A Community Informatics for the Information Society

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Abstract

Community informatics is an emerging, interdisciplinary field concerned with the development, deployment and management of information systems designed with and by communities to solve their own problems. From academic and policy-making perspectives, community informatics is now concerned with developing a coherent theory and methodology drawn from a now significant history of projects and the ever-increasing efforts to use information and communication technologies to solve life-critical community problems.

Community informatics might be considered analogous to the well-established discipline of management information systems (MIS), where the former is tailored to the unique requirements of communities and the critical problems they pose for developers of information systems. These requirements and problems are significantly different from those faced in MIS, thereby warranting a unique disciplinary focus.

The goals of this paper are to:

- motivate the need for a community informatics in the context of the World Summit on the Information Society (WSIS);
- give an overview of conceptual and methodological issues; and
- propose the parameters of a community informatics sufficient for addressing development goals established in recent United Nations initiatives, including the Millennium Declaration and the ICT (information and communication technology) Task Force, and, in particular, the forthcoming WSIS.

Many of the concepts and issues discussed here are the results of research and practice in the developed world. Nonetheless, an effort is made in this paper to link community informatics to the realities of communities in developing countries, as well as disadvantaged communities in highly developed countries. Suggestions for new areas of research are also made. A set of related resources is listed in the annex to this paper.

The Basis of Community Informatics

That technological systems are neither value-neutral nor infallible should no longer be in dispute. What should also no longer be in question is the fallacy of information and communication technologies (ICTs) as *a priori* solutions to societal problems. Yet, recent high-level policy discussions concerning the introduction of ICTs into society have often not clearly acknowledged this. Technocentric solutions have been pushed without a critical analysis of potential and realized impacts of technologies and without proper acknowledgement of the historical processes responsible for the social and economic inequalities for which ICTs are being proposed as solutions. This is not to mention the "technofilia" and "cyber-fetishism" that seem to be rampant in popular discourse.

Community informatics is an acknowledgement of more than the non-value-neutral and fallible nature of ICTs. It is a recognition that the idea of purely technical solutions to societal problems is a fallacy and, further, that the seeking of technical solutions must necessarily be a social process. Mumford (1934), in his seminal *Technics and Civilization*, showed that technology is technique based on interactions between people and environment, and thought and creation, in order to achieve a specific goal. Of course these interactions have often not been positive. For these interactions to benefit people or communities that will be impacted by the resulting artefacts, the design process must be participatory. Kristen Nygaard, a computer scientist, pioneered the practice of participatory design in the 1960s when workers raised concerns about the potential for ICTs being introduced into their factories to eliminate their jobs. Because new systems invariably introduce unforeseen changes into organizations, often with bad consequences, Nygaard called for user involvement throughout the life cycle of a system (its design and operation). He also showed that ICTs should be viewed as only part of an overall system, with humans being major components of systems (Hausen and Mollerburg 1981). Nygaard's insights have come to be supported by other research. Benjamin (1999), in the context of post-apartheid South Africa, has shown how community-based ICT projects have failed due to non-participatory approaches being used.

Participation is a necessary but insufficient condition for community informatics to be effective. Among the greatest threats of new technologies is that they have the potential to perpetuate and expand existing power relations and inequalities, as well as to enable new forms of state repression. To empower communities to respond to and avoid these threats, community informatics must enable a fully democratic process. That is, it must be more than political democracy embodied in a participatory approach. Community informatics must allow people to share control of the decision making around the economic, cultural, environmental and other issues regarding ICT-based projects. More fundamentally, community informatics must empower communities who contemplate ICT-based solutions to develop their own productive forces within the information society so that they can control the modes of production that evolve within it and, thereby, have the possibility of preventing and responding to its threats. The open source and free software movements as modes of production are prime examples of the necessary elements of a community informatics that can enable communities to develop their own productive forces.

Finally, a participatory approach must also respond to the diversity of users and needs that exist within communities. User communities cannot be viewed as homogeneous. This principle is embodied in the universal design approach discussed later in this paper.

While this paper emphasizes methodological issues within community informatics, references to design, deployment and analysis in the following discussion must be understood to be grounded in the participatory and democratic perspective articulated above.

The Potential of ICT Impact, and the Role of Community Informatics

Given the potentially serious threats that ICTs pose to communities, their putative benefits must be constantly challenged and weighed carefully against the risks. A critical insight here in locating reasons to consider ICT-based approaches in communities is that the relationships between technology and society are non-linear. A cyclic interplay is often possible. For example, while ICTs have the potential to fortify socially unjust power relations, they can sometimes offer entities in civil society flexibility in responding to their conditions. The potential benefits of ICTs can be seen at a base level within the responses of communities to social and economic problems. Communication research has shown that people in economically and socially marginalized communities spend an inordinate amount of time and energy seeking and managing information related to survival and security. Information and the ability to communicate it—to receive and impart it—are necessary (but not sufficient) conditions for communities to develop and for inhabitants to thrive within them. Appropriately designed ICTs can fulfil such needs. Research has also shown that economically and socially marginalized people spend an inordinate amount of energy negotiating geography and time. Recent work in the area of digital government, for example, has revealed the lack of appropriate access points to and integration of US government information systems, which hinders the provision of social services by forcing individuals—often the poor—to travel long distances between offices (Bouguettaya et al. 2001, 2002). ICTs in this context offer the possibility of introducing more flexibility into people's lives in terms of time and space. Specific advantages of ICTs are discussed below.

The potential impacts of ICTs in least developed countries and developing communities

The United Nations Millennium Declaration (2000) contains a series of goals for the improvement of human society by 2015 and 2020. The goals can be categorized under the areas of poverty and hunger eradication, universal education and literacy, reversing major diseases and improving health care, environmental sustainability, and gender equality.

In examining the specific potential impacts of ICTs in addressing poverty in the developing world, Accascina (2000) has argued for a broader definition of poverty, one that includes information poverty. Community informatics in this view would, thus, be concerned with facilitating access to information independent of specific technologies.

