DEVELOPMENT GATEWAY FOUNDATION

THE FUTURE OF INFORMATION AND COMMUNICATION TECHNOLOGIES FOR DEVELOPMENT

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INTRODUCTION[1]

Predictions of the economic and social impact of information and communication technologies (ICT) abound.[2] Many of these adopt a visionary perspective in which technological trends are extrapolated to illustrate the potential benefits and dangers of rapid progress in the ICT field and the resulting "revolutionary changes" they produce in the world economy. A related area of interest is the so-called digital divide. The greater the expectations of the impact of the information revolution, the greater are the concerns about those (individuals, regions, countries) on the wrong side of the divide. And the greater the hype about the prospects of ICT, the louder are the calls for action against digital exclusion.

This paper reviews some of the main ongoing ICT technological trends that are closely related to the basic dimensions of the digital divide: access (in terms of connectivity and affordability), basic skills (i.e., digital literacy), and relevant content (i.e., information that allows better social and economic decisions). The time perspective is a medium-term one, since we try to focus on areas where targeted interventions in developing countries and transition economies can make a difference in fostering digital inclusion.

The paper is structured as follows:

(i) first, it presents a review of key ICT technological trends and underscores the complexities of predicting the evolution of networked systems in the context of rapid technological change;

(ii) then, it identifies bottlenecks limiting developing countries from participating fully in the benefits of the "information revolution"; and

(iii) finally, it concludes with a discussion of the role that leadership by social actors, governments, and donor agencies can play in addressing these bottlenecks in the medium term.

TECHNOLOGICAL TRENDS

Advances in ICT have been particularly striking in the areas of digital computing and communication networks. We first review these trends by analyzing some of their driving forces and their potential long-term implications. This is followed by an analysis of medium-term developments that may have a significant impact in developing economies.

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[2] Cf. http://www.developmentgateway.org/node/133831/sdm/docview?docid=492330

THE LONG TERM: THE LIMITATIONS OF TECHNOLOGICAL DETERMINISM

A major technological driver of the "information revolution" has been the exponential growth of computer processing power. Since the 1970s, the number of transistors on a chip has been doubling roughly every 18 months.[3] Transistor density per chip, in turn, drives performance, and as the costs per chip remained stable, the performance/cost ratio of computing devices has increased dramatically. By 2000, you could buy computer devices with 66,000 times the processing power per dollar of what was available twenty-five years ago. Moreover, this trend is expected to continue at least until 2010, when computing devices are expected to have 10 million times the processing power per dollar compared to the computers available in 1975.[4]

Economies of scale are also playing an important role in increasing the affordability of computing. Personal computers have become commodities and the very large scale production has allowed fixed costs to be amortized over larger and larger volumes of sales. The effect is also pronounced in many software applications, since dissemination costs are small with respect to initial costs, and the software development costs are shared over increasingly larger numbers of users.

Another major technological trend of the last three decades has been the expansion of communication networks. This growth has been fueled by the declining cost of computing devices and communication infrastructure (e.g., optical fiber and wireless networks), the emergence of new communication protocols (the Internet), and the development of software (including the World Wide Web). Around October 1990 there were 300,000 computers connected to the Internet. By January 2003, more than 171 million Internet hosts were active.[5]

More recently, grid computing initiatives making use of the underutilized capacity of networked computers have suggested future trends toward "computing and information utilities." Many kinds of software have become more available and affordable, especially through the Free and Open Software movements, suggesting that for many needs software may become an affordable service delivered online.

This growing connectivity will be further leveraged as wireless devices increasingly become Internet-enabled. "Today the electronics to hook up any device to the network cost about $1. In ten years' time, the price will be down to one cent."[6] By some estimates, more than two billion people will be connected to digital networks by 2005.[7] In short, while it took 100 years to connect the first one billion people via landline telephony, digital networks are expected to reach twice this number of people in a period of roughly only two decades. The economic and social implications of this expansion will be profound given its network effects.[8]

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[3] This is often referred to as "Moore's Law" after Gordon Moore, the Intel Corporation founder who first observed this trend.

[4] For more details see, for example, Brad De Long's Home Page: http://econ161.berkeley.edu/e-sidebars

[5] Network Wizards (2003).

[6] "Moving up the stack," in Coming of Age: A survey of the IT Industry, The Economist, May 10, 2003. page 8.

[7] Gage (2002).

[8] As a rule-of-thumb, the total value of a network expands in proportion to the square of its number of users. This is often referred to as Metcalfe's Law (Metcalfe 1996).

