Aiming at Technology Leadership*

Making the Telecom and IT Revolution Work for Us

❍Ashok Jhunjhunwala

Products which are mature and therefore widely affordable in the West are generally not affordable to more than a few percent of the population in a developing country like India. As the Research and Development(R&D) focus in the West is intended naturally to satisfy the markets in the west, reducing costs of these products would no longer be their priority and instead the focus would be on enhancing value keeping the cost constant. The telecom case discussed below is only one such example. The case of the personal computer is another example. From 1983 to the present, the power and the features of a PC has gone up about 1000 times while the cost pretty much remains around $800. Yet, the advancing technology has not been used to come up with a $100 Personal Computer, which would still carry out basic functions like web-browsing, email, word-processing, spreadsheet and data-base.

It therefore becomes the task of R&D in countries like India to come up with disruptive technologies which bring down product cost by a factor of three to five. This alone would make the product widely affordable in India and create a market of hundreds of millions for such products. This could spur the manufacturing and service industries in India and also enable multiplication of R&D efforts. R&D efforts to achieve this difficult task requires a total mastery of knowledge and technologies in the field and then innovating upon them. Yet success would make India technologically among the very best. It would enable India to take up efforts to develop products which could be leading products in the world.

This article describes efforts in the telecom infrastructure area taken up by the TeNeT group at IIT Madras. However, similar efforts are possible in many other areas. There is no reason to believe that one can not come up with a personal computer which costs around Rs.5,000 and which performs the basic functions required. Similarly, it is conceivable to develop technologies that could produce power at an investment three to five times less than the current investments required. It should be possible to develop technologies, which would enable development of decentralized power generation at a lower cost and cut down transmission and distribution losses. It is conceivable to come up with technologies which would enable one to enhance the carrying capacity of Indian railways by a factor of about 5 to 10 on existing tracks.

The point is that by just following what is being done in the West, we will always remain only the followers. What we need to do is to understand our requirements, and master technologies to work towards our requirements — this different starting point in technology development would enable us not only to develop technologies to satisfy our requirements, but eventually to become technology leaders.

In 1991, both India and China had about 5.5 million telephones. Today, India has about 35 million telephones — a six-fold increase in a decade is no mean achievement in the conventional sense. But in the same period, the number of telephone lines in China has grown to about 200 million; and it is adding about 30 million lines every year. China's mastery in manufacturing probably has a lot to do with this.

The Internet has emerged in the last few years, not just as another communication means, but as sheer power. Access to the Internet provides access to a whole lot of information. It enables one to quickly reach out to a variety of training and education materials. It helps one close deals and carry out transactions and it enables one to perform tasks which otherwise required a lot of travel. India has less than three million Internet connections today. Lack of access to the Internet is going to create strong divides within India.

It is imperative that *India acquire at least 200 million telephone and*

*This is a slightly modified version of Ashok Jhunjhunwala's keynote address on Technology Day 2001 organised by the Ministry of Science and Technology, Government of India in New Delhi.

Internet connections as quickly as possible. Getting there is important, but equally important is the process of getting there, as this presents to us an opportunity to transform our facilities for research and development, as well as manufacturing and service industries.

Learning from the Cable TV

There are not many areas of activity where rapid growth has taken place in India in recent times. Cable TV is however an exception. From zero in 1992, the number of cable TV connections today is believed to have grown to over 50 million. What has enabled this?

The first reason for such rapid growth is simple economics. While a cable connection in India costs only about Rs.100 per month, the cost in the USA for a similar cable connection would vary from $15 to $30 per month. While a new colour television may cost as high as Rs.15,000, second hand colour TVs are available at Rs. 2500 and a 14 inch Black & White TV is sold in rural India at Rs.1200. Cable TV has been made affordable to over 60 per cent of Indian households.

The second reason for this rapid growth is the nature of the organisation that delivers this service. Cable TV operators are small entrepreneurs (at least when they start providing service). They put up a dish antenna and string cables on poles and trees to provide service in a radius of 1 km. The operator goes to each house to sell the service and collects the bill every month. He/she is available even on Sunday evening if any repair is needed. This level of accountability has resulted in less-trained people providing better service using a far more complex technology, than that used by better-trained technicians handling relatively simple telephone wiring.