Accascina provides a useful taxonomy for viewing the potential impacts of technological interventions. Impacts are considered along dimensions of geography and type of benefit that could potentially accrue to developing communities and, consequently, to individuals living in them. Potential impacts on poor individuals and communities are seen as originating from local or regional, national or global initiatives. For each, impacts may be either direct or indirect. Examples, including those cited by Gurstein (2000) and Finquelievich (1999) in the context of rural communities and non-profit organizations in both developing and developed countries, are given in table 1.

Thus, a community informatics can potentially make contributions at multiple levels in a society and through a variety of direct and indirect development relationships. In particular, community-based ICTs can be seen as contributing to the following Millennium Development Goal (MDG) areas:

Poverty and hunger eradication: Poverty and hunger eradication might be partially addressed through improved local access to information that impacts on local food production or other sectors of local economies such as tourism. Training in ICT-related skills can prepare people to take advantage of certain types of higher paying jobs in their countries, if and when they should become available.

Table 1: Potential benefits to communities from ICT interventions

Geographic span	Potential direct benefits	Potential indirect benefits
Local or regional	• Access to local or regional market information for small producers • Access to information about social and health services • Facilitation of customer-to-customer or community-to-customer transactions (for example, tourism) • Improve spatio-temporal relations for NGO work	• Employment in ICT-sector or jobs requiring ICT skills for family members • Better leveraging of human resources in response to community problems
National	• Access to information about legal or policy information • Access to information about jobs facilitating business-to-business transactions	• Overall improvement in human development and poverty indices
Global	• Participation in ICT-based systems (for example, trade) • access to services provided by international NGOs	• Overall improvement in human development and poverty indices

Education and literacy: The supplementation or improvement of primary education might also be facilitated by ICT-based solutions. This is arguably the case for societies whose teaching pools are already inadequate to meet MDGs or whose adult labour forces have been devastated by major diseases, such as HIV/AIDS. While not pedagogically ideal, a limited teaching pool might be extended "virtually" through the use of ICTs in different modes of distance learning. ICTs provide various means by which educational content could be captured, stored and managed for use in other locations. The content could be delivered live or in recorded form. Subject matter experts could also be shared for teaching higher level courses across wide geographic areas.

Illiteracy is another major factor in the MDGs, as well as human development in general, that could potentially be addressed through the application of advanced ICTs. Adult literacy rates remain below 60 per cent in many of the world's countries, with rates below 50 per cent in the least developed countries, or LDCs (UNDP 2002). Both video and audio modalities can now be supported through relatively low-cost computing platforms and some other types of ICTs. These could potentially offer alternate means of delivering information that would otherwise be inaccessible to illiterate adults. Additionally, the dual use of audio or video with text might be explored as one means of reducing the rate of functional illiteracy in adults. This is being explored in the context of iconic human-computer interfaces (Noronha, no date).

Reversing major diseases and improving health care: The delivery of life-critical health information might also be facilitated and improved through ICT-based solutions (Driscoll 2001). Lack of access to information and communication has been identified as a critical factor in public health crises around the world (Garrett 2000). Garrett suggests that providing citizens of underdeveloped countries with community-level points of access to health information would be a critical starting point for addressing health care crises. However, such access points should support more than one-way flows of information (for example, from expert to community or patient). Communities must be allowed to participate in the selection and creation of communication flows that they find useful and necessary to address health care (for example, between local health professionals and between patients). Examples of current efforts in this area include the dissemination of HIV/AIDS information using CD-ROM, diskettes and other types of ICTs in Africa, and a Web site, sponsored by the United Nations Development Programme (UNDP), for HIV/AIDS in Southeast Asia (Driscoll 2001).

Environmental issues: Dwindling water supplies, fresh air and sanitation have all been threatened by trends and pressures brought to bear by development. ICTs are seen as a component of solutions to such problems. One ICT-based approach to improved environmental stewardship is community-based natural resource management (Bhatt, no date). As with other issue areas, ICTs can facilitate improved delivery, co-ordination and analysis of information about environmental issues and strategies. One example here is the Sri Lanka Environmental Television Project (SLETP), which integrates television, video and the Internet to deliver information to broadcasters, educational institutions and individual homes.

Gender equality: Jansen (1989) and others have pointed out that technological designs and processes used to deploy them often reflect society's gender biases (see also Muller et al. 1997 and Sabanes Plou in this volume). This has unfortunately been the case in gendered attitudes toward advanced ICTs and opportunities afforded women and girls to learn information technology (IT) skills in many parts of the world. The potential of ICTs to address this area of the MDGs is, thus, less linear than the other issue areas discussed above. That is, the application of ICTs themselves cannot be viewed as improving gender equality. Rather, it is argued that significant, positive reinforcement cycles toward gender equality can be created in a society through improved IT-related opportunities for women and girls. It is further argued along this same line that improvements in other MDG areas beyond those likely to be realized through IT-related opportunities for men can be achieved by providing the same opportunities to women and girls. There are several arguments for this claim. Munya (2000) pointed out that most critical, culturally situated knowledge resides with women and, therefore, enhancement of the abilities of women to continue to exchange such information are a necessary part of any development that is to be realized in a community or region. In addition, Munya points out that women in the developing world are often central to agricultural production, and they expend more of their income on their families than men do. Thus, it can be reasoned that women are likely to better leverage the potential benefits of ICTs in all of the MDG issue areas discussed here.

The Need for a Distinct Informatics for Communities

The pressing nature of the problems outlined above calls for every tractable and useful strategy to be brought to bear to solve them, including the application of ICTs. It might be argued that traditional organizational informatics have long existed and are readily available to guide the development of ICTs in pursuit of MDGs and other types of community development. Organizational informatics (OI) is taken here to mean the traditional development of ICTs in resource-rich, high-capability settings, such as corporations or governments. This encompasses the application of disciplines such as systems analysis, software engineering and management information systems (MIS). The need for a community informatics as distinct from organizational informatics has been motivated by recognition of two realities. First, organizational informatics is itself known to be very difficult and the site of many failures. An overwhelming majority of government ICT projects fail, for example (McIver and Elmagarmid 2002). Second, the characteristics of communities are highly unique relative to organizations and, therefore, the development of ICTs for communities warrants a special focus: community informatics (Gurstein 2000, 2002).