Embedded devices are also becoming increasingly common. The automotive and appliance industries were able to achieve affordable quality improvements by incorporating microchip technology more than a decade ago, but as these devices become increasingly cheaper, chips can be embedded in an ever expanding array of products. As the chips attain communication capacity, formerly dumb and mute products can become smart and communicative. Boxes of goods, for example, can have chips embedded to learn and broadcast their identities within warehouses. These "machine conversations" add to the demand for and the value of ubiquitous networks.

If one extrapolates these trends over the next two to three decades, the vision of ubiquitous, networked computing and communication emerges as the core technological construct of a global information society. The challenges to transform this vision into reality are well known. On the technological front, the pace of evolution of software, rather than hardware, is the main constraint for the revolutionary impacts often described in the literature. On the human/institutional fronts, the limitations include the ability to absorb and effectively use these new technologies (digital literacy) and to adapt the "rules of the game" to networked environments (e.g., how to regulate e-commerce and protect intellectual property rights in cyberspace). On the economic front, challenges include how to derive tangible results from these innovations by building sustainable business models, while controlling for the costs of adjustment of displaced technologies (e.g., tensions between 3G and the expansion of wireless fidelity, Wi-Fi, in terms of wireless access to the Internet).

These concerns are often brushed aside by technological optimists. The upcoming Semantic Web, for example, is expected by many to open new opportunities to manage information while allowing for new Web functionalities with significant economic potential (e.g., the operation of software agents as match-makers, facilitating market transactions, scheduling, etc.).[9] Artificial intelligence (AI) and expert systems are expected by many to gain new power and utility as standards for distributed computing evolve and grid systems (large-scale integrated computer systems) spread around the world. Infrastructure developments, in turn, will open new possibilities for regions with poor connectivity to leapfrog stages of development by entering the "broadband" phase via wireless solutions. The Wi-Fi phenomenon, for example, is a good example of the "law of unintended consequences" in action as a technology originally designed to support wireless local area networks is beginning to pave the way to the establishment of low-cost broadband telecommunications systems.[10]

From these perspectives, the economics of Moore's and Metcalfe's Laws[11] will foster ubiquitous computing across the globe. Even though poor regions may lag behind with respect to access to these technologies at present, it will be simply a question of time for them to catch up in terms of basic access and to begin to benefit more fully from these developments. Moreover, as children are increasingly exposed

[9] The Semantic Web will augment the existing web with data that will allow computers to process the semantics of the information available on the Web. This will significantly increase the capacity of computers to "understand" the data that they process/display. For details see Berners-Lee, Hendler, and Lassila (2001).

[10] Negroponte (2002).

[11] Daly (1999).

to these opportunities for learning, digital literacy will quickly expand, setting the stage for a "learning revolution" in education that some analysts believe will have impacts on the world economy as profound as those of the quintessential pro-poor technological revolution of the twentieth century -- the "green revolution."[12]

Needless to say, there are dimensions of the IT revolution that will continue to be beyond the reach of most developing countries in the coming decades – see Box 1. And it is important to recognize that long-term forecasts tend to be driven by technological determinism at the level of specific technologies, downplaying the complexities of systemic interactions in a networked environment. They also often minimize the role of institutional constraints and limitations in the absorption capacity of individuals and societies vis-à-vis new technologies. Problems are more typically identified in the context of discontinuities – e.g., the point in time when AI will exceed or merge with human intelligence (sometimes referred to as the "singularity" point in the evolution of ICT) – and the dangers of man-made technology running out of control.[13]

Box 1: The IT Revolution and Basic Sciences: Implications for Developing Countries

The gap between rich and poor countries vis-à-vis high-performance computing (HPC), remote sensing, and high-capacity networks is in all probability going to grow. The importance of these technologies to development is perhaps not clear to many, because they are used by specialists for highly specialized tasks. But those tasks are crucial to the economy as well as to science and engineering.

For example, bio-computing is becoming a major field, as genomics and proteomics have been made possible by the new information technology. Bio-computing offers unprecedented opportunities to hasten the development of new vaccines for HIV and malaria, as well as better vaccines for many diseases, and new drugs to treat many diseases causing great problems in developing nations. But this kind of bio-computing requires HPC, and high bandwidth information networks.

