Workshop on "Development in the Information Society – Exploring a Social Policy Framework"

January 18th – 20th, 2007
Bangalore

Communication and Connectivity: *Core Elements in the Development Debate*

(Working Paper)

Arun Mehta & Vickram Crishna
Radiophony, India

IT for Change

With
HIVOS
Bread For All
United Nations Development Programme
Social Science Research Council, New York
International Development Research Centre

Communication and Connectivity: *Core Elements in the Development Debate*

(Working Paper)

Introduction

Telecommunication mandates connectivity. Some issues relating to the growth of connectivity in India are:

1. We have many kinds of connectivity divide in the country, between:
   0. rich and poor
   0. urban and rural
   0. men and women
   0. abled and disabled
   0. English speakers and "the illiterate"
   0. Us and "the world."
8. These divides are arguably all growing
9. Our telecom policy is not helping bridge these divides
10. A clear strategy exists, a way forward, for civil society to bridge these gaps

Who has connectivity in India? The affluent urban male typically has a good Internet and phone connection at work and home, plus mobile phones he changes each year, and increasingly now, a selection of radio (FM) channels to tune into. He does still struggle in international competition, indeed there too the gap is growing — in some countries, homes have gigabit connections — but for those on the left side of 1.1 - 1.4, access to the lion's share of India's connectivity resources is trivial.

The telecom companies have reaped rich rewards from servicing the rich and the middle class. They claim that someone who has a phone but does not make calls worth hundreds of rupees a month, costs them money. However, technology has made this view obsolete. What costs money is not the connectivity, but the overheads of the telecom company for billing and advertising, the mistakes they make in technology choice, etc. Many of these issues are inextricably linked to traditional centralised lines of control inherent in management methods, erroneously thought suited to such an industry.

For rural connectivity too, telecom companies want subsidy, for their technology is cost-effective only when large numbers of users are bunched together, as in urban areas. But rural community and grass roots initiatives around the world have provided their farmhouses broadband connectivity for orders of magnitude less than what the telecom companies claim it would cost.

Telecom companies and the government in India have made scant effort to increase female access to mobile phones among slum and rural households, where gender disparity in access to connectivity is worsening, since it is growing for the men, but not so much for the women. This could be easily fixed.

Computer-mediated connectivity has transformed the lives of the very few disabled it has touched. An English-speaking blind person who can afford a computer and Rs. 50,000 for screen reader software now has a backspace key, ubiquitous access to mail, the web. But there is no Hindi screen reader, so for a blind Hindi typist, the introduction of computers to replace typewriters in the office means the loss of livelihood. While the gap here is undeniably increasing as the abled get more access, there are successful initiatives here with tremendous promise.

Access to communication is, of course, only as useful as the ability to communicate. With functional literacy plumbing the depths nearly anywhere in the country, barring a handful of notable exceptions, only verbal communication has a chance, and with the opening up of community FM radio, CB radio, NGOs are presented with fresh means of communicating. The country needs to agree and work on a strategy to exploit these options. Particularly considering how disaster-prone our country is, ham radio must also form an integral part of this strategy.

Beyond learning how to read and write, our poor also need better access to English to be able to make optimal use of the information highway. Our record in this has also been patchy. Distance learning, taking advantage of a mix of media, may be the fastest way to address this.

This paper examines the technical options ahead for telecommunications in this country, and attempts to place the available choices for bridging these within a socio-political and economic framework. While, obviously, there are new developments constantly emerging, this paper only looks at the technologies for which the hardware, software and human resources are commercially available.

Contents

1. What is 'telecommunications'?

Information travelling from the brain of one person to that of another constitutes communication. For that to happen, several conditions must be met:

a. The channel must exist. If we are within shouting distance, the air between us may suffice. If not, a range of wireline and wireless technologies exist, to build the channel.

b. The "hardware" must function. The human has two inputs for communication that technology is able to extend long distances, the eye and the ear. For audio output, we have the mouth and tongue. So, when I speak and you listen, my output and your input organ must function, as must the hardware of the channel, of course.

c. The "software" must be compatible. The neurons of your brain must be programmed to understand English, or whichever language I choose to speak.

In short, there are three main links in the telecommunications chain: technology for the communications channel, human capability relating to vision or speech, and language skills. All of these have to work for telecommunications to take place.

In telecommunications technology, we differentiate between long-distance, and last-mile. For long-distance, we mostly use optic fiber cables, or satellites. Of course, relics from the past such as microwave towers do still exist. Optic fiber cables have such huge capacity, that where they reach, there is no cheaper, faster way to send information long distances. Satellites are useful to bring connectivity to hard to reach places, and are cheaper than optic fiber when the same information is to be sent simultaneously to a large number of people, as in television.

The last mile is, essentially, the connection between the customer and the nearest optic fiber. If optic fiber cables are canals, last mile solutions are wireline, analogous to the pipes that bring water to each individual home, or wireless, like a sprinkler system.

In developmental terms, the objective of any research or deployment is the person who is going to be affected, the intention being that the intervention has a positive result. For this reason, this link is called the first mile.

