '98
Qatar	3	1	1	1	1	2	July '98
Saudi Arabia	1	1	1	1	1	1	Mar. '98
Slovak Republic	3	3	2	2	3	2	May '98
UAE	4	3	2	1	1	2	Mar. '98
Uruguay	3	3	3	2	2	3	July '98
Venezuela	2	3	1	1	3	2	May '98
Yemen	1	1	1	1	1	1	Mar. '98

Sources: Daniel Pimenta (Dominican Republic), Ida Holz (Uruguay), Luis German Rodriguez (Venezuela), Ryan McCulley and Mike Lienen (Czech and Slovak Republic), Jose Soriano (Peru), MOSAIC Group (other).

dimensions, our framework considers determinants of Internet diffusion. One view of these determinants is presented in [3], which organizes them into government policies and nongovernmental 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.

One often hears the Internet erodes 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.

Our framework focuses on the nation as the unit of analysis, but an understanding of the global diffusion of the Internet also requires attention to multinational issues and organizations. These include the role of multinational corporations (cable and satellite providers, telecommunication companies, ISPs, connectivity 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, 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

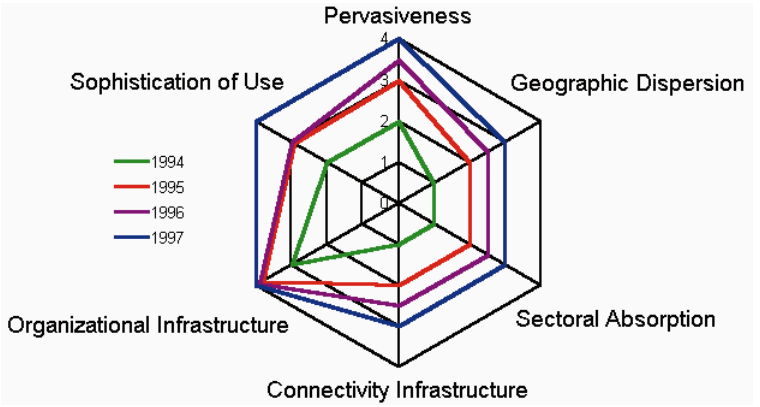

Figure 4. Changes in Finnish dimension values over time
Source: MOSAIC Group [5]

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. Tables 4 and 5 illustrate these for the case of Cuba, and Figures 4 and 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 [5], and they require considerable expense—from one person to 10 people visiting the nation under study and then 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 that took

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 Interministerial Commission was formulated in an element of increased *organizational infrastructure.*
Concern for national security given U.S. hostility	*Pervasiveness* is reduced by access restriction.
Protection of embargoed business activity	*Pervasiveness* is reduced by access restriction.
Propaganda to and from U.S.	*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 serve 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 4. Cuban determinants and the dimensions they affect

respondents less than one hour to complete. If we have chosen our dimension values well, we 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 each made 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 som.csudh.edu/fac/lpress/gdiff/ where you will find a questionnaire. C

Table 5.
Explanation of Cuban dimensions

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 sector, and *non-existent* 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 healthcare and biotechnology communities.

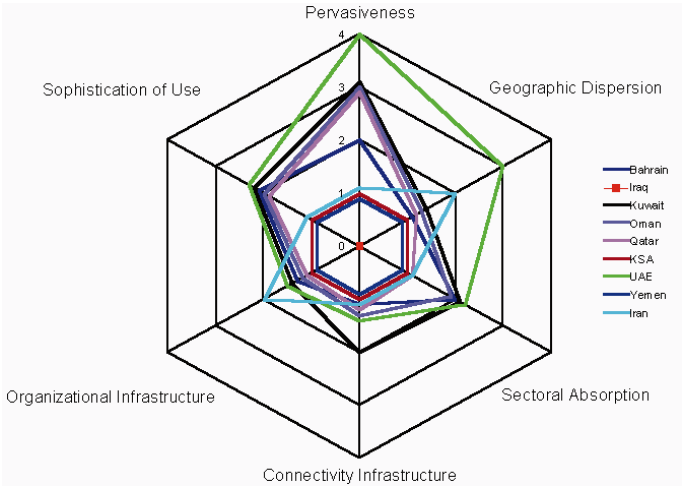

Figure 5. Comparison of Internet diffusion in several Persian Gulf nations Source: MOSAIC Group [5]

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