Note too that the benefits of bio-computing are not limited to medicine. There should be major benefits in agriculture, including in developing new and improved crop varieties, improving livestock breeds, combating crop and animal diseases, and managing crop pests. In many cases, the needs of developing countries for such improvements will not be met by developed nations, and poor nations will themselves have to develop such technology. Brazil already has taken a leadership position, having become the first developing nation to publish a complete genome. China and other developing nations are also making major investments in genomics and related fields.

Natural resource management is of course a major area of concern from which many examples can be drawn. Oil-producing nations are using HPC to understand and better manage oil reserves, and the technology could be transferred to hydrological reserve management. Management of water resources in developing nations would also benefit from better meteorology and climatology, which in turn would benefit

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[12] Resnick (2002).
[13] See, for example, Joy (2000).

In what follows, we focus on the next five years, with special attention to the "distribution" impacts of ICT progress. After all, independently of one's timeframe for the point of "singularity," it is true that the distribution of access, digital literacy, and content remains extremely unbalanced. The digital divide may be closing in certain dimensions (for example, aggregate numbers of connectivity show convergence in view of the performance of countries like Brazil and the People's Republic of China), but it remains acute in the case of least-developed countries.

from more extensive networks to provide meteorological information and more access to HPC. Management of soils, prevention of desertification, and management of forests and fisheries are all areas in which more data gathering through remote sensing and better modeling requiring HPC would pay sustainable, economic dividends.

The term "supercomputer" is still applied to the largest, most powerful machines available at any time. The supercomputer field evolves over time by the development of ever more powerful machines and networks. Sales of supercomputers worldwide were estimated at $7.5 billion for 2003.[14] *Supercomputers and comparable high-end ICT are obviously less affordable in poor countries than in rich countries; here a digital divide exists, and can be expected to continue to exist.*

Tera Grid in the United States, for example, is planned to be "the world's largest, fastest, distributed infrastructure for open scientific research. When completed, the TeraGrid will include 20 teraflops ($20*10^{12}$ floating point operations per second) of computing power distributed at five sites, facilities capable of managing and storing nearly 1 petabyte (10^{15} bytes) of data, high-resolution visualization environments, and toolkits for grid computing. These components will be tightly integrated and connected through a network that will operate at 40 gigabits ($40*10^{9}$ bits) per second—the fastest research network on the planet."[15] *The Earth Simulator*[16] *in Japan was judged to be the world's fastest supercomputer in 2002, with a measured speed of 35.85 teraflops.*[17] *Celera, which helped map the human genome and which was already the largest civilian user of supercomputers, in 2001 joined a consortium to build a 100 teraflops machine that will be needed "to develop new medicines, crops, and materials via proteomics."*[18]

Orbiting telescopes map galaxies billions of years into the past, shipping data to supercomputers to be analyzed by programs controlled from the desks of astronomers all over the world. Governments of rich countries build satellite networks to provide remote sensing data and build high-speed networks and supercomputers to provide all but unimaginable processing power. Multinational businesses have unprecedented access to economic, financial, and indeed social information, as well as unprecedented capacity to mine and analyze that data. This dimension of the digital divide, the ability of economic actors and research communities to use ICT in R&D activities, is unlikely to disappear even in the long-term perspective adopted in this section.

[14] http://www.hoise.com/primeur/02/articles/monthly/AE-PR-05-02-1.html
[15] http://www.ncsa.uiuc.edu/About/TeraGrid/
[16] http://www.es.jamstec.go.jp/esc/eng/
[17] http://www.top500.org/list/2002/11/
[18] http://h18003.www1.hp.com/alphaserver/news/sandia_celera_0101.html

The next section reviews some technological developments that can have a substantive impact in fostering participation of the poor in the ICT revolution. Emphasis here is put on the required leadership in the research and development (R&D) community to bring these products/services to the market. Needless to say, as pointed out by Gage's first law of technical change (*technology is easy; people are hard.*), such leadership is a necessary, but not sufficient, condition to introduce and scale up these innovations in a substantive manner.[19] We will revisit the issue of leadership in the closing section of the paper to discuss the other dimensions of leadership required to make a difference in terms of the medium-term evolution of the digital divide.

THE MEDIUM TERM: STEPPING STONES

Some of the new products and services that are currently reaching the market have the potential of significantly ameliorating the conditions of access/use of ICT in poor areas of the world. Examples of these potential "stepping stones" to facilitate digital inclusion follow.