1. What are the available choices?

Analogue and Digital

In the phone, we transmit voice. The signal reaches the phone as air pressure that varies over time. This is an analogue signal, which is measured, not counted. Before computers, the electronic circuitry used to transmit the signal over long distances was analogue too: in effect, it measured, instead of counted. Computers as we know them are digital: they work with numbers.
Digital technology has many advantages over analogue. It is less affected by noise (spurious electrical energy in the neighborhood), is more accurate, capable of being far smarter, and works with far more standardised hardware. Analogue technology is often cheaper, and easier for a technical person with modest skills to build and repair.

1. Wireline

0. POTS

POTS is an unkind acronym for Plain Old Telephone Service, basically point-to-point voice signaling only. It is unkind, because voice signals have certain unbeatable advantages in terms of effective communication. However, it is very wasteful, of both material resources and electromagnetic signal bandwidth. To enable a conversation (conversation= two way signaling), both devices must be physically and exclusively connected to each other. Naturally, this can only be handled efficiently by interposing a signal exchange device between, which can perform the same service for many such connections.

However, such devices impose centralised control structures in their day-to-day functioning, and furthermore, are expensive, which means they are also exclusive by nature. Computerisation of these devices has enabled adding on services, but only through additional cost and reinvesting in basic infrastructure, which has not only limited growth, but imposed constraints on who and where gets connectivity.

0. Value Added Services

In order to meet the competition brought in by new technologies, POTS services have added qualities that can be invoked by programming the exchange device, which is nowadays mainly digitial (in India). Such invocation involves making the service available and also billing for it. It is safe to say that billing overheads in traditional telephony systems constitute the major operational cost element. This is also a barrier to growth, one that has not been resolved anywhere.

Value added services include conferencing (multiple simultaneous connections in a single conversation), voicemail, call waiting, multiple number routing through a single circuit and so on. Some major failures in attempts to enhance such services include videoconferencing.

0. Connection media

Originally, connectivity in POTS was enabled purely through creation of physical resources in terms of pairs of copper wires (aluminium has also been tried in India, with mixed results) extending between switches, and between switch and user. A massive capacity increase has been made possible through substitution of copper by optic fiber, but this is continguous with changes made in the connection paradigm itself, from analogue to digital. Although the global investment in optic some six to ten years back eventually proved infructuous, with large percentages of cable linkages remaining 'unlit' or 'dark' (and many infrastructure providers going out of business or being sold), it is witnessing a resurgence, and has enormous potential in India. We shall discuss later in this paper just how such potential can be brought to fruition.

0. DSL

Currently, DSL technology, which allows digital transmission over normal copper lines, has become the only reason for people to get fresh land-lines. Internet (digital data connectivity with the global Internet) connections are available to the consumer today in 5 main ways:

a. via dial-up, in which the computer is connected to a POTS phone using a modem. This is very slow, and expensive.
b. via Ethernet, from the Cable TV operator. This is faster and cheaper than POTS, but can be unreliable.
c. through the mobile phone, which is rather slow
d. via a data card plugged into the laptop, connected to a CDMA service provider. This is faster than dial-up, reasonably priced, and mobile
e. via DSL, which is even faster, but also cheap and reliable. Even with the disadvantages of a tethered connection, DSL sales have been picking up.

DSL or xDSL, is a family of technologies that provide digital data transmission over the wires of a local telephone network. The original acronym digital subscriber loop, has been superseded in common parlance by digital subscriber line as a more marketing-friendly term for the most popular version of DSL, ADSL. Typically, the download speed of DSL ranges from 640 to 3,000 kilobits per second (kbit/s), or exceptionally from 128 to 24,000 kbit/s depending on DSL technology and service level implemented. Typically, upload speed is lower than download speed for asymmetric digital subscriber line (ADSL), and equal to download speed for the rarer symmetric digital subscriber line (SDSL). DSL is an excellent means of extracting additional value from existing investments in digital exchanges.

As far as rural connectivity is concerned, the biggest disadvantage with DSL is signal attenuation at distances over 2 km. Placing exchanges within 2 km of every user point is exceedingly difficult, and the potential for connecting enough subscribers to justify the cost of the exchange itself is very low. The country had an opportunity to actually initiate this in the late 1980s, when C-DoT (the Center for Development of Telematics) worked on developing a modular (256 line) switch intended to spur rural connectivity, but the process was unfortunately short-circuited, and then was overtaken by investments in large imported switches.

2. Wireless

Much like wireline, radio frequency (RF) communication is of two types, analogue and digital. In the early days of electronic communication technology, cost effective digital signaling technology was not possible, hence early systems were heavily analogue-centric. This situation lasted for about 50 years, during which regular one-to-many broadcasting became commonplace. However, the pressure of the Second World War forced research toward digital signaling, for reasons of security and economy of bandwidth.

1. Analogue

1. FM

FM, or frequency modulation, as against AM, amplitude modulation, is the technology of choice for high quality audio signaling. Due to longstanding international agreements, the spectrum for radio broadcasting and reception is well known, and economies of scale have allowed manufacturers to bring the price of receivers down to exceedingly affordable levels, even for India. FM is better than AM because it is not subject to radio interference from stray e-m signals, which affect amplitude–sensitive (signal level) broadcast and reception only.

The frequency range allotted to FM has a characteristic low-distance pattern of dissemination of about 50-60 km. It has a certain ability to bounce off reflecting surfaces, but not much, hence the signal is eventually attenuated for listeners by the curvature of the earth. Several materials, such as trees and waterbodies, tend to absorb radiation at these frequencies, hence further limit the reach.

