Information and communication technologies and the digital divide in the Third World countries

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The technophiles' view is that the Information and Communication Technologies (ICT) herald the arrival of the new information era and are key factors for social change. The technophobes view the advances in ICT as new and sophisticated tools that would further the industrial imperialism. In spite of these opposing views, it is a fact that ICT have been contributing to a significant part of the economy of many developing nations. This is substantiated by the actions of almost every Third World country in treating ICT as a high priority item in their economic planning. ICT is seen to play an important role in political, socioeconomical, and cultural globalization process. Many international organizations including the World Bank, United Nations (UN) and the International Telecommunications Union (ITU), have fostered multitude of initiatives in the Third World countries that not only help in bringing the benefits of ICT to the Third World, but also create a framework for influencing policy formulations, open up markets, introduce competition and deregulate the ICT market.

The changes brought about by ICT are rapid and ubiquitous. The uneven diffusion of this fast-changing technology has also caused the digital divide within the countries and between the countries. It is almost certain that the countries which do not adopt and adapt to these changes will be marginalized, widening the digital divide. Third World countries are precariously poised at this juncture and a careful planning on their part would decide if the ICT would bring economic growth for them or push them deeper into technological isolation. In this paper, we discuss the emerging trend in ICT, the state of their assimilation world over and the emerging digital divide.

Introduction

The advances in Information Technology and the advent of internet and e-commerce have resulted in the knowledge products forming a substantial portion of the economic growth of many countries. Countries that master the techniques of creating, managing and protecting their knowledge and information products would emerge as the superpowers in the ensuing knowledge era. The world is undergoing a transition from a paper economy to a digital economy. The need of the hour is a highly proactive role from the Third World countries either singly or jointly, that would take into account the changing scenarios in the information and communication technologies and their non-linear interactions and convergence.

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Changing technologies and their convergence

There are three basic constituents that shape the information technology world. These are computers, connectivity and content. Together, these generate knowledge that will then call for all the awesome power of information management and the planning to foster and protect. Many Third World countries (TWC) by virtue of their having large pool of scientific talents and being the oldest civilizations, are excellently poised to generate contents. Many factors contributed to the easy availability of computers and the skills necessary to optimally utilize them. First is the growth of the software industry that has enhanced the PC penetration. Second is the Moore's law, due to which the costs of computers have been falling at approximately 40% a year. But still a major hurdle in most of the Third World nations is their low levels of connectivity within and to the outside world.

Computers and smart access devices

The microprocessor that forms the heart of the PC is becoming smaller, faster and cheaper. The processor revolution is fuelled by an intense research in Material Science. The first microprocessor Intel 4004 introduced in 1971 had less than 3000 transistors and operated at a clock frequency of 108 kHz. Today, the Intel Pentium IV using the 0.18 micron technology, has nearly 42 million transistors and operates at a clock frequency of 1.5 GHz. The exponential growth in the number of transistors in a single chip and the clock rate for the microprocessor manufactured by Intel (www.intel.com) are depicted in Figure 1. The trends characterized by the well known Moore's Law[1] are similar for microprocessors manufactured by other major vendors.

