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INDIAN TELECOMMUNICATIONS IN THE NEW MILLENNIUM

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COMMUNICATION HISTORY

Since time immemorial, human beings have been communicating. It was around 31,000 years ago, that mankind began recording its destiny on Sumerian clay tablets. Only 3000 years ago alphabets of some kind began appearing. Just 500 years ago came the printing press. Then 150 years ago, came morse telegraphy followed by telephony which came 120 years ago. Radio telegraphy came 100 years ago and 10 years later radio / voice transmission followed. Just 50 years ago, came the television which was followed in 1975 by cable TV, assisted by satellites. Today in multimedia we have VCR, Cellular, PCS or Personal Communications Services. Multimedia can be described as 'TIME' industries. TIME stands for Telecom, Information Technology, Media and Entertainment. W.A. Knetsch has similar views.

Telegraphy brought about the breakthrough in information. Around 150 years later, one million bits of information on a single page may be transmitted in seconds from one place to another. This represents a factor increase of around a million times in the speed of delivery of information. Even the volume and contents have increased tremendously. In the post Gutenberg period 1000 books per year of printing press has grown by leaps and bounds to nearly 500 million pages per year of only one field i.e. technical information.

If we try to equate the speed of information technology with machinery in the industrial age, the differences are mind boggling. According to Delloite and Touche, if aeronautics had kept pace with the microprocessor over the last 30 years, the equivalent of a Concorde would then be able to carry half a million passengers for a little less than a dollar each, at a speed of 20 million miles per hour.

The speeds for transmitting information accelerate in tandem continuously along with the development of faster and better devices of communication. The question then arises that what is the ultimate delivery or termination point. According to Delloite and Touche (1994) the destination is, "a 3 pound electrochemical device which covers half a cubic feet of space, runs on glucose at about 25 watt, has 100 trillion or so transistors, processes information at 100 quadrillion functions per second. It is the world's first wet computer – the human brain". This according to Delloite and Touche is the ultimate point of termination.

The telecommunication network has emerged as an important component of infrastructure all over the world required to support economic development, scientific discoveries, educational opportunities and social advancement. Today, telecommunication is not simply a means to communicate with any one, anywhere all over the world, but also to access information timely and act as a catalyst in the overall economic development of every country.

Indian Telecommunications

On the eve of Independence in 1947, India had a very small telecommunications system. It comprised of around 300 telephone exchanges having around 80 thousand telephone lines. The Indian Telecommunication Network has undergone immense change in terms of coverage as well as quality and range of service. Today India with its

22 million telephone lines network stands 9th largest in the world. However, we still have a low telephone penetration rate of 2.2 per hundred population which is far below the global average.

There is vast scope for growth in India. India is one of the fastest growing telecommunication systems in the world. It grew at an average annual rate of over 20% during the last four years. In the next five years, India will be the third largest telecommunication network in the world.

The major breakthrough came with the National Telecom Policy in 1994. It paved the way for the private sector to participate in areas like basic telephony, electronic mail, radio paging, cellular mobile telephone, mobile trunking, voice-mail, audiotext, 64 kbps data using Very Small Aperture Terminal i.e., VSAT, videotext, videoconferencing, internet and credit card authorization. This progress is being further facilitated through the New Telecom Policy in 1999.

Trends in Technology

A remarkable new era of universal low cost personal and institutional communications has been heralded in with the drive towards software-based systems and the partnership of radio bearer technologies and optic fibre. Personal communications and broadband services have brought in mobility and capacity. This will effect a paradigm shift and will ultimately lead to unprecedented industrial growth. In a multi service environment emphasis will be laid on the pluralism of technologies. One user will be served by not just one universal telecommunications network but by a combination of many telecommunication networks. Users will be able to rightfully demand connectivity under global standards of design and operations. They will be able to enjoy alternative sources of supply from equipment on their premises to international services. Moreover, the emergence of broadband services will increase a speed of the achievement of economic crossover for laying optic fibre in the local loop. All over the world demand has emerged for broadband services delivered to the home such as high definition television.