<u>Low-cost devices:</u> Exploiting the implications of Moore's Law on the cost/performance envelope of hardware, companies like Via[20] are producing relatively low-powered processors targeted at the markets of developing countries. These processors are adequate for accomplishing basic functions like word processing, Internet browsing, e-mail, etc. Companies like Netcore[21] are developing "thick-server, thin-client" systems aimed at bringing down the average cost of networking. An Internet café owner, for instance, can deploy additional terminals at a lower marginal cost compared to traditional personal computers (PCs), a.k.a. "thick clients."

The shape of computers, as we know them, is also undergoing a major change. For years, the PC was the only form of computer known to the masses. Over the last few years, handheld computers have slowly come into the mainstream and have made computers more portable and affordable. The portability of these devices and the fact that they can run on batteries make them an attractive option for rural areas where power is not easily available.

Several organizations like the Jhai Foundation[22] and the Simputer Trust[23] are innovating computer technology to make it more appropriate for rural areas. The Jhai PC, for example, gets around the lack of power in rural areas by running low-wattage computers that are driven by pedal-power and that can survive harsh rural conditions. The Simputer Trust is building a multi-user computer that will be a shared device that can be personalized through the use of smart cards issued to individual users.

These are early examples of applying ICT for Development, particularly in rural areas, and are therefore worth keeping an eye on. The key challenge for devices, including PDAs that attempt to target lower cost structures, is building a profitable business model that permits the pursuit of the emerging (rural) markets that they

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[19] Gage (2002).
[20] http://www.viatech.com
[21] http://www.netcore.co.in
[22] http://www.jhai.org
[23] http://www.simputer.org

target. The target market is enormous, but unstructured, and has not been studied sufficiently to permit development of robust business plans. In some cases, manufacturers find it difficult to arrive at the price point that they may have originally desired for their devices, and are sometimes forced to work at higher price points with specifications that are more akin to non-digital divide products, features, and markets. The opportunity for national governments or even international donors to fund detailed market segmentation studies required by commercial organizations to help characterize the markets related to the digital divide may lower the barrier to entry of corporations interested in expanding to such markets, to actively pursue them.

Low-cost software (Free/Open Source Software, FOSS): Proprietary operating systems and applications are priced mainly for developed-world market conditions. The existing business models of software vendors are not designed for widespread usage in developing countries such as India, for example, where annual per capita incomes are around $460.

One of the reasons for the growing popularity of FOSS in the developing world is the cost factor—FOSS costs can be a fraction of the cost of proprietary solutions and can provide an alternative model for developing countries. Moreover, as software programmers in developing countries have the freedom to modify and adapt the software to their local context, FOSS is becoming increasingly relevant . A few examples illustrate this point.

Most software programs available today are developed in English and adapted to other languages in a process known as localization. In the case of proprietary software, the timetable for localization follows the market perceptions and priorities of the software vendor. Under the proprietary software model, a linguistic group that may be considered marginal by a vendor has no option but to wait for the vendor to localize the software to its language. In comparison, FOSS allows linguistic groups to take control of their digital destinies since the access to the source code of software programs allows them to localize the software. For instance, the Jhai Foundation is localizing the Linux-based KDE graphical desktop and office tools to the Lao language. Several Indian groups are actively at work localizing FOSS to Indian languages, and these include groups like Malayalam Linux,[24] Tamil Linux,[25] IndLinux,[26] and others. FOSS, therefore, is increasingly becoming a relevant alternative for developing countries.

Wireless solutions to leapfrog infrastructure bottlenecks: Telecom services, especially in rural areas, are a key challenge for developing countries. Landline and cellular telecom systems work well in metropolitan areas and smaller cities where subscribers are located in dense clusters that justify the high cost of equipment and licenses. However, connecting rural areas is a bigger challenge because subscribers are geographically dispersed, sparsely located, and economically weak. Few telecom companies want to venture into remote villages because the purchasing power in these villages is not enough to recover the cost of connecting them.

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[24] http://www.nongnu.org/smc/docs/faq.html
[25] http://tamil.homelinux.org/
[26] http://www.indlinux.org

The three characteristics that are critical to sustainable deployment of telecom systems in rural areas, therefore, are affordability, ease of deployment, and appropriate business models.

Wi-Fi technology offers the opportunity to be the *one* technology to address these issues. It has a few key advantages in its favor.