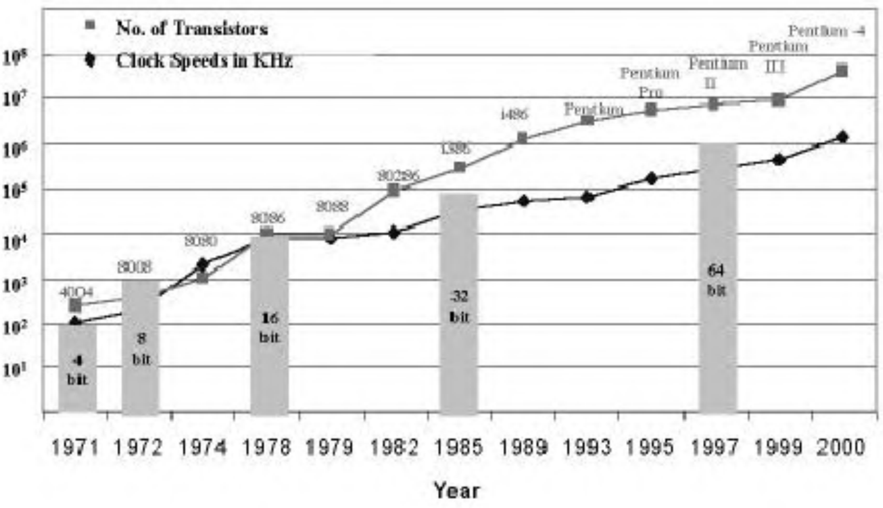

Figure 1. Trends in processor speed and number of transistors in microprocessors (based on the data from www.intel.com).

Conventional photolithographic equipments usually use ultraviolet rays at 248 or 193 nanometers. A series of lenses are used to reduce the image to a quarter in size. The rays are passed through the mask on which the circuit patterns are traced. The image is then exposed in a chemical on the wafer. Another chemical treatment etches away either the exposed or unexposed areas of the image, creating the chip[2].

Using Extreme Ultraviolet (EUV) one can embed ever smaller features on silicon, beginning with chips at 70-nanometer level. The EUV uses the 13-nanometer wavelengths. Most materials absorb UV light and the researchers needed to come up with materials that reflect this wavelength. This is in variance from the tradional transmitted-light photomasks used in the Deep Ultra Violet (DUV) photolithography. The microprocessors that will reach the market in 2005 will feature 70-nanometers. There will be a smooth transition in later years for producing chips with 10-nanometer elements. This will extend the present microprocessors soon to have a billion transistors and with clock frequencies in the range of 10 GHz (refs 3 and 4). This could result in a performance of 100,000 MIPS increase over the current processors.

One of the difficulties that arises in such highly integrated high clock rate microprocessors is the difficulty of transporting data and clock within the processor at rates near 10 GHz. The copper as a conductor at these rates would not work. Even 3 GHz would pose a serious problem. Over a dozen research groups across the world are racing to develop miniature optical devices capable of being integrated right into the silicon chip. There are basically two approaches to solve this problem. One is to use the silicon siblings such as GaAs as light emitting devices and these can be easily integrated into the silicon chip. The second approach is to make light emitting diodes from silicon.

For decades, silicon has been the cheap raw material used in transistors. But silicon without its ability to emit light, has been the limiting factor. Earlier attempts to make silicon emit light yielded efficiencies in the range of 0.1% which is far below the 1% minimum efficiency acceptable in the industry. Recent work of scientists at the University of Texas at Austin has resulted in processes that will produce stable microscopic nanocrystals out of silicon that can emit light. By changing the size of the silicon nanostructures, it is possible to change the colour of the light emitted (http://www.smalltimes.com/). Such small silicon microphotonic devices will be future alternatives for interconnects within the chip and between them. This will also be useful in making faster memories that consume less power and newer class of television and computer displays with full rainbow colours. In brief, with silicon as the base material, the road map predicted by Moore's law will hold at least for the next 15 to 20 years[4,5].

While the processor density doubles every 18 months, the Dynamic Random Access Memory (DRAM) density has been seen to double every 3 years. This has motivated the architectural innovations like the introduction of cache memories and the attendant memory hierarchy. It is today feasible to have 4 gigabits per chip of DRAM. The magnetic storage devices have medium access time due to their mechanical limitation and offer storage densities in the range of a gigabit per square inch. Due to the popularity of PCs and laptops, the trend is towards designing smaller, faster, high capacity and cheaper storage units. The increased market demand has also resulted in their cost halving every year.

Figure 2 describes the trend seen in magnetic hard disk storage evolution based on data available at www.ibm.com. It is seen in Figure 2 that the future laptops and PC's would offer low form factor storage of nearly a terabyte.