Telecommunication Development

A vast growth of telecom network and services was envisaged in the New Telecom Policy, 1999. The main objective was to raise teledensity from 2.2 per hundred population to 7 by the year 2005 and to 15 by the year 2010, according to W.A. Knetsch and the Government of India (GOI) Telecom 5 Year Plans. This works out to an increase of 150 million new telephone lines in India over a period of 10 years. Rapid expansion is expected in mobile services. Today there are hardly 1 million mobile users in India. The Siemens Telecom Report states that by 2010 the number is expected to go up to between 20 million & 25 million users. In the 5 to 10 years timeframe the impact of technology on the cost of the mobile services will be significant. The cost of mobile services will be equivalent to the cost of the fixed ground line. Thus the psychological gap between the mobile and the fixed service will be eliminated. According to their own convenience people will be using a telephone either in mobile mode or fixed mode. People will use a universal number encompassing both personal and instrument mobility. In the coming years this will result in a further boost to the growth of mobile service. To ensure growth of wireless services including mobile, spectrum availability will first have to be ensured.

For people who do not have individual telephones there is large scale provision of Public Telephones. This has been provided to ensure shared access to telephones especially to persons when they are travelling. These are increasing in number and being deployed both in urban as well as in rural areas. Most of these Public Telephone Offices (PTOs) will be converted to TELEINFO CENTRES which will provide Internet and multimedia facilities as well.

IMT-2000

The evolution of cellular communication began with the first generation of cellular communications which used analog technology. The impact has come with the second generation cellular communications which are using digital technologies. In spite of the enormous success of cellular radio and the limitless capacity of digital standards in provision of advanced service and features, the telecommunications industry is looking ahead into the future and the beginning of a third generation mobile communications system which will lead to personal communications.

The International Telecommunications Union (ITU) initiated studies for defining service and Radio

Transmission Technologies required for International Mobile Communication-2000 (IMT-2000). The IMT-2000 System is going to provide access by means of a single or many radio links, to a vast range of telecommunications services supported by fixed telecommunication networks, and to other services which will be specific to users of mobile communications.

The main features will include:

a. High degree of a worldwide common design.

b. Compatibility of services within the IMT-2000 and in fixed networks.

c. High quality

d. Use of pocket terminals having facility for roaming worldwide.

e. Capability for multimedia applications and a wide range of services which will include for example – video teleconferencing, high speed internet, speech and high speed data etc.

The International Telecommunications Union in the World Telecom Development Report, 1995, evaluated 10 terrestrial proposals for IMT-2000 and has built consensus and drafted new recommendations for the key characteristics of IMT-2000 Radio Interfaces. With design and construction remaining the same it is going to simplify the implementation of small, lightweight, multi mode, multi-band terminals. Thus this will facilitate an inter system roaming which will be on a regional, national and international basis.

Evolution of Telecommunication Network

The switches currently being used are highly refined versions of the earlier electro- mechanical vintage switches. They possess the intelligence to route telephone traffic in the most cost- effective way. For the support of an open interface, these switches are now being designed so that they can supply V5.1/V5.2 protocol. The digital switching systems support Common Channel Signaling System No.7 (CCS7) and narrowband ISDN (N-ISDN) services which provide services like 64 kbps data, videoconferencing, G4 Fax and other supplementary services. (See also H. Ohnsorge et al.)

The Bharat Sanchar Nigam Ltd. (BSNL) has taken account of the impact due to long holding time of increasing internet traffic and additional provision of special equipment is being considered. The department is also considering induction of ATM based extra large switching systems which will support over 4 million Busy Hour Call Attempts (BHCA) and other features like multimedia services.