It is imperative that India acquire at least 200 million telephone and Internet connections as quickly as possible.

However, what is even more important is that such a small-scale entrepreneur incurs a manpower cost several times lower than that in the organised sector. Such lower costs have been passed on to subscribers making cable TV affordable.

Lesson for Connectivity

In contrast to the cable TV industry, the telecom industry belongs to the organised sector that is burdened with much higher costs. A telephone company operator today spends around Rs.30,000 per line to provide telecom services to a subscriber. Taking into account finance charges on the investment (15 per cent), depreciation (10 per cent), and operation and maintenance cost (10 per cent), such an operator needs at least 35 per cent of the initial investment as yearly revenue just to break even. Add to this the license fees and taxes, and the revenue per subscriber needs to be at least Rs.1000 per month. Now, what percentage of Indian households can afford this — barely one to three per cent. How does one then dream of 200 million connections?

Cable TV has been made affordable to over 60 per cent of Indian households.

Fig. 1 provides the percentage of Indian households today who can afford telephones and Internet (assuming seven per cent of their household income is spent on communications) at various levels of investment per line. If the investment is more than Rs.30,000, barely a few percent of all homes can afford it. However, if one could reduce this cost to about Rs.10,000 per line, the affordability goes up to almost 50 per cent of homes. The 200 million connections then look definitely achievable. The key is whether one can reduce the cost per line to Rs.10,000.

A more detailed look at costs of telecom and Internet networks around the world reveals that in the West, the cost of providing a telephone line is around $800. We use the same technology and it is not surprising that our costs are similar. But this cost of $800 was reached in the West more than a decade back. There too, an operator needs

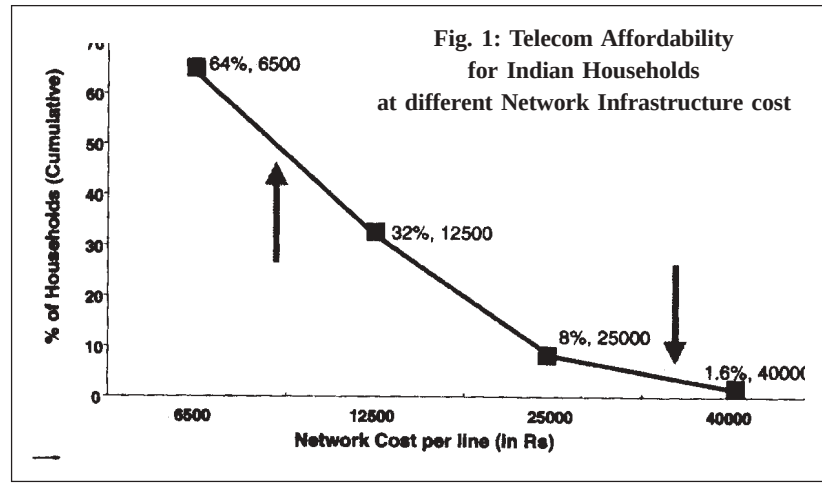

Fig. 1: Telecom Affordability for Indian Households at different Network Infrastructure cost

In the West, the cost of providing a telephone line is around $800. ...The cost needs to be reduced by a factor of three or more for telecom and Internet to be widely affordable in India. ...this becomes the task of Indian R&D.

between 35-40 per cent of initial investment as yearly revenue to break even. However, in the West this amounts to barely $30 per month and is affordable for over 90 per cent of all homes. Therefore, homes in the West have been fully wired up quite some time back. Now, reducing the cost further no longer expands the market. Their *R & D* focus therefore naturally shifts to the replacement and enhancement market, where more and more features and services are provided rather than lower cost products.

However, technology at this cost is hardly affordable to a tiny percent of the people in a country like India. The cost needs to be reduced by a factor of three or more for telecom and Internet to be widely affordable in India. Who would create a technology that lowers costs to such an extent? Not the R&D efforts in the West. Naturally, this becomes the task of Indian R&D.