'Pumping' the signal at higher energy levels will deliver slightly higher distances, but this cannot be guaranteed. It will cause interference to broadcasts at neighboring frequencies, though, which limits the numbers of channels available for reliable broadcasting. A definite 'distance' between neighboring frequencies increases the reliability, but wastes the bandwidth. The USA's FCC, considered authoritative in such technical matters, allows a separation of 200 kHz (200,000 cycles per second) between adjacent channels, while India's WPC believes that 800 kHz is essential. The former enables about 100 channels in a single physical area, and the latter only 25, but this has never been tested in practice in India. Needless to say, constraining the field this way opens it up to more exploitative market practices. Such systems are undoubtedly being abused, but with such a small number of players involved, investigation and correction of flaws is not a priority.

At the same time, the centralised control structure to license frequencies for this purpose has been an enormous hindrance to the use of this technology in India. It was not introduced till the mid-1990s, nearly 40 years after its use in the USA became common, replacing medium wave (short-distance, or local) AM broadcasting almost entirely. While the stated government policy is to encourage the same phenomenon, in practice the mechanism does not work. It takes from one to two years to obtain the permissions needed to set up a broadcast station, and the vast majority of stations licensed in the recent past are private. The government's All India Radio (Akashvani) service under its broadcasting corporation, Prasar Bharati, is very constrained for funding and human resources, in the face of stiff competition from private firms.

The authors of this paper have been instrumental in exploring other ways to use short-distance broadcasting, synergising the market phenomenon of affordable end-user equipment pricing created by the successful lead of the US in popularising this medium. Some of our indigenously developed applications include multiple simultaneous translation at impromptu venues, and dissemination of high quality sound at public meetings and concerts. We have also posited a hybrid wireless (Wi-Fi+FM) low power and low cost broadcast station concept, ideally suited to India's rural sector, based on research done in Chad (West Africa). However, a fog of obscurity pervades the legal status of even research and development in India, far less deployment, and uptake of such applications remains limited in the absence of a supporting framework.

1. CB

CB, or citizen's band, is a frequency spectrum 'equipment-licensed' for general use. Intended for relatively short-distance interpersonal communication, it usually features half-duplex low power handheld or car dashboard mounted transceivers, set for normal listening mode, with a button to press and hold for 'Talk' (ie transmit mode). It finds extensive application in highway driving, enabling motorists to be alerted for possible impediments ahead. As the name implies, user-side regulation is very limited, and is in fact very community driven. With a very small frequency allotment, conserving broadcast time is an essential feature, thus self-limiting user protocols have evolved. Another very common use is in rural trekking, where parties of independent trekkers can stay in touch, mutually increasing their safety.

In India, such handsets are typically used to manage large public events, such as meetings and concerts. Organisers and technicians can stay in touch across relatively large distances, where the human voice cannot carry or cannot be used in free air.

Since August 2005 (http://www.wpc.dot.gov.in/DocFiles/CB%20Radio%20Delicensing.doc), CB sets, up to 5 watts power and inbuilt antenna, do not need a license. This opens up very interesting possibilities for low-cost communications within and between villages.

2. Ham

Ham radio is the term used for amateur radio, distinguishing this from professional services (commercial broadcasting or communicating). Its status in India would be amusing, if not for its dire implications. Noted ham licensees in India include the late former Prime Minister Rajiv Gandhi, and the current Congress Party head Sonia Gandhi, his widow, continues to hold a license. However, the process for ordinary persons to obtain and keep licenses varies from place to place. Licenses are also place sensitive, which is entirely ridiculous, since an outstanding characteristic of ham operators is their willingness to set up emergency services in disaster-hit areas. Notable among these is the Andaman Islands (during the tsunami and its aftermath), Latur and Kutch (after their tragic earthquakes).

Ham radio was once very analogue-centric, but is moving towards digital communication, where the term 'packet radio' is in vogue. In the USA, knowledge of Morse code (a standard for binary signaling adopted for the telegraph and early point-to-point wireless) is no longer a prerequisite for ham licensing, reflecting its almost total disuse due to improvements in voice handling capabilities in consumer equipment.

1. Digital

1. GSM

According to Wikipedia, "The Global System for Mobile Communications, GSM (original acronym: Groupe Spécial Mobile) is the most popular standard for mobile phones in the world. GSM services are used by over 2 billion people across more than 212 countries and territories. The ubiquity of the GSM standard makes international roaming very common between mobile phone operators enabling subscribers to use their phones in many parts of the world. GSM differs significantly from its predecessors in that both signaling and speech channels are digital call quality, which means that it is considered a second generation (2G) mobile phone system." The first generation, of course, is analogu

GSM has been outstandingly successful as a mobile connecting solution worldwide, because the specification covers enough frequency bands and methods of cell management to take care of most eventualities. However, its success is very qualified, on deeper examination, because of what it cannot do.

Among these is the inability to provide cost-effective or reliable service in difficult terrain and sparsely populated areas. The terrain problem is partly due to it being a medium dependent on wireless, but it is not the whole story. The sparse audience problem exposes the root of the switch-technology cellular issue.