Disciplines such as computer science and mathematics periodically list "grand challenge" problems, a set of problems whose solutions are necessary to make major progress in the field and which possibly offer applications that would advance society. The identification of technically feasible candidate solutions to meet goals such as those in the Millennium Declaration is relatively easy in the context of an organization informatics approach. In community informatics, however, the grand challenge is to develop technological solutions for communities that are economically, socially and culturally appropriate and that are operationally and economically sustainable. This is especially true for developing countries, where resources and training may be even scarcer than in most communities.

The economic, social and cultural appropriateness of ICT designs factor in to the grand challenge in that they must address significant differences and deficits in knowledge and experience in the communities they are to benefit. Systems analysis and development is often done poorly even in well-funded, high-technology organizations in high-income countries. A number of realities suggest that communities in developing countries are likely to do worse without a special approach. The general history of technological development in organizations and for the consumer market is replete with cases of failure. Most are attributable to poor design practices. Systems analysis and design, software engineering, usability engineering and the other related disciplines that make up the constellation of generally recognized best practices all demand people with special training and experience. Communities without a proper educational framework and knowledge base are not likely to have access to such people. Based on the history of ICT development in an organizational context, it can also be argued that communities are not likely to arrive at nor apply best practices on their own. Thus, special community-level training in these skills is needed. The processes involved, as traditionally practiced, can also be costly. Consequently, communities may have to forgo best practices. Thus, alternate, cost-effective approaches to ICT development for communities must be developed.

Evidence suggests that the viability of technological designs for communities in the developing world is far more sensitive to the use of best design practices in general, and attention to economic, cultural and social dimensions of appropriateness in particular. Potential adopters of technologies in communities may be less able to withstand the economic and social impacts of poor designs. The costs of failure in ICT-based projects are on average high, relative to the size of an organization. Communities in developing areas are probably least able to withstand such impacts. In addition, social and cultural norms about the appropriateness of various facets of a given application of technology may differ significantly between communities and thereby impact the viability of a system. Such facets could conceivably be the functionality (or lack thereof) provided by a system, methods of interaction required to use it or the user interface metaphors that it employs. A major reason for poor designs is a failure to adequately involve the target user community in the design process. This is a common oversight in organizational settings (Landauer 1995; Norman 1998). Without proper training, it is likely that communities would also fail to employ user-centred design processes. Finally, research suggests that the general level of technical literacy of a system's users can have a significant impact on its perceived usability, with experts being less sensitive to problems of design. This suggests that communities in the developing world, whose citizens likely have a low level of technical literacy or experience, may have an even lower tolerance for poor designs than in developed countries, which would make the need for a sound and practical community informatics in the developing world critical. More research and practice is needed to better understand the needs of communities in developing countries in all the respects discussed here. However, it is clear from experiences in the broader world of ICT development that developing countries need methods of systems analysis and design that are geared specifically to their economic constraints, experience and training needs.

The operational and economic sustainability of ICT designs factor in to the grand challenge in that they must address significant deficits in investment capital, infrastructure and experience. The economics of a community will often preclude individualized solutions that are the norm in developed nations, such as home-based Internet access. Instead, approaches to developing group-based solutions must be sought. In addition, the remoteness of many communities will preclude certain modalities of communication, such as broadband. Instead, novel approaches to using wireless telephony, radio, satellites or low-power television will be necessary. In general, a community informatics must be open to using alternate design approaches and technologies. This includes the use of open hardware standards and open source software, the creative appropriation and adaptation of existing technologies of infrastructure, and use of traditional ICTs (such as print and radio). In addition, the use of open technologies—as opposed to custom commercial or commercial off-the-shelf (COTS) solutions—requires people in the community who have sufficient expertise to develop, operate and maintain systems. This is an added challenge for developing communities, where such expertise may be difficult to find and afford. A community informatics must, therefore, establish methodologies that empower communities to build the capacity and knowledge to sustain technological solutions. Communities that are to be properly involved in the development and sustenance of their own systems must also develop an educational foundation for their work.

In summary, the need for a community informatics exists in stark contrast to the domains of MIS, and science and engineering applications for which large bodies of knowledge and best practices have been developed. These practices generally assume an abundance of resources and expertise. The characteristics and needs of communities are significantly different from those of business and technical organizations and, thus, require different approaches to design, development, deployment and operation. The next section develops a canonical view of a community informatics necessary to adequately address the challenges discussed above.

Conceptual and Methodological Issues in Community Informatics

Community informatics is an interdisciplinary field concerned with the development, deployment and management of information systems designed with and by communities to solve their own problems. It is arguably a part of social informatics, which has been defined by Kling (1999) as "the interdisciplinary study of the design, uses and consequences of information technologies that takes into account their interaction with institutional and cultural contexts". Social informatics research has three principal areas of focus.

- *Theories and models:* The development of models and theories that explain the social and organizational uses and impacts of ICTs.
- *Methodologies:* The development of methodologies that address the social impacts of the design, implementation, maintenance and use of ICTs.
- *Philosophical and ethical issues:* The study of philosophical and ethical issues that arise in the use of ICTs in social and organizational contexts.

Thus, community informatics should be seen in the context of social informatics as a disciplinary site focusing on the development information technologies for communities, which takes into account research from social informatics, as well as MIS, software engineering and other technical fields. It might also be argued that the definition of community informatics should include that part of traditional MIS practice where the public's interests are properly considered. Examples here include publicly funded ICT development where democratic participation and oversight by citizens can help reduce traditionally high failure rates and address negative social impacts.