Such cost reduction is not easy. Coming up with a 'disruptive technology' (one that lowers costs and introduces a new paradigm) that could reduce cost by a factor of three would require total mastery of current knowledge in the area and a lot of innovations. But then R&D efforts are always a challenge. The important thing is that if one achieves this, one would also become a technology leader in this area. And if it results in a production of 150 million telephone lines in India (and maybe 500 million lines taking into account similar requirements of other developing countries), one would rank among the world's best product designers and largest manufacturers (150 million lines even at Rs.10,000 per line implies production of Rs.150,000 crores). A service industry that would operate and maintain 200 million connections would employ a large number of people.

Standing up to the World

But above all, such telephone and Internet connectivity can start changing the lives of people. Using the Internet, resources can be deployed more efficiently. With telecom and Internet connectivity, Indian villages would have the necessary infrastructure to stand up to the world. It could make our agriculture more remunerative and give our home-based industries a potential market for their wares at fair

prices.

Besides reduction of equipment cost, which reduces the investment required to provide telecom and Internet connectivity, one has to develop technologies that lead to reduction of the cost of operation. Conventionally, a large initial investment (of the order of several tens of millions of rupees) is required to start providing connections. It is possible today to come up with small access systems, which could be connected to a backbone telecom network. Such access systems would require low initial investment and could be operated very much like cable head-ends. A small entrepreneur could then serve a neighborhood (either a few streets in an urban area or a few blocks in a rural area) and provide low-cost service in an accountable manner.

Of course, for this to take place, one would require not only technology, but appropriate policies which would enable such decentralized operation.

TeNeT Group's Efforts

A group of faculty members at IIT Madras belonging to the Telecommunication and Computer Networking (TeNeT) group, took upon itself to pursue such R&D. The goals were clear:

- to develop telecom and Internet systems which would cost about Rs.10,000 per line;
- to develop decentralized access infrastructure technologies which would not only function in a harsh environment (high temperature and power fluctuation), but would also have a low initial investment requirement.

It was obvious that such tasks cannot be successfully undertaken without totally mastering the technologies, turning them upside down and innovating upon them. The first task was therefore not only mastering the existing technologies, but also to acquire an understanding of the directions in technology development and the costs associated with each element. While IIT faculty understood the concepts and theory and had some idea about implementation, the task at hand required significant industrial expertise. After toying with several ideas, the group decided to give a call to their alumni working in industry around the country to come together and form companies that would work jointly with IIT to take up such R&D tasks.

This was only the first step. One would require manufacturing tie-ups, funding and other tie-ups to make

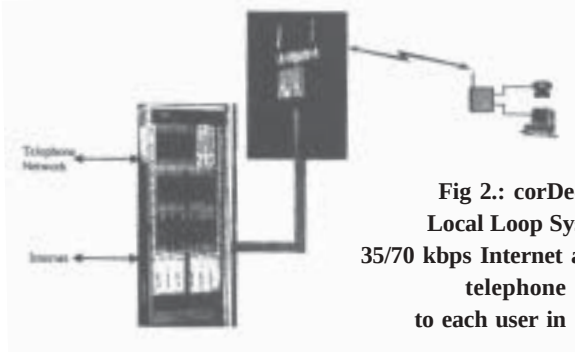

Fig 2.: corDect Wireless in Local Loop System providing 35/70 kbps Internet access & simultaneous telephone connection to each user in 10/25 km radius

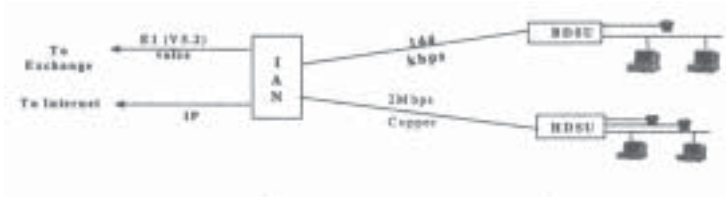

Fig 3.: DIAS (DSL onCopper) providing Telephone and High-speed Internet Service

world-class components. The group sold its concept to several Indian industries, carried out advance licensing of its technology, and raised the funds. Government funding was eschewed — the vision was large and since industry would benefit from it, the belief was that industry should fund it. Similarly, tie-ups with international component industries were established (such industries did not exist in India) based on an understanding that the products could have a large market in developing countries. In other words, the principle was that the large potential Indian market can and must be used by us to help us reach our objectives.