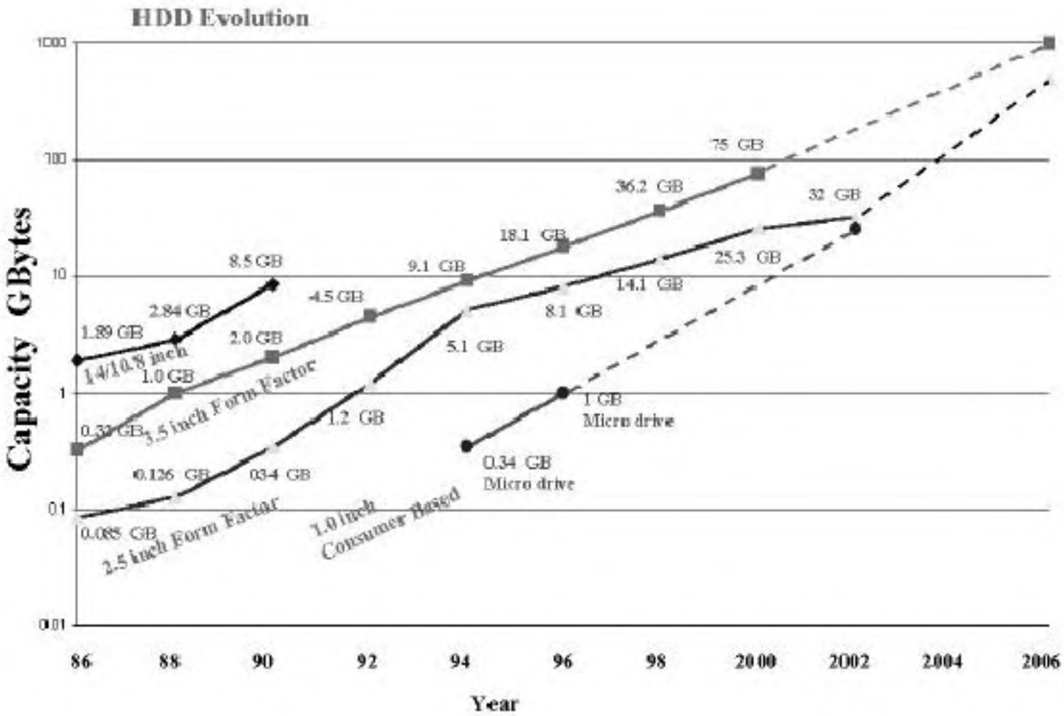

Figure 2. Trends in hard disk storage capacity (based on the data from www.ibm.com).

Optical storage systems have higher cost and inferior performance and are often used for backup and data transport applications. Optical storage densities of 45 gigabits per square inch are feasible today. Most reasonable applications call for storage of the order of 200 Gbytes of data at reasonable access time and cost today and future applications may demand a terabyte. The random access volumetric storage using holographic techniques looks promising to fill this need. At present their prohibitive cost is limiting their extended usage but this will soon be overcome. Molecular and chemical storages and storage technologies that leverage on the advances in nanosciences are also being touted as possible future candidates.

This high level of integration has resulted in paradigm shift in our perception of computers. In early seventies, computers were dominantly used for design of aircraft and weapon systems and were intended to improve the defence of the country. It was a cold war era and computers were tools that were considered strategic and their availability to other nations either denied or controlled. Performance often measured in megaflops were used to characterize the computers. Since their development was part of the strategic initiatives, the cost was of no concern, their development was slow and often did not need to make an economic sense. With the dismantling of the Soviet Union and the end of the cold war, the need to make an economic sense out of the computers became a necessity. This fuelled the microprocessor revolution with a view to make the computers an integral part of the society and for applications beyond mere computing. The word 'computer' soon became a misnomer and the present day computers are more of an information utility than compute engines. The present day microprocessors lay more emphasis on functionality than performance – performance being taken for granted. The net effect is the birth of more and more cheap one-chip systems. The discontinuous growth in VLSI integration levels have made it possible for different access, computing and communication devices to join and form new multi-purpose devices or smart devices. The way the devices and applications converge to form digital personal tools is also the drive towards natural interfaces – the urge of the mankind to interact with the 'computer' in ways similar to his interaction with fellow human beings. This has been the motivation for the newer class of I/O devices such as mouse, microphones, speakers and multimedic and small form factor screens and the softwares like automatic speech recognition and personal productivity tools. In simple words, the small, smart digital tools of tomorrow will provide language independent interface to the knowledge world.