In order to provide reliable service over long distances (the specification allows up to 35 km reach), the antenna must be mounted at a significant height, to compensate for the earth's curvature. This is an expensive proposition, so it only makes sense when the audience can pay. However, in the development scenario, the sparse rural audience is also the least economically ready, so the law of diminishing returns works with a vengeance.

The last sentence in the quote above from Wikipedia, about digital service, is the key for development-oriented civil society, which seeks to find ways to bring the benefits of digital technology to bear within the developmental scenario. At the time of writing, it is technically possible to access GSM in many parts of the country, and the availability of texting (use of short messaging service, or SMS) and its multimedia variant MMS has opened up some positive possibilities in emergency service alerts. Both of these services make use of spare time slots available within the control channel to transmit data digitally. Texting works well for single language alerts, in either English or Hindi, while MMS is used to send pictures of alerts in languages whose fonts are not supported.

1. CDMA

CDMA (code division multiple access) is a system of digital cellular cellular telephony that makes use of a multiple access scheme, such as those pioneered by Qualcomm, Ericsson, and W-CDMA by ITU, the International Telecommunication Union. CDMA, as a technology or technique, is used in many communications systems, including the Global Positioning System and in the OmniTRACS satellite system for transportation logistics. It is a form of multiplexing (not a modulation scheme) and a method of multiple access that does not divide up the channel by time (as in TDMA, or time division multiple access) or frequency (as in FDMA or frequency-division multiple access), but instead encodes data with a special code associated with each channel. It uses the constructive interference properties of the special codes to perform the multiplexing.

While its use in telephony is gathering support globally, has made its mark in India already, and arguably its introduction kicked off the present ‘insane-growth’ phenomenon in cellular telephony. Within the context of developmental society, it is slightly more attractive than GSM in terms of future orientation, because it delivers a higher data throughput rate. However, there are other choices, which are gaining currency because of the outdated approach to managing telecommunications.

Interestingly, data from mobile service research reveals that, although the convenience of personal mobility is the 'hook' used to justify which the premium costs of cellular telephony service, in reality over 60 per cent of cellular calls actually connect from homes or offices. Here, it would be far cheaper for the subscriber to simply use the Internet to communicate, rather the phone service.

This is not the only part of telco revenues that is fragile. On the Internet you do not pay roaming charges, nor do you charge the kind of shameless rate that telcos do for sending a small amount of text, as in SMS. Consider, for instance, that in competitions such as KBC, you could pay as much as Rs. 2.50 for a SMS, in which you are sending, perhaps, 10 characters. That works out to Rs. 2.5 lakhs per megabyte! An Internet service provider, who buys bandwidth in bulk from the same provider, is able to retail bandwidth to you a hundred thousand times cheaper.

Telcos do not seem able to adapt to a world in which bandwidth is too cheap to be metered. You can charge people for equipment -- people routinely change phones every couple of years, if not months. For bandwidth, it hardly makes sense to spend so much effort in determining what distance you called, at which time, on which plan, then enter into all kinds of dispute with your client because this is so complicated, you often get it wrong. Much more sensible are the sort of flat rates common on the Internet.

2. Wi-Fi

Wi-Fi is a term that was originally publicised by the Wi-Fi Alliance as having been derived from the expression Wireless Fidelity, mirroring the 'High Fidelity' term used for expensive audio music systems. Using equipment complying to the IEEE 802.11x family of standards, users can easily and simply set up a network without using physical Ethernet or other networking cables, connectors and devices.

A person with a Wi-Fi enabled device such as a computer, cell (mobile) phone or PDA can connect to the Internet when in proximity of an access point. The region covered by one or several access points is called a hotspot. Hotspots can range from a single room to many square miles of overlapping hotspots. Wi-Fi can also be used to create a mesh network (ie a network in which every node has the same status, and can interconnect with any and /or all the other nodes. Wi-Fi also allows connectivity in peer-to-peer (wireless ad-hoc network) mode, which enables devices to connect directly with each other. This connectivity mode is useful in consumer electronics and gaming applications. Both architectures are used in community networks.

When the technology was first commercialized there were many problems because consumers could not be sure that products from different vendors would work together. The Wi-Fi Alliance began as a community to solve this issue so as to address the needs of the end user and allow the technology to mature. The Alliance created the branding *"Wi-Fi CERTIFIED"* to show consumers that products are interoperable (ie, communicate with each other without any special tweaking) with other products displaying the same branding.

A Wi-Fi setup contains one or more access points (APs) and one or more clients. An AP broadcasts its SSID (Service Set Identifier, "Network name") via packets that are called beacons, which are usually broadcast every 100 ms. The beacons are transmitted at 1 Mbit/s, and are of relatively short duration and therefore do not have a significant effect on performance. Since 1 Mbit/s is the lowest rate of Wi-Fi it assures that the client who receives the beacon can communicate at at least 1 Mbit/s. Based on the settings (e.g. the SSID), the client may decide whether to connect to an AP. If two APs of the same SSID are in range of the client, the client firmware might use signal strength to decide which of the two APs to make a connection to.

The Wi-Fi standard leaves connection criteria and roaming totally open to the client. This is a strength of Wi-Fi, but also means that one wireless adapter may perform substantially better than another. Since Wi-Fi transmits in the air, it has the same properties as a non-switched ethernet network. Even collisions can therefore appear as in non-switched ethernet LAN's. Unlike a wired Ethernet, and like most packet radios, Wi-Fi cannot do collision detection, and instead uses a packet exchange (RTS/CTS used for collision avoidance, or CA) to try to avoid collisions.