Optic Fibre Communication

Telecom Services need the availability of a good network along with a large bandwidth. India has around 26,000 telephone exchanges. Since India is a vast country many of these are in extremely difficult areas like hilly terrain, deserts and islands. For the increase of telecom services it is vitally important that these exchanges are connected. In addition to the old, existing technology of coaxial cable and open wire system, optic fibre, microwave and satellite communications are being used. Despite rapid growth of optic fibre systems, 50 per cent of the exchanges are still being connected by the out dated analog technology. India has around 1,10,000 route kilometers of optic fibre systems till date, and another 250,000 route kilometers are going to be added in the next 2-3 years. The capacity of the system will also be increased. A Sanchar Sagar Network i.e. a National Optic Fibre Network is being installed using SDH technology of 2.4 GBps capacity. It has been commissioned at the end of 1999. From 2000 gradual introduction of 10 GBps system has been introduced.

All over the world, trials are going on for the DWDM optic fibre systems possessing capacity of 320 GBps and 800 GBps. When large capacity optic fibre systems are introduced the cost of bandwidth will become cheaper. This will result in the cost of a long distance call being nearly equivalent to the cost of a local call.

Integrated Services Digital Network (ISDN)

ISDN has evolved from the Integrated Digital Network (IDN). It provides end to end digital connectivity supporting a vast range of services inclusive of voice and non-voice services to which users have access by a limited set of

standard multipurpose consumer interfaces. The new services which can be provided with the introduction of ISDN are:

a. Multimedia services

b. Teleconferencing

c. Videotelephones

d. G4 Fax

e. Distance learning

f. Health care

g. Education etc.

In the ISDN, the termination of the telephone lines is on a common box known as the Network Termination which is provided at the subscriber's premises. Upto 8 ISDN terminals can be connected on the internal wiring in the subscriber's premises beyond this common box. They may be of various types, like ISDN telephone, Personal Computer (PC), Videophone, Desktop Video Conferencing equipment etc. Through PC add-on cards Data Transfer at 64 kbps is possible. Moreover, existing terminals like rotary dial and push button telephones, fax machines and modems can also be connected to the existing terminals by using Terminal Adapter.

Cable Transmission

The era of high- capacity traffic-carrying capacity has been heralded in through the advent of optic fibre. This technology has opened the ways of utilizing the existing telecom infrastructure more effectively.

High Bit-rate Digital Subscriber Line (HDSL) & Versatile Multiplexer (VMUX) technologies supporting Local & Access Network – A new innovation in the cable system is HDSL. It can carry 2 Mbps traffic upto 3.5 kilometers with optic fibre quality performance, utilizing 2/3 pairs of 0.5 mm copper cable conductors. To cater to these new services VMUX at 2 Mbps are being used. These two technologies namely HDSL and VMUX complement each other. They provide different types of telecommunications services including Data, ISDN etc. BSNL is inducting HDSL equipment. It plans to introduce VMUX for local access and to inter-exchange junction networks as well. Asynchronous Digital Subscriber Line (ADSL) is also on the anvil to be used for high speed internet users especially.

Digital Loop Carrier System on Optic Fibre Cable – The main characteristics in the evolution of modern of Access Network are digitalization, multi vendor integrity, delivery of high bandwidth and increasing reliability of telecom services. This technology will empower service providers to cope with the increasing demand of a variety of services to the customers in local networks. The Digital Loop Carrier Systems are being inducted in major cities.

Passive Optic Network (PON) – The PON Systems will be deployed upto the premises of the subscriber i.e. FTTH. The PON are basically optic splitter. The optic fibre is split in 16-32 ways. This increases the capacity of one single fibre so that it can be taken to plenty of directions. It is useful for sending multi point information transport facilities to remote sites. The BSNL plans to exploit this technology. See H. Ohnsorge et al for more details in this regard.