(a) Maturity: It is a proven technology for corporate local area networks and carries both voice and data. It is well understood.
(b) Affordability: This technology enjoys the advantage of being part of proven industry standards (IEEE 802.11b, a, g, etc.) and is an integral part of high-volume commercial deployments. This has made the technology affordable.
(c) Pervasiveness: Although popular in most corporate environments, it is becoming even more pervasive. Technology advancements and market thrust of Wi-Fi as part of the future business plans of a market leader such as Intel Corporation is worth mentioning, as is Intel's innovation of integrating the Wi-Fi technology with its processor technology, which will automatically provide each new consumer of its products a Wi-Fi-enabled product. The incremental cost to the consumer is marginal. One could characterize this as a structural push toward "free Wi-Fi" – as far as availability of Wi-Fi-enabled products -- a key requirement for ubiquitous spread of a technology.
(d) Corporate interest: Other companies like Intel Corporation have demonstrated that they have active technology and business plans, including investment funds, that will further the spread of this technology. They are also taking an active interest in the spectrum de-licensing landscape.
(e) De-licensing awareness: Many countries are now taking a close look at their spectrum regulations and are working on deregulation of the Wi-Fi spectrum.

Some notable pilot projects are emerging, such as the Digital Gangetic Plain, pursued at IIT Kanpur as part of Media Lab Asia program. This project has established a multi-hop Wi-Fi network across 75 kilometers between the Indian cities of Kanpur and Lucknow. It offers the potential to provide a proof-point for enabling rural communications for both voice and data. Another technology project that has gone on to pilot stage is DakNet, in the Indian state of Karnataka, where it is attempting to extend the Bhoomi Land Records project to kiosks that do not have connectivity. DakNet offers Wi-Fi-based asynchronous broadband linkage where wired communication is not available.

In many cases, telecommunications companies are required to fulfill a Universal Service Obligation to provide services to rural areas. Wi-Fi based technologies have the potential to offer a less expensive alternative to telecommunications companies in place of more expensive conventional telecommunications switches.

More work needs to be done to help refine the technology for ease of deployment, while simultaneously pursuing business models around Wi-Fi ISPs in semi-rural and rural areas.

Content localization, relevance, and search technologies: The absence of content in local languages is a key limiting factor in the spread of the benefits of ICT to the underserved masses. Most people in poor nations don't speak a European language, and thus can't read most of the content on the World Wide Web. Technologies that convert content in one language to another provide an exciting area for research. Progress using UNL – Universal Networking Language -- for example, is underway. UNL allows storage of domain-specific information in a particular language in its semantic form. Technology advancements are now demonstrating access to domain-specific information from a different language than that in which it was originally stored. This is enabled by new search technologies that allow the querying of information from these semantic representations in different languages. The Research and Training Center of the Development Gateway Foundation in India is involved in this research agenda.

The problem of availability of local content from the perspective of the poor is compounded by the fact that a lot of the locally relevant knowledge in developing nations is not published. OneWorld.Net, with a number of partners, has created the Open Knowledge Network.[27] The initiative seeks to connect existing knowledge centers in developing countries into a new network to unlock the potential of the poorest communities to use ICT. It is based around key concepts such as: operating agreed standards for exchanging digital content worldwide with explanatory metadata, networking knowledge workers and translators across developing countries in a peer-to-peer architecture, and licensing for the common public good through new forms of "Open Knowledge License."

Moreover, much of what has been published relevant to developing countries has been published abroad, sometimes in languages other than those of the countries that could best use the information. New technology to identify the location in which published information might be relevant is being developed, and should be deployed. Directories and search engines that find and warrant development information can play an important role in this context.

In some cases the bandwidth of content must be changed to meet the needs of people in developing nations. Poor people have lower bandwidth access and often prefer information in a more stripped-down fashion than the average Internet user in developed countries. Moreover, inter-modal linkages are much more relevant in poor markets. Integration of the Internet with community radio, for example, and mechanisms to facilitate e-mail dissemination of Web content are some of the relevant areas for research in this context. Examples of such integration include "Strengthening Women's Leadership in Community Development through Radio-Internet in Brazil"[28] and the WorldSpace Foundation's[29] efforts to help African media and NGOs utilize its digital satellite multimedia service.