Classes of community-based systems

A wide spectrum of technologies—both hardware and software—can be considered for use within community-based systems. These include technologies that "externalize" non-governmental organizations (NGOs) or government by enabling people to interact with processes inside of these organizations, and those technologies that can be used to improve internal processes within organizations that benefit communities. The former type of technologies will be referred to as externalizing systems and the latter as internal systems. The prime examples of externalizing systems technologies are the Web-based services that provide government services, which have become prominent in the past few years in the developed world. Internal systems technologies include novel applications of computing techniques in communication, geographic information systems (GIS), database management and image processing to solve critical tasks within government or NGOs. Of course, many externalizing systems employ the services of internal systems. The architectures of systems in both the categories of externalizing and internal systems are in most cases database-centric.

The dominant vision of externalizing systems for most organizations has become—like many other areas of the information technology sector—Web-centric. Commercial Web service offerings have clearly raised citizens' expectations of the level of service provided over the Web (Cook 2000). These systems can generally be characterized along two dimensions: the architectural relationship they have with their clients and the type of service they are capable of providing for their clients. Architectures include intranets to support intra-organizational processes, public network access to facilitate organization-citizen interactions, and extranets for supporting interactions between organizations (for example, government-to-business, government-to-NGO, NGO-to-NGO).

Four basic types of Web architectures are seen among current externalizing systems, each corresponding to a level of service (McIver and Elmagarmid 2002).

- *Level 1 externalizing services:* These services provide one-way communication for displaying information about a given agency or aspect of an organization.
- *Level 2 externalizing services:* These services provide simple two-way communication capabilities, usually for simple types of data collection, such as the registration of comments or requests with an organization.
- *Level 3 externalizing services:* These services extend on level 2 services to provide the ability to carry out complex transactions that may involve intra-organizational work flows and contractual procedures. Examples include voter and motor vehicle registration, and brokering systems between third parties (see Gurstein 2000).
- *Level 4 externalizing services:* These services are characterized by the emergence of portals that seek to integrate a wide range of services across whole sectors, regional bodies or geographically distributed organizations. The eCitizen portal developed by the government of Singapore is a prime example of this type of system.

A wide spectrum of technologies can be considered to fall within the category of internal systems, including those that perform tasks common to large organizations, such as financial management, document processing and communications (for example, email). The development of novel systems that would likely have benefit for communities would fall generally into two categories.

- *Integrative and communicative systems:* These are systems that provide support for interorganizational integration and co-operation. These types of systems can enhance the sharing of data and the co-ordination of processes in and among organizations.
- *Domain-specific processing and knowledge management systems:* These are systems that provide support for processing and interpretation of data within ontologies that are unique to an organization, community or government. These include the processing of agricultural statistics, management of community assets, co-ordination of social services policies (that is, rules) and data, and management of geographic images from government geological surveys.

Principle issue areas in community informatics

As discussed above, community informatics might be considered as analogous to MIS. The following are the principle issues that community informatics must address and which set it apart from MIS.

Prioritizing social requirements: Community informatics differs from MIS in that it must, in the interest of social and cultural goals, be open to creative solutions for communities that may be outside the orthodoxy of traditional MIS solutions or cost-benefit analyses.

Accessibility, universal design and participatory design: Community informatics must also have a commitment as a matter of principle—and law in many countries—to the development of ICTs for communities such that the widest range of citizens can enjoy their benefits, particularly those with disabilities (Glinert and York 1992). The concept of universal design has evolved out of the objective of designing systems that are accessible to people with disabilities. It has been recognized, however, that universal design benefits all people, not just those who have disabilities. General principles for universal design have been developed by a number of organizations. Universal design principles have also been developed for the specific software engineering domain of Web applications (W3C 2001). Finally, universal design must take into account literacy and linguistic barriers.

Sociotechnical geographies: Communities are geographically situated and, thus, there are often significant geographic components to their problems. For example, rural communities worldwide have historically faced major geographic barriers in gaining access to infrastructure necessary to use ICTs, including electrification and telephony.

Technology lifecycle constraints: Communities also often face tighter financial constraints than business or governmental organizations in attempting to address their problems in terms of the costs of implementation and long-term maintenance. The seeking of IT-based solutions must, therefore, include consideration of low cost, public domain or open source solutions. The development process must also include training of community members and the development of local capacity to participate in the design process and to provide ongoing technical support for their own systems.

The development of technology for communities without due consideration of the unique requirements cited above has often had unfortunate consequences (Rudolph 2002; Margonelli 2002). Community informatics as a discipline, therefore, must develop a coherent body of theories and methods to address the issue areas above. Each of these areas is examined in greater detail below.

Prioritizing social requirements

In community-based ICT projects, social and cultural issues have greater priority than they might in organizational informatics. In the interest of social and cultural goals, therefore, community informatics must be more open to creative solutions for communities. Candidate solutions might be considered for communities that exist outside the orthodoxy of traditional cost-benefit analyses likely to be used in an organizational setting or user expectations that might exist in a consumer context (for example, individual Internet access).

A commonly cited example here is the argument about digital divide strategies, which is that it makes little sense to prioritize the introduction of advanced ICTs in a developing country where major deficits in Human Development Index components remain. In particular, it could be argued that it is not reasonable to implement individual Internet access in a society where literacy rates are low, and public health and other basic services are lacking.

In this context, advanced ICTs such as the Internet must be considered only "candidate solutions"—in the parlance of systems analysis—within a community informatics approach. They must also be viewed as only potential components of overall solutions to a given problem, where other non-technical and social components are assumed to play major roles. The overriding concern then should be to select technologies that are suitable and appropriate to a community, given social, cultural, sustainability and economic factors. To achieve this, it is necessary to be open to the full range of communication modalities and technologies, including analogue broadcast technologies, interpersonal communication methods, and institutional mechanisms such as libraries.

What must also be realized in prioritizing social requirements is that most telecommunication technologies can be deployed at granularities appropriate to a community's needs and resources. That is, a number of advanced ICTs can be deployed in a range of access scopes, from community-level access down to the individual. This perspective sets community informatics apart from an organizational or consumer approach in many applications in the developed world in that expectations are often oriented toward individualized access.