This convergence of many devices and applications would soon change the PC that we know today and would also change the information access patterns, thus placing very stringent conditions on the network. This convergence will be preceded by the 'material convergence' wherein a single material will be used for the processor, memory, auxiliary storage, display and even communication.

The changing trend in the demands that the interface between human and the machine will be like the interface between human to human, changes the computing demands from the world of quantitative calculations base characterized by the binary bits and silicon to the world of qualitative computing or perceptive computing or information processing. The future computing architectures and the materials beyond silicon will be dictated by this paradigm shift and will be first preceded by the material convergence. Several possible alternatives including the quantum and bio computing are being pursued vigorously all over the world. On the material front, recent developments promise that nanotubes which measure 5 to 10 atoms wide are the most promising replacement material for silicon in the future chips[6]. Flexible transistors and chips made from plastic and organic materials are also being investigated as possible successors for silicon. It is believed that the Moore's law will have a larger longevity than ever anticipated, but silicon's dominance may end in around twenty years.

Communication

The communication technology has been growing at a pace faster than that seen in the performance of microprocessors. The communication bandwidth has, in fact, been doubling every year. Starting from telegraphy to modern day fiber optic based Dense Wave Length Division Multiplexing (DWDM), the communication technology has been exponentially increasing in both reach and richness[7].

Since the information network infrastructure is expensive and consumes large amount of time to deploy, world over, the research and development efforts have been directed towards improving the bandwidth over existing media that were laid for voice telephony and television. These include the telephone, fiber optic and TV cables, VSATs and wireless.

The greatest bottleneck in communication over optical fiber is the need to convert the signals from electronics to optical for transmission and back to electronic for regeneration, packet routing and processing. While the electronics of today is sufficient for packet routing at the speeds of communication, the tremendous growth in the data traffic predicted over the next five years will push electronic to the fundamental limits. This has also spearheaded an acceleration in research in optoelectronics. Todays DWDM systems offer 40 gigabits per second transmission per wavelength and support multiple wavelengths on a single fiber. This is expected to increase to 250 gigabits per second per wavelength. Hence the future need is for terrabit transmission and routing. Current routers use electronic integrated circuits using silicon or GaAs or InP transistors. The fastest InP transistor has only been demonstrated to work at 176 GHz (ref. 8) in the laboratory, a far cry from terrabit operations needed for the future communication systems. The research and development efforts towards building an all optical switching is highly promising.

The first efforts in optoelectronics has focussed on all optical amplifiers and semiconductor optical amplifiers that replaced the need for conversion to electronics for regeneration, thus resulting in operational long haul transports. The next breakthrough came in the form of optical switches including those based on MEMS, that route traffic at the wavelength level without the ability to route at the packet level and also the Raman Amplifiers that amplify over a broad band. Optoelectronics is at the same stage as where electronics was fifteen years back. If the present trend in optoelectronic research continues, it would be soon possible to switch and route data at terrabits rate with all optical switches. The possible candidates include the Terrahertz Optical Assymetric Demultiplexer (TOAD), Ultrafast Nonlinear Interferometer (UNI), Nonlinear Waveguide Switch (NLWG), Nonlinear Optical Loop Mirror (NOLM) and MEMS[9–11].

While the research on fiber optics has been focussing on obtaining ever-increasing bandwidth through the fiber, without the need for replicating costly infrastructure, similar trends have been noticed in increasing bandwidth through the copper cables and wireless networks.