Radio and Microwave Transmission

Over adverse terrain for spur routes and where fast deployment or low initial cost is required, radio may be used for complimenting fibre in the telecom network. Over adverse terrain the construction cost of radio (using existing tower structures and feeders) may be substantially less than the cost of aerial or buried fibre. The term adverse terrain is inclusive of geographically difficult routes and routes with costly or unavailable rights of way. Since vast areas all over the world are either specially populated or difficult to provision, the economic vehicle of choice automatically becomes radio.

A new concept which is now being addressed to enable a vast multitude of services by stations located at a height of 20-50 kilometers above the surface of the earth is high altitude platform stations. Such a station will be a repeater to the earth and will have a fixed relative to appoint on the earth's surface. Therefore, the problem of delay which accrues in satellite communication will be avoided. It will be visible over a large area due to its height. An entire nation may be covered with a few systems.

In the long term more fundamental shifts could occur. They could include migration to even higher frequencies like extensive use of infrared transmission for infra office communications or even substantial use of millimeter waves. In the area of wireless telecommunications, frequency use there could be the most radical change. The technology now exists for dynamic ranging over many Megahertz of frequencies and it has been suggested that there should be choosing of temporary frequencies for use on demand. This new technology will allow practical expansion of the total telecom capacity over existing static allocation procedures by around two orders of magnitude.

BSNL is inducting radio and microwave equipment in metropolitan cities, rural areas and in long haul backbone transmission network. The new equipment is primarily being based on SDH technology.

Satellite Transmission

Satellite Communication had been introduced in international communication for fixed services using geo-stationary satellites with the set up of INTELSAT. India along with a few countries in the world had the foresight of the opportunity of satellite communication for its domestic communication. A very extensive satellite network exists at present for providing message, data and telephone services.

Mobile Satellite Services which were initially started by INMARSAT for maritime use mainly for distress, search and rescue operations, are now being used for provision of telecom facilities in remote areas like isolated hills, islands and inaccessible villages. The BSNL has inducted some of these terminals to be used in remote and inaccessible areas.

BSNL is using multi purpose satellites in INSAT series for provision of point-to-point and point-to-multipoint fixed services along with mobile satellite services. Initially networking, using VSATs was introduced for data communication for computer networking. Its usage has now spread to telephony, videoconferencing, village telephone, distance education and tele-medicine.

Extensive use is being made of satellite communication using the INSAT series of satellites. They are vital in inaccessible areas like islands and hilly terrain etc. Digital technology is being used in all new transmission media including satellites so that the future needs of multimedia services can be catered to.

Customer Premises Equipment (CPE)

The present trend is allowance of more intelligence being placed in CPE. The intelligence built into CPE will enable the choice of optimal network to be used. Prediction of which applications will catch on is nearly impossible. In the 1980s the unprecedented growth of fax and cellular radio networks is an example. A clear trend is emancipation of CPE. BSNL has given permission for customers to install CPE of their own choice for which they get a rebate in installation charges.

All over the world the latest trend is cashless payment using cards. This will be made by using normal telephones or pay phones. BSNL and Private Operators plan to introduce pay phones based on smart card technology.

Market

Through seamless, ubiquitous communications network for voice, data and image with real time, high quality applications and with network intelligence under the control of the customer a myriad of new services will be available. The result will be downward movement of tariffs and greater parity or equilibrium, between and among all service providers. Satellite, cellular, wire and other forms of telecom will reach common or nearly the same cost and price levels without major discrepancies occurring between them. A part of this will be the result

of the over all driving force of digital processing in all these transmission technologies. It will also equalize current discrepancies in telecom rates which result in serious problems and inequalities in international collections and settlement processes. The countries or telecom entities which prefer to hold out against this overall macro level trend may find that they are losing business, investment or even their stand in the international market as a progressive or enlightened nation.