The process resulted in the setting up of several companies including *Midas Communications, Banyan Networks, Nilgiri Networks, AdventNet Inc*. Thus began the process of developing world-class technology and products aimed towards the market of the developing countries.

Without getting into technological details, let us look at a few products that have resulted from such an effort :

Wireless in Local Loop

The first product developed by the group is corDECT Wireless in Local Loop (WLL). This gives to a subscriber a fixed wireless connection (not mobile) at home or office, providing both a telephone as well as a 35/70 kbps Internet connection at the same time as shown in Fig 2. The equipment can be installed at a low initial investment (about Rs.2 million) and provide service to about 1000 subscribers in a neighborhood of about one km or so in urban areas and 10-25 kms in rural areas. The cost per line amounts to about Rs.13,000, including about 30 per cent taxes. One key feature of this Multi-Carrier Time Division Multiple Access (MC-TDMA) system is that while it provides simultaneous telephone and Internet connection to subscribers, the Internet traffic is separated at the exchange from voice traffic and carried separately so that the telephone network does not get congested.

It is worth noting that such a service cannot be provided by any other product in the world today at even double the cost.

Digital Internet Access

Another product developed by the group is a Digital Internet Access System (DIAS), focussed on middle and higher-end markets in the urban areas as shown in Fig.3. Using Digital Subscriber Loop (DSL) technology which has matured in the mid-nineties, the product provides simultaneous

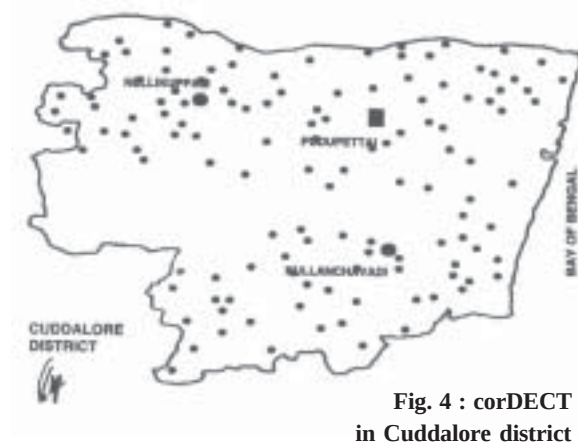

Fig. 4 : corDECT deployment in Cuddalore district of Tamil Nadu. Telephone / Internet connections have been provided to farmers in 50 villages

telephony and Always-On high speed Internet connectivity on existing telephone cables. With an investment of about Rs.13,000 per line, an existing telephone subscriber could be provided 128/64 kbps Internet connection along with a phone. A 2 Mbps Internet connection along with eight telephones can be provided to business at a slightly higher cost. The upgradation takes only a few days. About 40 faculty homes at IIT Madras have been provided such connections for more than a year.

The TeNeT group has taken up the development of several other products. The key is that these products are being integrated. They will enable an operator to install an integrated Access Centre and provide multiple services in a neighborhood. While a corporate or upper middle-class subscriber can be provided high-speed DSL connection, a middle-income household can be provided a wireless telephone and 35/70 kbps Internet access, and a lower middle class home can have a shared wireless telephone, or a plain telephone using copper wires.

The complete hardware and software for these products have been developed by the TeNeT group and its associates and the product designs are fully owned by these groups. The products are being manufactured by several companies in India today and a few companies outside India. The deployment of corDECT WLL has taken place in more than 10 countries today and the product has been validated by the telecom departments of eight countries. **Figure 4** shows a typical deployment in a rural area. Using these Access Products and standard backbone network products and switches, it is possible today to build a state-wide telephone and Internet network at an investment of around Rs.18,000 per line. This is still far from the target cost of Rs.10,000 per line but the target looks much more achievable today than it did five years ago.

It is possible to provide telephones as well as medium rate Internet connections in all villages of India in about two years time with modest investment. The TeNeT group has gone ahead and incubated a company which will operate telephone and Internet service in small towns and rural areas. It is in fact already in the process of installing connections in every village of Cuddalore, Madurai, Dhar, and Sikar districts.