The trend that is seen is that the future network will be a combination of terrbit capable for transport through optical fibers for inter-city long haul point to point traffic, copper cables at gigabit speeds for the corporate and intra-city in a connectionless environment with multicasting and wireless for connectivity within the homes and in the metro at several megabit data rates for short range point-to-point and broadcast. The access end for the user would support multimedia communication and would span applications ranging from entertainment, information access, communication and commerce. When the network becomes faster and faster, the trend would be for mobile access to information than moving with the information.

Convergence

Seen together, the advances in computers and communications have ensured the death of time and distance, making information available at any time and at any place. The Internet may become the only medium of communication in the future. The voice and data would merge soon and the data traffic world over would exceed in the year 2005, the voice traffic. Traditional voice may be carried as Internet packets instead of the analog data. The only thing that will remain is the democratization of access so that the information is available to anyone regardless of language, colour, caste or creed.

Content

While it is well known that the computer and communication powers grow exponentially, it is less known that the storage capacity increases exponentially at rates even faster than all of these. In fact, storage capacity doubles every nine months and the cost of storage plummets much faster than the drop in the cost of computing and bandwidth. This has even made it possible for one to imagine wild possibilities of storing all the human knowledge and not just the human genome in digital form accessible by all human beings with any time, any place and any one paradigm. The last one contributes to democratization of knowledge and if it succeeds would lead to one race human village.

Ancient civilizations like those found in many Third World countries used the 'word of mouth' to disseminate their knowledge. When the paper and printing technologies were introduced as part of the industrial revolution, many nations did not adapt well to this change and in fact lost most of their precious knowledge. A similar threat is seen in the horizon when the world turns digital. The advances in scanning technology and the Optical Character Recognizers (OCR) have enabled most advanced civilizations to digitize, store, process and disseminate the entire knowledge of their civilization. However, for many countries in Third World, this is still a distant dream since the OCR in their language is still not available.

Software

A major part of the functionality of the computer and communication technologies will be vitalized by the software and it will form a very significant part of the cost of total ICT solution. This in fact gives ample opportunity for the Third World to capitalize on the ICT trends. While the computers have grown from simple bimedic or monomedic devices that understood only characters and numbers to Graphical User Interface based ones to totally multi media and virtual reality engines, the software has also kept pace with it. Starting from the era of scientific computation and simple data processing chores, it has matured, traversed the path of expert systems to that of emulating human performance to hear, talk and think and the very futuristic software that will give superhuman powers to the computer. This is depicted in Figure 3. The vital role that software innovation will play in the future will be the basis of our knowledge society. The software will enable the computer to grow from raw number crunching device with poor knowledge content to a device that is superhuman in every aspect of qualitative and quantitative computing and perception[12].

The future

The PC that we know today may be dominantly used for software development than for information access and processing and may be found only in places like the Software Development Houses and a few educational institutions. The PC with large Plasma Display Systems would be used in shopping malls and houses for display and infotainments. The largest use of the PC in its changed avatar would be for information access and would be done through tethered and untethered mobile gadgets that will have adequate processing power to present information through a natural information interface-voice and video like the Simputer (http://www.simputer.org). The two extreme ends of the PC spectrum that will dominate are the handheld PCs and the home computer which would double as an entertainment centre. The obsolescence rate of these would be of the order of three years. On an average an individual will have access to and continuously use around 300 gigabytes of information. The moderate compute power of the mobile access and communication devices would shift the computing loads to the network and it will see the reemergence of 'data centres' of the past through Application Service Providers (ASP).