While these issues undoubtedly exist, a leading cause for preferential adoption of this technology by rural communities worldwide is the fact that it is served by products made for a consumer-driven market, hence both equipment and standards are responsive to the needs of such communities. It is also possible to rather easily and very cheaply build high gain, planar and directional antennae for this frequency band, hence it naturally allows many comparatively less qualified persons to participate in building such networks. Using such antennae with off-the-shelf inexpensive 'radios' (access points and routers), signals can routinely cover distances of 15-20 km, and the current world record is about 300 km. Since the technology is highly dependent on line-of-sight clarity, mounting the antenna at a height sufficient to overcome the Earth's curvature is the most expensive part of setting up very long distance connections.

Most successful rural communities therefore do not commit to excessively long-distance connectivity, instead using multiple hops from a backbone access point to 'feed' their local networks. Configuring such networks using OLSR (optimised link state routing) ensures acceptably high quality and reliability. At the time of writing this paper, work is ongoing to develop an alternative approach to implementing mesh networking, known as BATMAN, or Better Approach To Mobile Adhoc Networking. This aims to address remaining issues in traditional mesh deployments. Scalability and uptime, both relevant to rural connectivity, are expected to be resolved. Since the same technology is increasingly being used in developed countries, the solution also aims to improve ‘handing over’, staying connected when the device moves from one radio (access point) to another.

3. WiMAX

The WiMAX Forum defines WiMAX as Worldwide Interoperability for Microwave Access. The forum began to promote conformance and interoperability of the IEEE 802.16 standard, officially known as WirelessMAN, in June 2001. It describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access, as an alternative to cable and DSL".

As the official name implies, WiMAX is designed to service metropolitan area networks (MAN), enabling wireless digital access within the precincts of an urban agglomeration. In the last couple of years, taking a cue from two different emergent factors, it is being promoted in developing countries as a viable means of building access in rural areas. The first of these factors is the failure in real terms of the 3G initiative in mobile telephony. Unproved technology, this was rushed into the market in order to corner scarce spectrum in advanced countries, and the price paid has been too high, with bankruptcies and restructuring of very large telecom service providers a direct fallout.

The second factor is the growth of Wi-Fi as a viable alternative. While the technology was originally mooted only to serve local area networks, matching Ethernet's 100 meter attenuation limit (hence the now discarded term "wireless Ethernet"), subsequent developments using standard off-the-shelf equipment make village networks feasible, with interconnects between neighboring villages also built from the same technology. Most importantly, such networks belong to the builders, not to external service providers, and the traffic on the network can be carried at little or no cost.

Naturally, telecom service providers perceive this as a major potential threat, and it is entirely in their interest to promote alternatives that deliver sufficient throughput while retaining control with the service provider, for whom this is a revenue business.

As of the time of writing, wrangling between different technology developers has stalled agreement on a unified standard under IEEE 802.16, hence interoperability between equipment made by different manufacturers cannot be guaranteed. This means that service providers are in danger of being ‘locked in’ to single vendors, and if the standard adopted eventually leaves that equipment incompatible, the entire investment will be wasted. Current moves to hasten the deployment of WiMAX networks in India and neighboring countries are an attempt to force the hands of the standards body to recognise particular features of the concerned manufacturer’s equipment as de facto.

4. Comparison between Wi-Fi and WiMAX

These two technologies are in discussion for broadband wireless connectivity. Please note that Wi-Fi is also known as 802.11, of which there are two kinds, 802.11a and 802.11b, which operate in different frequency bands. The third kind, 802.11g, is backward compatible with 802.11b by design.
There are also two kinds of WiMAX, that which requires line of sight (LOS) between antennas, and that which doesn't. Non-LOS WiMAX is not available yet, but it would be great to have: for line of sight between antennas, they have to be mounted on high towers, which are often the costliest part of a remote installation. With non-LOS, we could save a lot of cost by using lower towers, or the roofs of existing installations. However, since the technology is not available yet, it is not discussed here.

1. Technology Roundup

Different technologies serve different needs. This may be a result of the nature of the technology, complicated sometimes by legacy issues.

CB, Amateur radio and FM radio are all analog wireless technologies, suited for broadcast and one-to-many communications. FM radio is very popular in the country, but so far it has mostly been a government monopoly. Private FM channels do exist, but since they are not allowed to carry news and current affairs they are virtually useless for civil society purposes. Amateur radio has a small but dedicated following. It has been very hard to get a license, which is sadly noted each time there is a natural disaster. Because it can be set up very easily and afford instant connectivity with the outside world, amateur radio plays an important part in the aftermath of disasters.

CB radio is not a consumer device in this country, but now that its spectrum has been delicensed, this space can become the object of some interesting technological innovation.

GSM and CDMA are very successful mobile telephony platforms. However, they are beginning to show their age. The bandwidth they can carry is very little. They are unsuited for small-scale deployments, needing customer clusters in the hundreds, if not the thousands, to be viable. In any case, these technologies are only open to basic and cellular services providers, not to the general public.