Accessibility, universal design and participatory design

A community informatics approach must ensure that the widest range of people are able to enjoy the benefits of ICTs. The particular concern here is for those who have disabilities, and those who face linguistic and literacy barriers to accessing information.

The concept of accessibility encompasses not only the direct human-ICT interactions used to conduct transactions, but also factors that limit citizens' physical interactions with organizations or individuals. Barriers to physical interaction include both disabilities and disabling conditions, and problems of geography and time, independent of disabilities, that prevent people from travelling to sites where community-based services and information are offered. The integration of telecommunication and computing technologies has, of course, served greatly to reduce barriers of geography and time, though many infrastructure issues remain.

The Trace Center for Research and Design at the University of Wisconsin, United States, identifies four major categories of disabilities or impairments.

- *Visual impairments:* Visual impairments range from low vision to blindness. Some visually impaired people are able to see light, but can discern no shapes; the vision of some people is dim or fuzzy; some people cannot differentiate between certain colours; and others can see no light at all.
- *Hearing impairments:* Hearing impairments range from partial hearing impairment to deafness.
- *Physical impairments:* Two major types of physical impairments exist: skeletal and neuromuscular. Those with skeletal impairments may have a limited range of movement for certain joints or they may have small or missing limbs. Those with neuromuscular impairments may have paralysis in all or part of their body or they may have poor neuromuscular control.
- *Cognitive/language impairments:* Cognitive/language impairments include problems with memory, perception,

problem solving, conceptualizing, and comprehension and expression of language.

Often people have multiple impairments. Responding to all of these types of impairments will be critically important in areas of the world where people suffer from war injuries.

ICTs are the basis for a wide array of solutions for accommodating people with disabilities. Solutions include text-to-speech and speech-to-text conversion devices and software, text magnification features offered in desktop operating systems and applications, voice-activated controls for computer applications, telecommunication devices for the deaf (TDDs), closed captioning for video data, and computer-based Braille devices for the blind.

Approaches to accommodating specific types of impairments (or combinations thereof) are not always obvious and, therefore, deserve the attention of specialists. For example, many hearing-impaired people in the United States use American sign language (ASL) to communicate. It cannot be assumed, however, that ASL speakers understand English, as it is a completely different language from ASL.

The concept of universal design has evolved out of the objective of designing systems that can accommodate people with disabilities. The goal of universal design is to develop systems that can be used by the widest possible range of people without special design modifications. General principles for universal design have been developed by a number of organizations. Universal design principles have also been developed for the specific software-engineering domain of Web applications (W3C 2001). Web site accessibility is discussed later in this section.

Two points must be stressed in motivating the use of universal design. *First, it is critical that universal design principles be applied from the inception of a project.* Accessibility features can be made more useful and easier to use when they are made into integral parts of the design. It is also usually far more cost-effective to include accessibility features into a design than to retrofit them into a completed system. Second, *universal design benefits all people, not just those who have disabilities.* Techniques developed to provide those having a specific type of impairment with access to some system are often found to be useful to others. For example, text-to-speech conversion has been found to be useful for "hands free" applications, such as having email messages read to people as they perform other tasks. Closed captioning is useful not only to those with hearing impairments, but also to hearing people working in noisy environments.

The National Institute on Disability and Rehabilitation Research in the United States (Connell 1997) has developed the following universal design principles:

- systems should accommodate a wide range of user abilities and preferences;
- it should be easy to adapt systems to a broad spectrum of user preferences and abilities;
- system interfaces should be intuitive and simple to use;
- systems should be able to employ different input and output modes according to user abilities and ambient conditions;
- systems should be designed to minimize hazards and to be tolerant of user errors;
- systems should be usable with minimum physical effort; and
- the size and spatial placement of system elements should accommodate a wide range of body size, posture and mobility.

Special attention has been paid to accessibility in the context of Web content. Different aspects of markup languages pose unique problems for various adaptive systems. Some text readers, for example, have difficulty processing HTML tables. Guidelines for designing accessible Web content have been developed by the World Wide Web Consortium (W3C) and are continuously revised as markup languages evolve (see W3C 2001). A number of tools are available for validating Web content against these and other accessibility guidelines.

Specialized browsers and devices have been developed that provide alternate ways for people to use the Web. These include special browsers for the visually impaired that allow Web content to be read aloud or displayed on devices such as Braille bars; general screen-reader devices and software that allow users to have any on-screen content read to them; and other adaptive technologies, such as voice input systems, telephone-based Web browsers, and systems that transform or filter existing Web content to make it more accessible.

User-centred and participatory design

Landauer (1995) has pointed to the "failure to design well" as the central cause of problems with usefulness and usability of computer-based systems and processes. These failures, he points out, are often due to a lack of focus on users in the design, development and operational phases of systems.

Landauer also cites some other major factors as impacting usefulness and usability.

Hardware and software limitations: Usefulness and usability are often limited by the functional limitations of software systems and, in some cases, the technical limitations of the hardware systems that they control. The case literature is replete with examples of software systems that overly constrain the ways that tasks can be performed or that do not allow them to be performed at all. Media-rich Web sites often tax the limited processing power and bandwidth limitations of many users' hardware. Bandwidth limitations will remain of particular concern to community informatics practitioners working in the developing world.

Unreliable systems: Systems fail due to software errors, user errors and hardware failure, with the first two factors being the most common. Landauer assigns responsibility for user error to computer systems. They should be designed so as to prevent users from causing erroneous conditions. The production of technologies that meet this latter requirement is likely to be far more difficult in communities, where people have little experience using advanced ICTs.

Incompatible systems and data types: While standardization of software systems and data types (for example, file formats) has become widespread, particularly in the context of Web technologies and desktop environments, incompatibility problems continue to limit the usefulness and usability of many systems. Though Web clients (such as browsers) have brought about a significant improvement in the interoperability of data sources from different applications and operating systems, the use of data sources such as PDF files and RealAudio streams requires clients to support special adjunct software systems (for example, plug-ins). Compatibility problems due to this issue are likely to be more acute for economically disadvantaged citizens and community organizations (for example, schools and libraries) that cannot upgrade from older or relatively low-end equipment.