The PC sales across the world is tending to saturate, just like the sale of cars, TV and telephones. The smart devices revolution is already on – world over and in particular in countries like China and Japan, there are

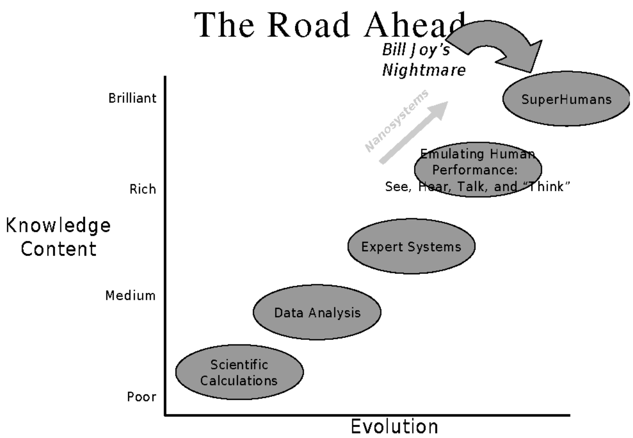

Figure 3. The software evolution[12].

already more mobiles phones than PCs. In India, the annual sale of PC's crossed the 1 million mark recently. The PC sale may saturate in India at around 2 million in a few years.

The PC and tethered and untethered telephone systems would increase across many countries even without a coordinated action plan, because of their low cost of ownership. But, connectivity across the country, without which the full potential of a knowledge society cannot be realized, requires well planned infrastructure development. Careful planning and policy development are required since these infrastructures are expensive. This is in spite of the famous belief that the cost of bandwidth will be so low that it will be available freely – a commodity that is too cheap to monitor.

The only major hurdle in many TWC now for them to spring into the digital world is the connectivity. Currently the Internet users are predominantly located in the developed world and the Third World has a very minor presence on the Internet. Thus, the lack of connectivity is likely to be the single most hurdle in making the e-commerce and other internet applications grow in tune with the exponential growth in the developed countries. In fact, it is more likely that initially business-to-business secure commerce transactions would be the ones that will emerge in many Third World countries, leaving B2C behind.

It is believed that good connectivity will provide easy, guaranteed and secure access to the network and this would accelerate the development of applications for distance learning including the 3L's of learning – the Library, Laboratory and the Lectures all in the digital form, entertainment, e-commerce, health care and agriculture – all the necessary ingredients of the modern digital society. The lack of connectivity in a country, often heralds the beginning of the digital divide.

The ICT world market and the new opportunities

It is indeed useful to look at the commercial aspects of ICT. Global spending on information and communication technologies is projected to grow from 2.2 trillion dollars in 1999 to 3 trillion dollars in 2003. The e-commerce in the business to consumer sector is expected to grow from 25 billion dollars in 1999 to 233 billion dollars by 2004 while the business to business e-commerce is expected to lie in the range of 1.2 trillion dollars to 10 trillion dollars by 2003 (ref. 13).

We could also arrive at this estimate from a different angle. It is most likely that the future cell phone would cost around US$ 100 and a home PC around $ 500. Assuming that around billion people own these two devices and equal investments each in the hardware needs of the institutions and the network equipments and infrastructure, it is easy to see that the ICT hardware market alone would be nearly 3 trillion dollars. The above estimate of the cost of PC's is not in tune with Machrone's Law which states that the machine that you want always costs $5000.

With the plummeting hardware costs and increased quantum of software in a total solution, it is envisaged that a major portion of the ICT market would also be software centric. This has lead many pundits to brand the next decade as the software decade.

Third World countries could capitalize on the software centric advances and this could open up bigger avenues than ever before to increase their GDP. The Third World countries could find a larger market place for their products, become a cost effective destination for many business process outsourcing, value chain integration and software development. India has shown that with reasonable investments on infrastructure and manpower training and proper policy management, it could increase the software exports from 150 million dollars in 1990 to 4 billion dollars in 1999. Its projected goal is to enhance the software exports to 50 billion dollars by 2008, which would be 30% of its exports and 7.5% of its GDP. India and many other countries have also witnessed another face of the application of the advantages of ICT. The use of internet connectivity to rural villages allowing critical meteorological, health, crop and market information to be accessed and shared, has yielded very successful and encouraging results in many parts of the country and are waiting to be scaled to encompass larger parts of the country. India's efforts in applying ICT to e-governance, judiciary, police and law enforcement, banking and finance and distance education have also resulted in reducing the cost of transactions, while improving the efficiency and transparency of operations. While India's achievements are stupendous, many other Third World countries have also started to benefit from ICT through their applications in the betterment of life of their citizens and in creating economic centers that capitalize on the service and software development needs of the developed countries.