Latest Trends

Internet – Internet is a worldwide network of networks. At present the internet is being supported by different agencies without any central control. A technical body known as the Internet Engineering Task Force (IETF) takes decisions regarding technical issues related to this technology. On the Internet, every computer is identified by its unique Internet Protocol (IP) address, a number which is registered with an International Internet Body. The provision of internet services is basically in two forms. They are Shell access and TCP/ IP access. The shell access gives access to textual information. TCP/IP access gives access to the entire range of Internet services using graphics, availability of browsers like Netscape Navigator, Microsoft Internet Explorer etc. The ordinary user running on a graphical user interface has been facilitated to navigate the World Wide Web easily, which is a vast collection of documents, sounds, images and video, of web servers from the entire world. In 1999, the number of users of internet was over 50 million. At the end of 2000 there were more than 200 million internet users. This number increases every day. The latest trend among corporate business houses is to deploy internal network using internet technology in the form of intranets.

India has also witnessed an explosive growth in the internet. At present in India the base of internet users is around 400,000. They are mainly being served by BSNL, VSNL and MTNL. At the beginning of 1999 internet provision was opened up for private investment. The growth of internet is going to be basically limited by the number of PCs in homes and offices. Within the next 10 years the number of internet users in India may exceed over 25 millions. Every day various new applications of the internet are being developed. Electronic Commerce (E-commerce) is one of the most important applications. There will be massive growth in this field.

Integrated Services Digital Network (ISDN) – ISDN service has also started growing in India. Presently, this service is available in 80 towns and cities having total customer base of 6,000 till date. Over the next two years when ISDN services are extended to all parts of India the usage of ISDN will receive a greater boost.

Global Mobile Personal Communication Services (GMPCS) – Uptil now the conventional satellite systems had been based on the concept of geo-stationary satellite systems. Today this paradigm has been challenged by the non-geo-stationary orbit satellite system. Mobile service using satellites is known as GMPCS. It can be provided very quickly in inaccessible areas and difficult terrain. Mobile cellular coverage however, takes a long time to be provided and is also uneconomical in implementation. The need for making terminals handheld has paved the way of using a constellation of satellites in circular Low Earth Orbits (LEO). Depending upon the distances of the orbits from the earth, the number of satellites for 24 hour global coverage required is calculated. When the orbits are less than around 1000 kilometers they are called LEOs. The ones below GSO are known as Medium Earth Orbits (MEOs). Iridium GMPCS have already begun operating. Gradual operation of other operators for example – ICO-P, Globalstar, Teledesic and so on is on the anvil. For licensing of operation of such networks various regulatory and policy issues for example – security, customs clearance, frequency sharing etc, are involved. The BSNL has taken the decision to license these services on a first-come-first-serve basis.

Intelligent Network (IN) Services – IN services were introduced in 1998. It is showing incredible potential for growth. These IN services include Free phone services, Premium rate service, Virtual Private Network, Account Card Calling, Televoting, Universal numbers etc. The introduction of IN services will be of great significance for business and industry since new and modern services will be made available in a cost-effective manner. The provision of flexibility of service by IN will start services which only have the limitation of the service provider's creativity and the customer's communication needs.

The main aspect of IN services is that depending upon the needs of customers, new services can be immediately provided. The ITU has defined capability Set-1 IN services which have been introduced by many countries in their telecom networks. ITU is in the process of defining capability Set-2 and Set-3 of IN services. In telecom

operation major savings are foreseen by call completion to busy subscribers and call booking ahead, by not blocking resources when the subscriber who is being called is busy.

The BSNL has begun IN services in 16 cities. These services are going to be extended over the whole of India.

Asynchronous Transfer Mode (ATM) – There have been great improvements in computing power and associated environment for example – Graphical Users Interfaces like MS-Windows, and multimedia. They have created demand for information to be transported with different characteristics ranging from burst data services till high definition television signals and from ordinary telephone services till state-of-the-art multimedia services. The fast-packet technology of ATM is responsible for making this possible. Thus ATM was chosen as the basis for transportation of Broadband ISDN (B-ISDN). It is capable of handling a variety of services like voice, data and video over one, single, universal ATM packet fabric. Since ATM technology provides the four elements which are lacking in internet infrastructure today namely scalability, quality of service, performance and reliability, ATM technology is now being considered for provision of high-capacity pipelines for Internet infrastructure. BSNL has initiated a pilot project and installed ATM switches in 5 metros in the first phase.