The telecom industry sees its future in 3G and WiMax. 3G hasn't been much of a success anywhere, and going by the largescale GSM and CDMA deployments still taking place in the country, it seems that Indian industry is lacklustre on the subject. WiMax technology is still very new. It will take a while before interoperability issues and other teething troubles are addressed. Only then will a realistic assessment of its potential be possible.

That leaves WiFi. Its spectrum is delicensed, the hardware off-the-shelf, the software free, the technology well understood and documented. Technical backup is available, both nationally and internationally. The same technology is used for wireless LANs in homes and offices, so even if WiMax or something else should prove to be better technology, the WiFi gear would easily find other use.

To complement mobile and landline telephones, the ideal combination of technologies seems, at the present time, to be:

a. FM radio for broadcast
b. CB for communication among smaller groups
c. Amateur radio for long-distance post-disaster communications
d. WiFi to interconnect intra-village networks of the above 3 kinds and to connect to the nearest optic fiber for Internet access and other kinds of long-distance connectivity.

1. Spectrum Management

India has a terrible system for the management of spectrum. Almost all usage of wireless in the country requires clearance from SACFA (Standing Advisory Committee on Radio Frequency Allocations, see http://indiaimage.nic.in/pmcouncils/got/report/chap3.htm). This committee consists of over 30 government departments, each of which has veto power over every application.

Doubtless to meet exigencies that were once reasonable, the government has defined RF transmission as ‘broadcasting’ at absurdly low energy levels. In other words, if you follow the letter of the law, you need clearance from over 30 government departments every time you put up a tube light in your house, because the tube light radiates so much energy at radio frequencies, that it qualifies as a transmitter, according to government rules. That is not, however, the only reason why spectrum management needs to change in the country.

The manner of spectrum regulation is being critically reexamined all over the world, because changing technology has made conventional spectrum management often unnecessary. With older technology, each broadcaster in a given area needed an exclusive slice of spectrum. Modern smart technology makes it possible for multiple users to share spectrum, as in the case of WiFi.

With conventional technology, there were two approaches to making spectrum available for new applications, auctioning, or beauty contests.

Auctioning of spectrum puts unbearable burden on any new technology: it may, for instance, have dealt a fatal blow to 3G before it was born. Imagine how high WiMax spectrum would be bid, in open auction. That money would have to be extracted from the pockets of consumers, whose numbers therefore would be small.

A **beauty contest** system requires the government to play technology god, deciding, via spectrum allocation, which technology gets a chance in the market, which doesn't. As this paper is being written, the government is seized with the problem of issuing licenses in respect of fresh spectrum for cellular operators, a matter that has conspiracy theory hounds baying for blood.

Neither of the conventional approaches is satisfactory. The best way to handle spectrum is to learn from the spectacular success of Wi-Fi, and delicense large sections for shared use, in which the government only sets the parameters for fair usage and sharing, instead of pursuing a command-and-control regime that invites abuse, promotes unhealthy business practices, and worst of all, stifles research and development into wireless communication technologies.

Particular attention needs to be paid to spectrum in the lower frequencies, which allow communication without line of sight, thus reducing the height and cost of masts. It also enables service providers to reconsider energy levels at each node or cell repeater, lowering them far below potential risk levels. As it stands, cellular service operators have been permitted to establish powerful cell transceivers on housetops with complete disregard for potential health threats to residents, including school-going children.

1. The Rich-Poor Divide

The benefits of telecommunications are denied to the poor in two ways: the channels of communication do not extend to where they stay, or the cost of using them is too high.

Telecom companies have been preoccupied convincing the affluent to buy new phones or new services for them. They claim that it is not lucrative for them to extend their communication channels to the poor.

A way to address this is for the poor to organize themselves with the help of NGOs and set up their own channels, which would then be almost free to use, as has happened in many parts of the world. Simultaneously, NGOs might take up with government, that it should pay only the extra cost for lighting unlit fiber, to provide free of cost bandwidth to all villages and slums for the next five years. These two moves together would give almost every poor or rural Indian free of running cost broadband access.

This could start with as little as a PC per village, and some accessories costing very little. The capital cost per village is not more than a few thousand rupees. For example, a router costs less than Rs 3,000, with built in antenna. A directional high gain antenna can be built for Rs 100, but the special RF connectors and cabling to attach it to the router will be an additional Rs 500 or so (a pair is needed for a long distance connection, hence these figures must be doubled). Connecting devices within a reasonable sized village is almost free, if they are all wireless, or else Ethernet cabling can be used within tiny networks (assuming there are so many computers in the village), interconnected using a similar pair of wireless routers. A village or group of villages can share such networks, extending to the nearest fiber-optic termination point, in order to gain national and international data connectivity.

1. The Rural Divide

Bridging this has become a high national priority recently, best exemplified by Mission 2007, which aimed to bring the benefits of telecommunications to every village by August 2007. The goal for 2007 was reduced to 100,000 villages — roughly one in six — a project being executed by the Ministry for Information Technology.

This top-down approach has generated a lot of discussion between Mission partners, as has the shrinking of the goal and the capacity of the proposed channel to each village. Most communications occur between people who are within commuting distance of each other, i.e. between the six villages that are expected to share a phone. According to Metcalfe's Law, the value a network generates is proportional to the square of its size, suggesting that the smaller network would be far less viable than the larger.