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27 http://www.oneworld.net/external/?url=http%3A%2F%2Fwww.dgroups.org%2Fgroups%2Fokn%2F

28 http://wbln0018.worldbank.org/ict/projects.nsf/20c7f8205b9d190185256b180057ba4f/8dd09eedddc08d 685256b10005b7ed0?OpenDocument

29 http://www.worldspace.org

It also important to acknowledge that many poor countries are more verbal than rich countries and more dependent on face-to-face than print-mediated contact; indeed, far larger segments of developing country populations are functionally illiterate than one would find in developed countries.[30] Cultural preferences may involve the structure of content presentation or many other features. Therefore, technological solutions that facilitate the presentation of content in forms that are adapted to cultural needs and preferences can be of great value. Interesting examples in this context are the use of same-language captioning on TV in India, where broadcast television is used as a culturally acceptable medium for teaching adults to read (or re-teaching them to read) or the use of "soap-opera" formats for educational programs in Brazil. Putting instruction in the context of music videos that are widely watched, even in rural areas, can make a difference.[31]

REALITY CHECK: CHALLENGES FOR DEVELOPING COUNTRIES

The reality of the introduction of these new technologies in developing countries, however, remains quite distinct from the science-fiction like optimism of technology enthusiasts. Most developing nations don't have the human resources required to fully explore the technology future we have outlined. Nor will they unless there are radical changes to their educational systems. Needs for human resources exceed availability at all levels. Very large numbers of people will need to become ICT literate in a very short time. Large numbers of people will be needed to build and maintain the ICT infrastructure and to create the ICT industries. Still larger numbers of people will have to become digitally literate to improve the productivity in agriculture, industry, commerce, resource conservation, mineral exploitation, health, education, financial services, and the rest of the economy. While clearly some of these ICT human-resource requirements will be relatively modest, for example, preparing a farm cooperative staff member to utilize the cooperative's computer and Internet connection, some will be quite large. Preparing a meteorologist to properly utilize ICT in making good weather or climate predictions, for example, is a major undertaking.

Moreover, radical reforms are still needed in policy and regulation. While liberalization and privatization of basic telephone services have occurred in many countries, there are still numerous countries where regulatory barriers to entry constrain the ability of new entrants to deploy technologies and to contest the market of inefficient incumbents. The regulatory reforms required for proper operation of basic and value-added telecommunications services remain a priority. In the same vein, the development and adaptation of financial systems and institutions so that they can better support e-commerce and e-government transactions remain a major challenge.

Institutional, organizational, and cultural inertia are likely also to pose grave constraints to e-development. Consider, as an example, introduction of ICT in the educational system or the health system. To do so fully would require large numbers of professionals to change their professional behavior – teachers to teach differently, doctors and nurses to practice medicine differently. This means changes in the

[30] cf. Hopmann (2003).
[31] http://sls4literacy.tripod.com/ongoing2.htm

structure of their schools and hospitals, of professional organizations, of professional training programs, of licensure, etc. Many people can be expected to oppose such change, and even without resistance, planning and implementing such efforts is by no means simple.

Poor countries don't have the financial resources to make all the investments that would be required. The annual cost of providing computer-based instruction in primary and secondary classrooms , for example, was calculated to range from $78 to $104 per student per year in three Latin American pilot projects.[32] This, in turn, is several times the value of the annual discretionary budgets per student available in most developing countries. And there are many other economic barriers. For example, there are few, if any, institutional mechanisms for the production of public ICT goods at the continental or regional level in Africa, Asia, or Latin America. Nor are there adequate mechanisms to allow use of high-end ICT infrastructure in rich nations to solve the problems of poor nations, even where such efforts would have high priority for humanitarian and other reasons. Thus it seems clear that there will be less than desired utilization of proteomics ICT systems for HIV/AIDS and diseases of underdevelopment for lack of such institutions.

There is also a "chicken and egg" situation where lack of established institutional models limit the application of ICT, while in turn development of such models is hindered since their importance is not recognized. Thus, lack of business models and market research data limits commercial investments, which in turn are unable to justify the investments required to conduct exhaustive market research, especially at times when corporate (research) budgets are declining and the economic situation is not optimistic.

A final point worth making is that a key ingredient for a high-performance networked economy is trust. Trust, in turn, depends on transparency and accountability. Similarly, knowledge for development relies on openness to information and willingness to change when new information suggests change is appropriate. Transparency and accountability are not necessarily welcome by those in power, be it governmental, business, or non-profit organizational power; and openness to change is often in short supply. Much less trivial reasons than corruption or reactionary traits exist for resistance to transparency, accountability, and openness. Elites may often be unwilling to trade the comfortable known for the uncertainty of new technologies and the changes that have to be made to fully utilize them. The expansion of modern networks puts in motion forces that promote transparency. Resistance to these forces, however, may further hinder ICT solutions targeted to the bottom of the economic and social pyramid.