In the midst of these unprecedented opportunities for the Third World countries to improve their GDP through ICT, there is a lurking fear that the uneven diffusion of ICT would remit in a *Digital divide* that is likely to be far larger, deeper and wider than the other technology driven divides that the world has witnessed so far.

Even before the beginning of the digital era, there has been divide between the rich and the poor nations. Earlier inventions such as electricity, telephone, agricultural implements, automobiles and modern manufacturing machinery have all been subject to stagnating diffusion in the Third World countries due to their staggering costs, lack of infrastructure and skilled manpower. Their uninhibited growth in the developed nations has been the cause of widening divide in the last century. The ICT growth rate is stunning and far faster than all those witnessed earlier. This would infact, if not properly understood, create the wide in a compressed time frame with no time or avenue to take corrective measures.

For the developed nations, reaching out to the Third World countries is a very strong necessity without which even the developed nations cannot see the benefits of ICT fully. In order to make an economic sense, there is an urgent need for the developed nations to have unhindered access to the market place of the Third World. The growth of ICT, is dependant on the availability of top quality technology professionals. Even after rearranging its manpower away from the outsourced service sector to work more in the knowledge and innovation levels, USA, Japan and Europe find that the shortage of top technology professionals too large to depend totally on indigenous sources. This has even prompted the United States to approve a legislation allowing 1,95,000 more work visas each year for the skilled professionals. Almost 40% of these are from India while a major part of the rest are from other Third World countries. Similar exercises have also been done by Germany and Japan. Creation of several off-shore research laboratories in the countries like India and China is another avenue explored by the developed nations to utilize the vast talent pool in developing countries[13].

Identifying the digital divide and taking measures to smoothen them are tasks that daunt equally the developed and developing nations. It is now very clear that a world with a deep digital divide would be unstable and if the divide continues unabated, it would reach an 'yield point'.

Digital divide

Digital divide refers to a substantial asymmetry between two or more populations in the distribution and effective use of information and communication resources. It is probably one of the most widely studied topics in the recent times and the world wide web is full of documents dealing with various perceptions of the digital divide and remedies. The digital divide is a measure of the various differences among and within countries. The indicator of the digital readiness is often measured by the available communication infrastructure, telephone and computer penetration, the internet hosts and internet access and the number of secure servers for e-commerce. Beside, the digital readiness is also felicitated by governmental policies that promote globalization of ICT, permit improved access to the local market, uncontrolled telephone and internet access and promulgation of laws that foster digital signatures and e-commerce and protect digital property right and individual privacy.

The cost of going 'on line' today is of the order of US$ 1000. In a world where more than 2.8 billion people have income levels below 2$ a day, a major part of them in the Third World countries, it is unlikely that the purported knowledge society would become global in the true sense of the word. Further, there is also a content divide that results from the dominance of western and, English-based information of relevance to the elite netizens on the web. This makes the web not only unaffordable to a larger part of the Third World but also unusable. The ICT can only benefit those who can afford it, thus causing a further divide between information haves and information have-nots.

Digital divide in a developed country

Even in a developed country like the United States, the web has created a digital divide within the country. Today the web in the US is dominated by white males, under 35 years old, college educated, in the high income group and English speaking.