Negative ergonomic and social impacts of computer systems: Computer systems are now recognized as potential sources of ergonomic problems such as repetitive stress injuries and fatigue. Many negative social impacts have been attributed to the deployment and use of computer systems. These include impacts on work and work life, privacy, culture and the natural environment.

Landauer and many others have long recommended user-centred approaches to design, development and deployment as necessary to the creation of useful and usable computer systems. Using these approaches, designers, developers, procurers and maintainers of systems would engage in iterative processes of systems analysis, implementation and operation, with each process having users as their central focus. Unfortunately, these approaches are not used often enough. Financial and time constraints are common reasons for forgoing user-centred processes.

Designers working in a community informatics framework would work continuously in direct interaction with users in the design phase to gain an in-depth understanding of their needs and to explore possible approaches to meeting them. In the development phase, developers would engage in iterative cycles of implementation, evaluation of usability, and design modification based on test results. Once a system is ready for operation, user-centred processes would be used to determine how best to integrate it into human work flow processes, to determine what skills are necessary to use it, and to periodically monitor its usefulness and usability. Deployment, including procurement of software systems and hardware developed by other organizations, would also be user-centred, having inputs from the people who would use and manage such systems.

Sociotechnical geographies in the information society

Information and communication technologies have come to be seen as spatial systems that change space and time relations to create new "virtual" geographies (Gillespie and Robins 1989; Kitchin 1998). These include geographies defined by communication, economics and social formations.

Geography presents significant problems in many community-based ICT development projects. Analyses of the needs of users in domains such as e-government, for example, have revealed serious geographic barriers in providing social services. Situations have been identified where people seeking particular types of social services are often required to travel large distances between various social service and health agency offices (Bouguettaya et al. 2002). Such barriers can be eliminated through availability of online services and local access points (such as computer terminals, telephones, and automatic teller machines, or ATMs).

An effective community informatics must be concerned with facilitating access to a geographical area in which access points or other appropriate telecommunication infrastructures exist. Such geographies include work environments, libraries and schools where access points likely exist.

Less obvious are the relationships between the deployment of these technologies and urban planning by both public and private sectors. Both urban and rural geographies must either have an evolving infrastructure to provide telecommunication services sufficient to sustain community informatics projects, or policies that allow communities to appropriate newer ones (for example, licensing structures that permit the deployment of wireless fidelity, or WiFi). Characteristics of emerging technologies are allowing community informatics projects to "leap-frog" older telecommunication technologies to build infrastructure at lower costs.

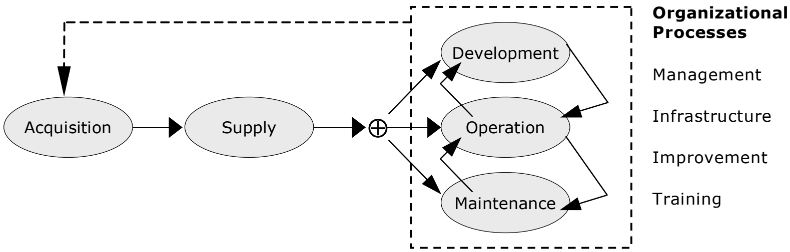
Access to knowledge has traditionally required access to the physical geographies in which the desired information exists. Such geographies include not only technological access points, such as records or books, but, most importantly, points where human agents who possess knowledge can be reached and from which they can transmit. It is in this latter context that community informatics projects may have the most profound impacts toward the MDGs. Automated information delivery will not suffice in meeting MDGs on education, health care and other domains in which human expertise must be consulted continuously—unlike the provisioning of engineering artefacts such as water or environmental technologies.

Managing technology lifecycle constraints

The design, development, deployment and operation of ICT systems have traditionally been viewed as a lifecycle in that such systems undergo iterative processes cycling between their birth and their modification or replacement. This type of perspective is important in managing the complexity of designing systems, putting them into operation, and responding to faults or changes in system requirements. Many articulations of the life cycle model exist. The ISO/IEC 12207 standard is a widely recognized version.

The information technology software life cycle processes defined by the International Organization for Standardization and the International Electrotechnical Commission under standard ISO/IEC 12207 (ISO/IEC 1995) contains the following primary processes: acquisition, supply, development, maintenance and operation (Moore 1998). The life cycle may be viewed in figure 1.

Figure 1: ISO/IEC 12207 Life cycle



Several key relationships must be examined between traditional views of life cycle processes and the development of a community informatics.

Primary processes

Acquisition: This process involves identification of system requirements, analysis and design of the prospective systems, and the identification and acquisition of its components or services necessary to develop the components. That is, acquisition could involve commercial off-the-shelf components or contractual agreements with developers.

Communities often face tighter financial constraints than business or governmental organizations in attempting to acquire technologies and other resources required to implement ICT-based solutions. Public domain and open source technologies offer potential approaches to mitigating acquisition costs. This is discussed below.

Supply: This process involves the delivery of system components, intended to satisfy the system requirements, which were contracted for during the acquisition process. Supply can involve several possibilities or combinations of the following: commencement of the development process to produce a unique system, or commencement of the operation process using a turnkey system or a third-party service.

This process is complementary to acquisition and as such it too may be impacted in a community informatics context by the financial constraints that communities face. Additionally, supply involves the enforcement of contractual arrangements and co-ordination of their delivery. In a community informatics context, unlike an organizational one, this should be supported by appropriate oversight and governance mechanisms.

Development: This process involves the production of a new system. This occurs either through the integration of existing components or the implementation of hardware or software (for example, programming), or some combination of these two types of activities.

Maintenance: This process involves either the correction of faults in an operational system or its enhancement in order to realize new requirements. New requirements might be new features desired by users, tasks that are mandated by new legal requirements, or some other fundamental change desired in the operation of a system.

Operation: This process involves the ongoing activity of setting a system into a functioning state: that is, into a state where users can begin to realize its benefits. This process may be arrived at through one of several paths: when the development process has been completed; upon completion of a maintenance process; or directly from the supply process, in which case a service has been contracted. In the third case, no development is necessary since an existing system is being used (that owned by the service provider).