Voice over Internet Protocol (VoIP) / Internet Telephony – Gateway devices allowing conventional telephones and not just PCs to be used on either ends of the call, including features like call waiting, caller ID, conferencing and hold are maturing, allowing possibility of cheap, flat rate usage charges to speak to anyone, anywhere in the world, using the internet. Internet telephony having valuable applications for example – uploading and downloading of files while speaking makes it more attractive to plenty of users.

The VoIP is possible between PC to PC, PC to telephone, telephone to PC and telephone to telephone, using dedicated trunks to carry IP. On the other hand, in internet telephony, there is no provision of dedicated trunks and voice is carried over public Internet. One of the major issues i.e. quality of service can be assured to a certain extent in the case of VoIP.

Information Superhighways – There is convergence of the two separate worlds of IP technology and telecommunications. Integration of the advantages of both these environments fulfills the promise of information superhighways. Global Information Infrastructure (GII) shall be an integrated structure of an information superhighways with an information "Super Skyway". The integrated services of voice, text, data, graphics and video are now defined as multimedia. They will become the major menu of future telecom services in the GII.

GII is expected to provide service features which may be categorised as any kind of service, at any place, at any time and to any one. These four "anys" can be achieved only by the combined network of wireline and wireless (including skyway transmission). Many feel that the information superhighway is synonymous with the Internet. The Secretary General of ITU Dr. Tarjanne, is of the opinion that with this definition there will be a number of potential problems. He feels that the Internet is too unstructured, does not have any service quality guarantee, is not optimised for multimedia traffic and despite wide spread availability, 97% of the users of the Internet are in countries in the high income group which account for only 15% of the world's population.

Another possible alternative pointed out by Dr. Tarjanne is that an alternative information infrastructure presently emerging will over a period of time replace the Internet. This alternative network may begin from the intelligent TV set rather than from a computer. It might be based around a cell switched transmission standard like ATM, rather than a packet switch standard like Internet Protocol.

The I.T.U. "World Telecom Development Report", 1995, refers to varying developments in defining National Information Infrastructure (NII) as a "cabbage patch in which wired, weird and wonderful species are blooming between the experimental plots and field trials". If NII is a cabbage patch of networks, then formation of a global infrastructure in the implication of the concept of the Superhighway, will need more coordination particularly due to converging telecom, entertainment and computer technology and disparities in infrastructure development among the developed and developing nations. The ITU has recently approved new recommendations for SDH system, ATM equipment, audio-visual systems and low bit rate multi media communication over the telephone network.

The end to end digital telecom world tomorrow will have the characterisation of adequate transmission and computing capability. It will be adapted to prevailing requirements of customers. There will be a high proposition of wireless communication, intelligent network management, user oriented multimedia interfaces and application friendly product design which will create personalised interactive, process oriented applications for meeting demand.

Future Networks

The basis on which new networks are going to be built will be the growing market acceptance of ATM as the prime multimedia standard. The overall architecture of the networks is now understood generally. Many alternative solutions like fibre co-ax, ATM based passive optic networks, ADSL, microwave distribution systems and satellites have become available in the access segment. Infrastructure network should be opened to alternative service providers. An open architecture will allow a host of service providers. They will be able to take advantage of the new infrastructures and bring traffic to the operators. Moreover they will be profitable due to low initial investment.

In the year 2005 communication will be characterized by man and machines exchanging information in a simple, reliable, secure and cost effective manner, at any time and in any place, using a medium of their choice, whether, it is voice, image, data or multimedia.