Almost the only hope for rural Indians has of consulting medical specialists, is telemedicine, for it is often not practical for poor and sick people to travel, nor do we have enough doctors willing to be stationed in rural areas. Likewise, we lack the teachers to pull this nation out of illiteracy in the short or even medium term. Distance learning may be the only hope of imparting enough education to our unemployed masses, that they actually can get jobs as a result.

Both telemedicine and distance learning are only possible if our villages have broadband connections capable of video conferencing, for teacher and student must be able to see each other, as must doctor and student.

A major disadvantage of the top-down centralized model is noticed during disasters. Telecom companies have designed the network such that mobile phones cannot talk directly to each other. They must communicate via the exchange controlled by the telecom service provider. When there is a disaster, and the roof of the exchange collapses, all phones go dead, just when you need them most. If local people were the ones to set up the telecom network, they could restore communications quickly enough to be able to actually save lives.

1. Deployment Models

1. Government Owned and Deployed

This has been India's classic approach, in which the government was the monopoly telecom service provider. For decades, India had pathetically low teledensity, which supported the correlation found worldwide between teledensity and prosperity. Our rates were among the highest in the world, and the quality was terrible. This is a terrible, discredited model, because it treated telephony as a luxury, a viewpoint that regrettably still pervades the administration.

1. Privately Owned and Deployed

Once the private sector was allowed into Indian telecom, prices quickly fell and teledensity soared. However, growth was highly skewed, and because some people (mostly urban males) were able to rapidly improve their access to telecom, the divide grew.

The market by itself will not quickly bridge the connectivity divide. This is true not just of the developing world, but of the developed as well. Their interest is only in reaching profitable customers, not in universal access.

2. Public Private Partnerships

A model that is being looked at seriously around the world, public-private partnerships seek to take advantage of result oriented management practices and physical resources available with the private sector, to provide goods and services for the public weal. Examples include software applications developed under contract by private organisations for the enabling of good governance in some states, the physical distribution channels provided by retailers for free contraceptive devices, and the manufacture of keypad telephones under contract to the public telecom service provider.

In some circumstances, this model provides excellent results, but not always. For instance, while the distribution of contraceptives was comparatively outstanding, the disjunct between supplier and user made it difficult to adjust for huge losses in the system. In addition, the distributors made little or no effort to study actual end-use volumes, thus contributing to continued wastage. The ultimate flag of success, a meaningful drop in birthrate, is all too visibly furled, compounding the urgent problems of developmental economics.

In the case of software applications, controversies have arisen regarding the status of proprietary licensing and hidden costs, not to mention national identity and security. Defining the parameters of the work can limit bidders for the project, casting doubts on the transparency of the process.

The key disadvantage of such approaches is that the private sector organisations tend to fit problems into their own skillsets, rather than develop a skillset envelope that suitably addresses the problem. This is rather like a hammer that treats every problem as a nail.

3. Community Driven, Publicly Owned and Deployed

The best example is from Djursland, in rural Denmark, an area that was suffering increasing deprivation as people moved out, and businesses and utilities shut down. In an attempt to bring the benefits of broadband to local schools and businesses, the local community contacted over 30 companies in Scandinavia, one of the most advanced areas of the world, who all turned them down. Finally, the local community itself set up a wireless broadband network, using off-the-shelf Wi-Fi equipment, mostly inexpensive consumer goods. So far, they have connected more than 5,000 establishments, at a cost 1/180 of what the telecom companies estimated.

In India, the most wildly successful case is Amul, a brand of milk products popularised by a cooperative. Originally a local setup in one part of the country created to promote livelihoods within the dairy farming sector, it expanded and ultimately changed its form. The original structure became a victim of its own success, indicating that such models need to be carefully managed to handle growth. In general, cooperatives as a structure for the management of community initiatives have a long, but very chequered, history in India.

There are other, less formally structured, approaches to organising in order to achieve common objectives. Unfortunately, their tendency to work effectively without appointing ‘leaders’ also means they are not as visible as more popularly known structures.

1. The Case for the Community Model

Community networks typically commit themselves to providing connectivity to everyone in the community, not just the affluent. This may be therefore the only viable option for universal access. When the community sets up the network, far more local jobs are created, and the money raised from providing connectivity is largely locally spent. During a disaster, the difference between community networks and centralized ones becomes immediately apparent. During the floods a couple of years ago in Sylhet, north Bangladesh, only those nodes actually completely immersed in water went offline. The others were quickly put back into action, and were active all through a very devastating flood.

Another significant advantage is the cost saving. For less money than the government is proposing to spend for networking 100,000 villages, it should be possible to network all the villages in India, if the community takes responsibility for this. The reasons are many: in the community model, most of the workers are volunteers or modestly paid. Barter plays a big role in keeping costs down. For instance in Djursland, when they needed access to a high point, say a grain silo, for their antenna masts, they did not pay for such access, instead they gave the owner free Internet access.

1. The Gender Divide

Only the affluent can afford a phone for each member in the family. Where there is just one mobile phone, it is most likely to be in the grasp of the male head. Women often receive poorer education, hampering their ability to communicate.

There is therefore need to make special effort to empower women's organizations, such as microfinance self-help groups, in telecommunications. Also, efforts need to be made to attract women in greater numbers in IT related professions, who will then develop software and services that better address the needs of women.