In a community informatics approach, the development, maintenance and operation processes all require training and capacity building in communities if they are to be supported adequately by community members. To be done properly, this requires a formal set of activities carried out in a highly disciplined manner. Along with the costs required to perform these processes, the skills required to do so constitute the major elements of sustainability in community ICT projects.

Organizational processes

The ISO/IEC 12207 standard also includes sets of supporting processes and organizational process. The primary and organizational processes are of greatest importance here. The organizational processes are management, infrastructure, improvement and training. Organizational processes are processes that are necessary to administer the primary and supporting processes.

As with development, maintenance and operation, communities must have the ability to perform these processes themselves if projects are to be truly sustainable. Again, training and financial resources are key here.

Selected Cross-Cutting Issues in Community Informatics

Issues discussed here intersect with many of the key conceptual and methodological issues discussed above.

The potential of existing and emerging technology frameworks

As Innis and others have shown, ICTs and transitions to new types of ICTs have historically had profound impacts on communities (and whole civilizations). In addition, he has shown how characteristics unique to different media have determined the natures and biases of the impacts they were able to make in terms of space and time (Innis 1964:3–32, 33–60). It is reasonable, therefore, to look proactively at new and existing technological areas in considering general systems design approaches within a community informatics approach.

Media and data convergence

Many NGOs are currently arguing for attention to traditional ICTs (for example, radio and television). While this approach is prudent for various reasons in a community informatics context, the unique properties of the technologies that enable the Internet cannot be underestimated in terms of their potential contributions to community-based ICT projects. The properties of the enabling technology for the Internet must be examined in a community informatics since they offer solutions for bridging traditional and advanced ICTs, as well as supporting different modalities of communication. Its technical characteristics have enabled unique dispersion possibilities, and it supports almost all earlier forms of communications.

The packet-switching nature of the Internet allows a distributed infrastructure, which distributes set-up and access costs to different organizations or communities, and amortizes infrastructure development costs. Use of packet switching is also independent of the physical transmission medium—copper, fibre optics, radio or satellite. Its store-and-forward means of operation allows it to support multiple modes of transmission: continuous, discontinuous, synchronous and asynchronous. These technical characteristics have made its dispersion potential high. In fact, dispersion has taken place over many types of infrastructure.

At the application layer, packet switching has provided a nexus for different forms of communication. The Internet is, therefore, able to support all components of J. Richstad's framework for communication: interactive, participatory, horizontal and multiway communications (Richstad 2003). The implication of this for community informatics exists at the application layer, in that it can enable the integration of all elementary forms of communication: text, audio, images and video, and most communication technologies: postal services, telephony, radio, film and television, and collaborative applications. In this way, the Internet is now able to serve as a bridging technology between new and older forms of communication (for example, broadcast radio to Internet). Thus, while it is prudent to retain traditional ICTs in a palette of technologies to be considered in developing community-based systems, a strong focus on deploying packet-switch data communications (for example TCP/IP/Internet) should be stressed.

Wireless data communications

Wireless data communications, including WiFi, is widely viewed as having significant applicability in the developing world. Wireless data communications has offered developing countries the possibility of leap-frogging the developed world in terms of acquiring advanced communication infrastructures. The high costs of deploying landline infrastructures required in traditional telephony have been an economically intractable barrier for many countries. The deployment of wireless data communication infrastructure, on the other hand, requires fewer material resources (for example, wires and poles) and is far less labour intensive. Wireless data communications also makes possible the distribution of communications over wide and rugged geographies where landline approaches may not have been possible. Finally, some wireless data communication standards can be deployed and scaled in an incremental and distributed way. WiFi, for example, can be used to build an evolving network, where individuals or organizations contribute to the expansion of a network as they acquire and make new nodes operational (for example, installing WiFi service on their platform). A community informatics approach must maintain a focus on deriving maximum benefits from technologies for financially constrained communities by leveraging technologies such as these.

Open source and public domain development

Open source can potentially enable communities to be self-sufficient in replicating, maintaining and enhancing ICT-based development projects. This approach allows a community to have complete access to the internal workings of the technologies (for example, software and hardware). Many open source technologies are also public domain, alleviating developers of much of the cost of acquiring technologies.

Open source is of great interest among NGOs involved in the World Summit on the Information Society (WSIS). At the second preparatory committee (PrepCom 2) of WSIS in February 2003, for example, a partnership with African NGOs initiated an open source technology project. The goal is to foster greater development throughout Africa through the diffusion of free, open source technologies. Many participants from civil society have consistently declared their desire for the creation of a global commons for this very purpose in statements to WSIS. Also, the United Nations Educational, Scientific and Cultural Organization (UNESCO) started a Web portal in 2001 to promote free and open source software. See the annex below for more information.

Low-cost hardware

On the hardware side, an effort was initiated in 2000 to create an open, public domain design for an affordable computing device for the developing world. The approach taken was to create a non-profit trust in which many people volunteered to produce a design. The result is called a Simputer. In its current version, it has 32MB of memory and has a Linux-based operating system. It is handheld with a pen-based interface and it runs on three AAA batteries. It is now being offered for sale by several organizations, including Simputer.org, PicoPeta, and Encore Software of India. Its current cost is approximately $200. While this cost may be prohibitive in many areas of the world, it is a beginning and the general approach taken to its development should be factored into the development of a community informatics approach to meet the MDGs.

Public involvement in information society governance

Democratic policy, accountability mechanisms and socially responsible practice by computer professionals are necessary for communities to ensure that ICTs are designed and deployed appropriately. It is the case, in fact, that citizens and NGOs like Computer Professionals for Social Responsibility (CPSR) have historically played major roles in defining and implementing not only the technical structures of various parts of the information society, but also in making and enacting policy recommendations concerning their operation. This includes Internet governance through the Internet Corporation for Assigned Names and Numbers (ICANN) and Internet standards development. For a community informatics to be truly meaningful, these types of mechanisms must be strengthened and maintained.