Obstacles by Government

While the TeNeT efforts were entirely privately financed and have resulted in products which are being deployed in substantial numbers today, it encountered numerous road blocks along the way. Some of them are described below, so that one may understand what needs to be done to de-bottleneck the road from R&D to the market.

➢ To begin with, there was total disbelief that such efforts which would reduce costs substantially below those prevalent in the West, could ever succeed. The disbelief was not misplaced and was based on the fact that similar efforts have often not succeeded in the past in developing significant commercial technology and very tall claims have been made at times without success.

➢ The opposition really started when the first product was ready and put on trial. In the words of a senior telecom official associated with evaluating the effort, "we just humoured IIT to begin with, as we never believed that anything will come out of the effort. But once the product started working, we did not even know how to react." Egged on by competing companies, all kinds of obstacles were put up to prevent the product from being commercially

deployed in India. One suddenly tempted with large sums of money to sell our rights and R&D to companies. If we refused to be bought, we would be starved of funds. We had to carry out our first commercial deployments in some far-away countries even before we got a hang of what is involved, and while being unprepared on the interfaces used in those countries. Here too, we could only go so far, as competing multinationals, with their financial muscle, would question the use of an Indian technology which did not even have significant deployment within India.

We however refused to be defeated, and continued to make improvements required to keep our technology ahead of the others.

➢ We had hoped that the privatization of telecom services would solve our problem, as private operators should definitely prefer a lower-cost higher performance system. We were obviously novices in business. We had no understanding of the role that finance plays in such decision-making. Vendor financing was key to such sales, especially for cash-starved private operators, but financial institutions kept us mostly at bay.

➢ Even today, a twin campaign, claiming that our wireless technology is anyway obsolete (although no other system can provide simultaneous telephony and a dedicated 35/70 kbps Internet connection to a subscriber at even two times our cost) and that Indian rural areas need only telephones and not Internet (Internet is being dismissed by policy makers as a

luxury for rural areas), has been unleashed against us. We failed to realise the importance of lobbying and did not even set up a one-person office in Delhi till recently.

- Large orders were placed for less functional and much more expensive imported products by the state-owned telecom operator. This support helped these products to mature, catch up on functionality with our product and eventually compete with us in price. Once again we consider it as our shortcoming that we failed to stop such orders.
- We failed to realise that the Indian telecom manufacturing industry is weak. They are not used to high volume-low margin manufacturing and sales.

Our refusal to be cowed down is finally giving results. We have orders for about 100,000 lines today and should be able to deploy close to half a million lines this year. BSNL, MTNL and several private operators are currently using our technology and we have some major potential orders and tie-ups outside India.

The Road Ahead

Developing 'disruptive technologies' for developing countries enables one to master the best technological skills and cater to a large market, which is otherwise deprived of the fruits of technological advancement. But this in itself does not make India a technology powerhouse. Even though we may master design, there are two critical aspects in which our skills will not necessarily be enhanced by such efforts. One is time-to-market and the other is ability to market and deliver products in the highly competitive western markets. One needs to acquire such skills to be a technology leader, and for this, we have to make products for and compete in the developed western markets.

If we first acquire technological as well as financial strength through products designed for developing countries, eventual entry into western markets will become an option. Today, a large number of companies who have mastered telecom technologies exist in India and there is a high degree of confidence in their capabilities. It is conceivable to put together efforts in India which would enable us to compete with an Ericsson or a Nortel in four to five years time. Such efforts initiated today have to be multi-institutional, multi-company efforts. Each such effort will require large funding (of the order of several billion rupees), but venture funding for this can be and should be raised from private sources at present. Accountability at each stage of such efforts will be important for success. However, the key to overall success (and to begin with even to raise large funding) is national support.

More on the issue of national support later; let us first take a look at the telecom and networking areas, where India has a potential to be counted as amongst the world leaders. The key is that Access products will amount to 70 per cent of the value in the infrastructure area and India certainly has the potential to be counted amongst the world leaders in this area.

Subscriber terminals and equipment, have a very large market. China and the far-eastern countries have dominated the area. Critical to making a mark in this area is the ability to manufacture at very low cost and deliver in very large numbers. We have a chance to compete in the area, only if we can straighten out our manufacturing industry, to which, unfortunately, our policy makers have paid very little attention so far. However, if this is taken up as a mission, we can start seeing results in a couple of years.