1. The Abled-Disabled Divide

Tens of millions of people in the country have vision, hearing and speech defects. The intelligence of the computer and its ability to produce and process audio-visual information has transformed their lives. Consider, for instance, the case of the blind.

Until the development of screen reader software for the computer, the blind were unable to access written material, except for the meagre amount available in Braille. This made higher education extremely difficult for blind people, and only those with exceptional motivation and excellent support were able to succeed. Now, using PCs with screen reader software, all information in electronic form becomes available to the blind, thus dramatically reducing the information gap. Indeed, by simply asking the teacher to use a PC with overhead projector networked to the computers of the blind, it would be easy to integrate the blind and sighted in most education. This would allow the blind to become far more productive members of society.

Similar considerations apply for many other kinds of disability. All persons with disability have mobility issues: whether you are blind, wheelchair bound, cannot hear or speak, traveling is inconvenient at the very least, if not downright dangerous, given the lack of access facilities in our transport systems and myriad other problems. In such cases, availability of telecommunications facilities is a great boon, for they can allow the disabled to get or supplement their education, maybe even find employment, without traveling a great deal. An increasing number of jobs can be done from a distance, which also become available to the connected disabled. The need is for a facility to identify or open up such opportunities, and to train disabled persons so that they can take advantage of them.

1. The Language Divide

Because of historical overtones, a discussion of language has the potential of hurting the sensibilities of people, and dividing them. Here, the attempt is to look at language as simply an information technology: a means to gather and disseminate information.

Without a doubt, English is by far the most prevalent language on the Internet. For example, wikipedia has over 1.5 million entries in the English version and only a few thousand in Hindi (see http://www.wikipedia.org/). The IT and other export-oriented sectors have benefited tremendously from the large numbers of people in India who are fluent in English. However, an ambivalent attitude towards the teaching of English exists among policymakers in the country. While their own children typically attend English-medium schools, they do not make serious efforts to provide the same benefits to the rest of the country. English language skills are essential for higher education, and greatly facilitate employment.

While the effect on other languages is undeniable, it is quite possible to teach English widely, without harming native cultures. Those among us who are fluent in English surely do not feel less Indian as a result. NGOs need to pressure the government to make sure that English language skills are not neglected in rural and government schools, and also to modernize the teaching of English, so that we can bridge the language divide, and take better advantage of globalisation.

1. Gleanings from the Conference

2. Summary of Policy Recommendations

a. The setting up of a facility to promote rural communications. This will demystify the technology, train NGO management and field workers in the relevant aspects, keep abreast of new developments in a rapidly changing field, and interact with government to ensure that policies are poor-friendly.

b. The setting up of a facility (which could be the same as 'a.' above) to cater to the communication needs of the disabled. This would train disabled people in developing such solutions. As customers of these solutions also, they would be best suited to design them. Since they would be improving their own lives in the process, motivation would be high. They would consequently bring a long-term commitment to the project, ensuring that the systems would be properly maintained. In the process they would be learning hardware and software skills that would make it easier for them to get jobs or to start their own companies. Several fine software applications (JAWS, emacspeak) are testimony to the value of this approach. The technology thus developed would have relevance not just for the disabled. For instance, software that works for the blind, also works for the illiterate, since both only have easy access to spoken language.

c. Promotion of English language training. NGOs interested in improving the lot of the disenfranchised through the use of IT would do well to lobby with government so that the availability of quality training in the English language becomes widespread.

1. Conclusion

Bridging the communications divide is vital for development: this is no longer in debate. What is disputed is the manner in which to achieve it. The conventional top-down approach, in which large telecom service providers are awarded a large government subsidy, sees them invariably attempt to cherry-pick, both geographically and demographically. Companies fixated on quarterly bottom lines cannot be relied on to provide universal broadband access, without which we will never be able to widely make quality education and health care available. The fact that it was necessary to launch Mission 2007 is an indication that, left to itself, the market would not solve this problem.

Meanwhile, in many parts of both the developed and the developing world, a new grassroots movement has taken hold. Communities are themselves organizing to provide broadband telecommunications, using low cost, off-the-shelf equipment. Not only are they saving money (approximately 500 Euros per household per year in rural Denmark), and ensuring better education for their kids, they are creating jobs. People are required for the setup and maintenance of the network and also as a result of the availability of cheap bandwidth to local businesses. Further, community networks are far quicker rebuilt by local people after a disaster, while in areas with conventional telecommunications networks, they have to wait for bridges and roads to be rebuilt before the technicians from the cities can come and start rebuilding.

The attempt of this paper is to look at different segments of society affected most by the communications divide, to see what needs to be done to begin addressing these. It also tries to highlight available technology options, and suggests which choices to make. A combination of low power FM radio, amateur radio and Wi-Fi-based broadband networks is cost-effective, participatory and robust.

However, technology changes rapidly, and besides addressing concrete, current needs, thoughts must also be cast longer-term. To ensure that people trained in designing, installing, maintaining, and using such networks are not in short supply, a training facility is proposed. The facility would focus on rural communications and the special problems of the disabled, starting with the blind, since solutions developed for and by them also work for the illiterate. It would also keep an eye on future developments, even making them happen, as need be, and provide government with sound advice in policy-making, ensuring that civil society takes effective part in such deliberation.