A big demand is expected from customers in image communication. There will be an upward trend. There will be an increase in the number of video services home via telecom. These services will justify broadband network from the beginning to the end. Multimedia services will gain further ground. The services are available on desktop PCs. Telecom users in 2005 will require more and more personalised and customised network services. Private customers require a service which emulates a private network on top of a public network i.e. the so-called Virtual Private Networks (VPN). Through widespread use of Intelligent Network (IN) applications a majority of these services will be possible.

There will be further increase in demand for mobility. Apart from the existing cellular network, there will be implementation of new systems like PCS/ PCN, UMTS, IMT 2000 and Skyway Networks. In 2005 penetration of wireless services will be ubiquitous.

On the one hand there will be increasing demand for processing power and on the other hand there will be shift from large mainframe computers to workstations and PCs. This will be explained by growing demand for networks which link these distributed processors. The cost effective use of data bases and other servers will lead to a further increase in this demand. These local networks will become so popular that in today's offices they have taken on a spider structure. It is impossible to imagine life and business without them.

Local networks being offered to meet this demand in 2005, will put aside the popular Token Ring and Ethernet Local Area Networks (LANs). These networks will be based on faster 100 Mbit/s Fibre Distributed Data Interface (FDDI) and 50 Mbit/s and 150 Mbit/s ATM LANs as defined by the ATM Forum. After the success of the cordless phone, wireless LANs having bit rates which exceed 10 Mbit/s will conquer a portion of the market. Heavier and broadband-hungry applications will still need wired LANs.

With the popularity of high bit rate Local Area Networks (LANs) in 2005 and the presence of global mega corporations with branches scattered all over the world, there will be increase in the need for massive exchange of information among the subsidiaries via the public network. The network 2005 will provide these information highways carrying hundreds of Mbit/s between work stations which are located thousands of kilometers away from each other. The distance barriers of LANs will disappear without performance degradation. There are stringent requirements on the networks: an information transfer between and work station located in Asia and a remote party located in USA can be very short in time (sub seconds) but very demanding in bandwidth (megabit). A moment later, the same resources of the network may be used for another communication between two other different locations for a short time period.

It is for this reason that, connections data communication techniques, which are used in LANs will also be available in public network. This public connections data service may be based on the Connectionless Broad

Data Service (CBDS) Switched Multimegabit Data Service (SMDS) or an enhanced version of Internet Protocol (IP) on ATM. The Network 2005 in addition to the demanding performance will also offer other facilities like address screening realising closed user groups i.e. virtual private networks.

This evolution which has been described above has considerable impact on the architecture of the future network. The network 2005 will show the following key characteristics:

a. It will be broadband. It must support all types of services, multi-media and of various bit rates. Each customer will have a few Mbit/s at its disposal but in the trunk network hundreds of Mbit/s and Gbit/s will be required.

b. It will guarantee universal connectivity and interworking.

c. It will be capable of offering worldwide access to all possible information sources whatever the storage and medium of communication being used.

d. It will be flexible in meeting requirements of users.

e. It will be consistent, reliable and safe.

f. It will be able to reach persons and locations.

g. It will have a flexible bandwidth allocation mechanism which will support a full, wide range of services.

h. It will offer environment flexibility for private as well as public operation.

i. It will have a flexible network management.

See W.A. Knetsch (1995).

The future of telecommunications will be dependent on:

i) Accelerated deregulation, with the aim of open market access for operators, vendors and users.

ii) The development of social and corporate culture, geared innovation and change.

iii) The analysis and articulation of user requirements.

iv) The use of public demand to stimulate the market.

v) Politics as a promoter and shaper of supporting conditions.

An essential ingredient in attaining competitive advantages is creating networks which facilitate the transfer of skills and knowledge, better health of citizens, increased Gross Domestic Product and above all the development of trust between individuals. India must work towards increasing its competitive advantage through the establishment of National Information Infrastructure in order to progress in this new Millennium.

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