To be a technology leader ... we have to make products for and compete in the developed western markets.

Enterprise networks and devices are another area where we can become a substantial player. Once again ability to design customer-premises products, manufacturing at low cost, and marketing will be the key. It is possible for our R&D to drive efforts in this area.

Application products are typically software products. There is no reason why we cannot become leaders here. We would require necessary market tie-ups and investments for marketing. R&D efforts making us the very best in this area can be driven from India.

What Holds Us Back

This brings us to our weakness. Our component industry is very weak and our R&D in the area has very poor linkages to industry. This area requires multi-disciplinary focus on areas like materials and semiconductors, processing, packaging, etcetra. The investment required to build a state-of-the-art foundry is astronomical (several billions of dollars) and the plant can get outdated before one completes it. The strategy in this area would be to get some multinational to set up a plant for wafer manufacturing or packaging, tie-up with an IC fabrication facility, and wait for the right opportunity. Our large potential internal market must be used here to get someone to ultimately set up a state-of-the-art manufacturing facility in India.

Optical components is another area where a similar situation may come about in a few years. However, there are some opportunities for

assembling and packaging houses. Once again, the success of such an effort is handicapped by the weakness of manufacturing industry in India.

The area where we can make significant progress quickly and hope to become world leaders is in VLSI design. It is in this area that we can become the very best and hope to drive the market for devices. The key here is education and training linking oneself to design houses.

But our dreams of becoming world leaders in any area requires national support. Are we once again talking of protection? No. Let me clarify.

Meaning of National Support

Governments all over the world help their telecom industry so that products developed and produced in their country become the dominant products in the world. The United States government banned the entry of GSM cell phones for about eight years, so that a nascent IS-95 (CDMA) technology being developed by Qualcomm, USA could mature. The South Korean government started a national effort to help LG, Hyundai, and a few other Korean companies become world leaders in IS-95 terminals and banned the use of GSM in South Korea. Similarly, some European governments prevented entry of IS-95 in their countries to support their GSM developers and manufacturers. Not only is competition kept at bay, but sufficient time is provided to local technology to carry out large-scale deployment and thus mature. All efforts are made by service providers of these countries to create an edge for their national product.

Unfortunately, India is one of the few countries where not only is this not done, but often our government goes out of its way to favour products from outside, in preference to products of Indian entrepreneurs. The

India is one of the few countries [that] goes out of its way to favour products from outside in preference to products of Indian entrepreneurs.

case of corDECT WLL is just one example.

❑ ❑ We cannot hope to develop technologies and become the best in the world without long-term national support – not protection for expensive and less functional products, but time-bound support to efforts which can help us in vying for the world market. The support should come from standards-defining bodies, which will define national standards to help local industry and R&D efforts. The help has to come from a national policy to refuse entry for products which do not conform to these standards to come in for at least a few years, and the support has to come from financial and tariff policies which will slightly favour products coming out of such efforts, at least for a limited period. This support has to be calibrated carefully ensuring at each stage that what is being nurtured is best for the country. ❑

Ashok Jhunjhunwala is one of India's leading and much celebrated scientists doing pioneering work in telecom and information technology. He is head of the Electrical Engineering Department at IIT, Chennai, and recipient of several awards, including the prestigeous Shanti Swaroop Bhatnagar Award.

Now Available in Paperback

Religion at the Service of Nationalism

& Other Essays

Madhu Kishwar

Oxford University Press, 1998

Paperback edition : 2001

This collection of essays from MANUSHI written between 1984-96 in response to specific situations of ethnic violence and conflicts triggered off by the politics of religious nationalism in India and the struggle of regional parties against overcentralisation of power:

● analyses the causes and forces behind communal conflicts and massacres in India ● pays special attention to the specific impact on and the role of women in ethnic conflicts ● makes suggestions for keeping ethnic conflicts under control and strengthening the tradition of peaceful co-living among various communities within a democratic framework.

323 pages, ❖ Price: Rs 295 ❖ Overseas Price: US $ 15

Send advance payment to **MANUSHI TRUST**