The role of international organizations

The need for a community informatics can be motivated by the goals and imperatives established in human rights frameworks. The Universal Declaration of Human Rights articulated rights that can be directly linked to social implications raised by information systems and to technological advancement in general, Article 27, section 1 states: “Everyone has the right freely to...share in scientific advancement and its benefits” (United Nations 1993).

Community informatics is arguably a necessary means, given the existing economic dynamics of ICT development, for enabling “a social and international order in which the rights and freedoms set forth” in the declaration “can be fully realized”, as Article 28 states, for those communities who are not able to negotiate the marketplace of advanced ICTs. Many communities will have to acquire or develop their own technologies.

A major area of contention in the development of an information society through a community informatics will be in defining and enforcing the rights of all stakeholders as well as the particulars of its governance. Critical issues in addressing rights and governance are:

- democratic management of international bodies dealing with ICTs;
- information and communication rights of governments, business and citizens;
- privacy and security policies and rights;
- censorship and regulation of content;
- the role of the media;
- defining, identifying, and responding to criminal activities within an information society;
- the application of ICTs for government and decentralization (McIver and Elmagarmid 2002); and
- media ownership and concentration.

A major emphasis here for civil society and some governments has been to establish support for the empowerment of citizens. The relationship here is non-linear, as in gender equality discussed above, in that many view an information society as enabling the reform and strengthening of democracy, which in turn will presumably improve citizens' participation in community informatics processes. Mueller (1999), Hamelink (1999) and others have shown the importance of structures of accountability and participation for the maintenance of the public's interest in the development and use of ICTs.

Finally, international organizations such as UNESCO, the United Nations Research Institute for Social Development (UNRISD), and others can continue to play a role in supporting the development of community informatics in a way analogous to the International Telecommunication Union's (ITU) role in the telecommunication sector. For example, UNESCO now maintains a Web portal for free and open source software use and development. A number of programmes within the United Nations University (UNU) have mandates to perform training and research in information technology in developing countries, as well as study the social and economic impacts of new technologies. These include the International Institute for Software Technology (UNU/IIST) and the Institute for New Technologies (UNU/INTECH). UNRISD's project on the Information Technologies and Social Development has been playing a critical role in supporting research on the role of policy making and institutional factors affecting "the likelihood that new information and communications technologies can be used to improve the lives of large numbers of people in developing countries".

See the annex for additional information about community informatics resources, both within UN organizations and the NGO community.

Recommendations

Community informatics offers promise in helping to achieve the MDGs. However, it is still an evolving meta-discipline, and additional research and experience is required to make it more effective. International organizations can play a major role in making progress in this area. The following recommendations are made toward this end.

Support for research: Research geared toward evolving community informatics must be supported. This would include the development of a research agenda among practitioners, scholars and communities; the cataloguing of community informatics projects and identification of factors for both failure and success; and support for research projects and systems trials.

Support for a conference: An ongoing, international conference in community informatics is required. This would create a centre of focus and a forum in which researchers, practitioners and communities could exchange results and maintain a coherent, field-wide research agenda, as is done in other fields.

Develop standards: ISO, IEC and other relevant bodies must be involved in the development of standards that are tailored to community informatics. This might include an examination of the ISO/IEC 12207 life-cycle standard.

Establish governance mechanisms: WSIS and similar processes must establish global information society mechanisms of governance that empower citizens to apply and manage community informatics processes in meaningful ways. This would include the creation of intellectual property mechanisms that protect and encourage the use of open source technologies and development processes. In addition, it would provide mechanisms that ensure that the public interest is taken into account when community informatics processes involve the private sector.

Annex: Selected Community Informatics Resources

This section provides a list of selected community informatics organizations and projects.

Community Informatics Research and Applications Unit (CIRA): CIRA is located at the University of Teesside, Middlesbrough, in the United Kindgom. CIRA is a multidisciplinary entity in which the social and economic impacts of ICTs on communities are studied. An emphasis is placed on studying the growth of the Internet and "the consequences for community development, economic restructuring and social inclusion" (www.cira.org.uk).

Community Informatics Resource Center (CIRC): CIRC is a programme within the Rural Policy Research Institute at the University of Missouri, United States. It attempts to provide an environment in which the "implications of issues impacting rural America can be more effectively visualized, analyzed, queried and mapped" (http://circ.rupri.org).

UNU/INTECH: The Institute for New Technologies of the United Nations University (UNU/ITECH) in Maastricht is a research and training centre of the United Nations University. It conducts research and policy-oriented analyses and performs capacity building in the area of new technologies. In particular, the research examines new technologies with respect to their diffusion characteristics; the opportunities they offer; and the economic and social impacts they present. Emphasis is given to developing countries (www.intech.unu.edu).

UNU/IIST: The International Institute for Software Technology of the United Nations University (UNU/IIST) in Macao has a mandate to help "developing countries strengthen their education and research in computer science and their ability to produce computer software". In particular, IIST works with universities in developing countries on curriculum development in computer science and software engineering, as well as the development of research programmes (www.iist.unu.edu).

Jiva Institute: Jiva is an organization that attempts to develop sustainable technology projects in India (www.jiva.org).

The UNRISD Project on the Information Technologies and Social Development: This project has been playing a critical role in supporting research on the role of policy making and institutional factors affecting "the likelihood that new information and communications technologies can be used to improve the lives of large numbers of people in developing countries". In particular, the project supports research on trends and patterns of concentration within the global IT industry, new developments in international regulatory policy impacting IT development, and research by people from the developing world on "specific uses of information technologies" in their countries (www.unrisd.org).

The Simputer Trust: The Simputer Trust was established by academics and industry experts to develop a public domain design for an affordable computing device called the Simputer (www.simputer.org).

UNESCO Free Software Portal: UNESCO maintains a Web portal that serves as a publicly accessible repository of documents and Web sites that promote the "Free Software/Open Source Technology movement." It also provides ancillary resources for users and developers of free software (www.unesco.org/webworld/portal_freesoft/index.shtml).

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