THE ROLE OF LEADERSHIP

Wilson[33] explores the importance of leadership in different segments of society – government, private sector, civil society organizations, and the R&D community, in the context of the so-called "quad" framework – in facilitating the

[32] Potashnik, Michael and Douglas Adkins (1996). http://wbln0018.worldbank.org/HDNet/HDdocs.nsf/C11FBFF6C1B77F9985256686006DC949/167A6E81A893851B8525675500681C7E/$FILE/v1n3.pdf

[33] Wilson (2003).

transition toward the information age. From the perspective of the introduction of ICT solutions of special relevance to the needs of the poor, this paper underscores the following issues as of special relevance to the "quad" leadership.

LEADERSHIP NEEDED FROM NATIONAL GOVERNMENTS

- **Active Regulatory Support:** Bridging the digital divide should be part of the national agenda of each developing nation. Bridging the "communications divide" is a critical part of this. Pursuing regulatory approaches that foster the deployment of Wi-Fi solutions and facilitate the de-licensing of spectrum should be a high priority in this agenda.
- **Sustained Funding for Digital Divide Research, Projects, and Pilots:** Sustained political and bureaucratic support is required to enable this to happen. It is important to recognize that multiparty democracies have a larger challenge as to this commitment, and funding will need to be established and sustained across political boundaries and governmental changes.
- **Leadership in Digital Divide-Related Technology R&D:** The world has not focused in a sustained manner on the needs of the next five billion people who are the likely beneficiaries of ICT. It is imperative to strive for international and national awareness to establish a sustained focus and funding in educational and research institutions.
- **Leadership, by Example, in E-government:** This is an area where developing countries can effectively leapfrog stages of development by using ICT as a lever to reengineer the public sector. Programs in countries as diverse as Brazil, the Republic of Korea, and India concretely illustrate the power of these actions in setting the stage for public sector reform and greater transparency.

LEADERSHIP NEEDED FROM CORPORATIONS

- Allocating **investments in financial, human, and organizational resources in ICT** in developing nations, helping build local ICT industries, and exploring globalizing e-markets.
- **Bringing ICT technologies that are relevant to the needs of poor countries and poor people to market**; such technologies should be culturally sensitive, affordable, and scalable beyond pilot experiments.
- **Increasing corporate social responsibility budgets for technology-based efforts to bridge the digital divide.**
- **Increasing investment in R&D efforts on technology related to addressing the digital divide**. As markets develop, these corporations will be the early commercial beneficiaries of such efforts in these emerging markets, especially when many existing markets are becoming saturated for continued growth.

LEADERSHIP NEEDED FROM THE TECHNOLOGICAL AND SCHOLARLY COMMUNITIES

- **Researchers will be needed to step forward** and respond to the challenge to develop the technologies discussed above, exploring creative new institutional arrangements and networks.
- **Researchers in developing nations will be especially important** in assuring that technologies needed by the poor, but not being developed in rich countries, are indeed developed.

- The scholarly community needs leaders to radically **improve the response of educational systems in developing nations to the challenge of the information revolution**.
- These communities also need to show leadership in the **development** of content needed in developing nations, and the **localization** of that content.

LEADERSHIP NEEDED FROM CIVIL SOCIETY

- Leveraging the process of transforming ICT technology into **weapons for transparency**, with emphasis on benefits to the poor.
- Creating sustainable civil society mechanisms for ICT innovation and development by further **engaging grass-roots communities in the delivery of these solutions**.
- Facilitating the spread of **open-source software solutions and ICT training** tailored to the needs of poor communities.
- Experimenting with innovative mechanisms to **magnify the reach of the Internet** by coupling it with community radio and other conventional media.

In addition to leadership in the context of the "quad" framework, **leadership from multilateral institutions and international agencies** in their funding is also needed for:

- **Living (research) pilots**: In many cases, pilot projects are funded based on a specific approach with specific technologies. In many cases these plans, once approved, do not allow for the need to dynamically revise approaches, technologies, and other variables. The ability to dynamically adjust relevant financial and technological variables in internationally funded pilots should be encouraged.
- **Pilots to scaled deployments:** Pilots have to be actively managed to take to scaled deployments. Otherwise, pilots wind up as good reports for future pilots. Strong leadership in getting funding necessary to take pilot projects into formal deployments is critical for visible successes to occur.
- **Continued support in mobilizing resources for roll-out of ICT infrastructure:** This support should be based on appropriate policies and institution building efforts of developing countries to allow such roll-out and to appropriately regulate the developing infrastructure.
- **Continued support for applications of ICT in all sectors:** This is needed especially where such applications address key development constraints, and where they help efforts to alleviate poverty.

Leadership is also needed from these agencies to help create the regional and global institutions that can foster the development and application of these technologies. An example in point is the Development Gateway Foundation. [34] Even though its resources are quite limited when compared with the challenges involved in bringing the benefits of the information revolution more fully to poor nations and poor people, it can play an important role in this process given its multi-stakeholder partnerships and reach. Most importantly, it can utilize ICT in new ways to promote sustainable development and can help in the reduction of poverty, especially through:

[34] http://www.dgfoundation.org

- Country Gateways for networking leaders, framing issues, development coordination, and knowledge sharing;
- The Development Gateway Portal[35] with its:
  - dgMarket (e-procurement platform) as a means of enhancing transparency and expanding business opportunities in developing economies;
  - AiDA – the largest available database of development activities -- as a platform to promote donor coordination, sharing of experiences, and standards for information dissemination;
  - Knowledge topics that help build communities of practice and leadership in key development areas;
  - Open-source architecture that promotes cooperation in a distributed manner.

The Development Gateway Foundation can also play a leadership role in advancing ICT for Development by:

- Continuing ICT Development forums such as this Petersberg Forum;
- Offering prizes to recognize and thereby encourage leadership in ICT for Development;
- Promoting e-government through development grants, training, and building a community of leadership practice; and
- Promoting knowledge creation and sharing about ICT for Development through its Research and Training Network and through grants and investments.

In sum, the logic of the networked economy can be one of inclusion rather than one of exclusion. As technological progress continues to push the costs of ICT down, opportunities for development-oriented applications will multiply. It is incumbent upon all of us to work together to make this prediction a reality.

[35] http://www.developmentgateway.org

REFERENCES

Anonymous. “Compaq, Sandia and Celera join forces to develop 100 TeraOPS supercomputer.” Hewlett Packard, January 2001. <http://h18003.www1.hp.com/alphaserver/news/sandia_celera_0101.html>.

Berners-Lee, T., Hendler, J., and O. Lassila. “The Semantic Web.” *Scientific American*, May 2001.

Daly, J. “A Measure of the Impact of the Internet: A Tutorial.” *iMP*, December 1999. <http://www.cisp.org/imp/december_99/daly/12_99daly.htm>.

Emmen, A. “International Supercomputer Conference 2002.” *Primeur*, March 27, 2002. http://www.hoise.com/primeur/02/articles/monthly/AE-PR-05-02-1.html

Gage, J. “Some Thoughts on How ICTs Could Really Change the World.” *The Global Information Technology Report 2001-2002: Readiness for the Networked World (GITR)*, New York: World Economic Forum, Oxford University Press, 2002.

Hopmann, C. “Communication + Information ? Organization: A missing Dimension.” April, 2003 http://www.developmentgateway.org/node/133831/sdm/docview?docid=504285

Joy, B. “Why the Future does not need us?” *Wired Magazine*, Issue 8.04, April 2000. http://www.wired.com/wired/archive/8.04/joy.html

Metcalfe, R. "The Internet After the Fad." Remarks of Dr. Robert Metcalfe at the University of Virginia. May 30, 1996. http://www.americanhistory.si.edu/csr/comphist/montic/metcalfe.htm#me7.

“Moving up the stack” in Coming of Age: A survey of the IT Industry. *The Economist*, May 10, 2003.

Negroponte, N. “Being Wireless.” *Wired Magazine*, Issue 10.10, October 2002. http://www.wired.com/wired/archive/10.10/wireless.html.

Network Wizards. Internet Domain Survey, Jan 2003. http://www.isc.org/ds/WWW-200301/index.html

Potashnik, M. and A. Douglas. “Cost Analysis of Information Technology Projects in Education: Experiences from Developing Countries.” *World Bank Education and Technology Series*, Volume 1, Number 3, 1996. http://wbln0018.worldbank.org/HDNet/HDdocs.nsf/C11FBFF6C1B77F9985256686006DC949/167A6E81A893851B8525675500681C7E/$FILE/v1n3.pdf

Resnick, M. “Rethinking Learning in the Digital Age.” *The Global Information Technology Report 2001-2002: Readiness for the Networked World (GITR)*, New York: World Economic Forum, Oxford University Press, 2002.

Wilson, E. J.III. “Leadership for a Networked World.” ICT Development Forum, Development Gateway Foundation, May 2003.