In spite of a commendable exercise towards digital inclusion, it is reported that in US, while 41% of the households nationally have Internet access, it is only 23.5% for the Black and 23.6% for the Hispanic households. Between December 1998 and August 2000, the gap has widened by 3% in the case of Blacks and 4% in the case of Hispanics. Even with respect to individuals, while 44.2% of the US population uses the Internet at home, only 16.1% of the Hispanics and 18.9% of the Blacks use the Internet at home. However, US has been very successful in marginalizing the gender divide and also the rural and urban divide to great extent due to its well planned infrastructure deployment. The United States has 116.5 million users online at some location. This will be an order of magnitude larger than the number of online users in the entire Third World. Large average levels of penetration of nearly one third of population and a marginal divide by a factor two between Blacks, Hispanics on the one side and Asians and white Americans on the other are typical of the most developed countries. Such divides are also driven predominantly by the educational background of the different ethnic groups. Statistics for the other developed countries show a similar trend of a deep penetration and a moderate divide. Such divides can be called the digital differences and could be smoothened or arrested from further widening by proper planning and proactive policies.

Digital divide in a Third World country – India

It is seen from the Table 1 that the internet connection per thousand people in the states of Orissa and Uttar Pradesh is 0.12 as compared to 8.21 in Maharashtra – a

Table 1. The digital divide within India

Indian state/territory	Access to electricity (percentage of households) 1994	Telephones (per 1000 people) 1999	Internet connections (per 1000 people) 1999
Maharashtra	59.7	43	8.21
Punjab	83.5	47	1.24
Kerala	61.1	43	0.87
Karnataka	63	29	2.73
West Bengal	15.6	16	2.51
Orissa	18.8	9	0.12
Uttar Pradesh	20.1	10	0.12

Table 2. The telephone penetration in the continents[18]

Continents	Internet hosts (per 10 K)	Internet users (per 10 K population)	No. of PCs (per 100 population)	No. of telephones (per 100 population)
Africa	2.75	52.56	0.94	2.49
America	1029.23	1504.49	24.26	35.19
Asia	19.48	324.5	2.88	9.79
Europe	157.01	1264.32	19.81	39.31
Oceania	647.4	2539.69	42.14	40.52

factor of nearly 68. The telephone penetration rate is more than four times in Maharashtra than in Orissa.

The situation in China is also similar. The divide exists between urban/rural as well as coastal/interior regions of China. The information revolution has come mainly to the eastern part of China to places like Beijing, Shanghai, Guangzhou and Shenzen Special Economic Zone where the science and technology and the economic progress have been well established. In China, the netizens in Beijing account for 12.39% of the national total and in Shanghai 8.98%. While the Internet has barely touched Tibet (0.0%) and Qinghai province (0.31%) with only 0.3% of the netizens living in the country side, the urban network dissemination ratio is 740 times that of the rural areas.

In many of the Third World countries, the gap within is far larger than what is seen in India, which in itself is fairly large. This in essence shows that the digital divide in Third World countries is far wider and is in fact increasing to reach alarming proportions.

Digital divide between continents and between countries

The telephone penetration, the cheapest and the most useful of ICT, the numbers of PC's, the number of Internet users and hosts are presented in Table 2.

It is seen Asia and Africa are nearly 2 and 15 times less connected than the rest of the world. This is in itself not surprising. What is more surprising is the fact that the disparity within the countries in Asia and Africa compared to their continental average is very large indicating much larger digital divide within.

The approach to closing the gap in Third World

Not withstanding the enormous opportunities for the Third World to benefit from the ICT revolution, one of the greatest dangers in the promotion of ICT is that the Third World countries would be lured too quickly into purchasing of expensive, sophisticated and rapidly obsoleting technology that they can neither afford nor sustain, in the hope that improving infrastructure and providing computers, telephone and Internet to all would automatically boost their economic performance and solve all their problems. It is important that the Third World invests in a commensurate way in developing highly skilled manpower who can assimilate and further innovate in ICT.

For example, the telephone penetration in India is around 3.2% while it is only 0.4% in rural areas. The government's plan is to increase the penetration nationally to around 10% by 2005 and to 18% by 2010.This would require investments to the tune of $35 billion till 2005 and $75 billion till 2010. If adequate top quality professional manpower is not generated, these infrastructure could not be sustained nor would it result in any tangible outcome. In order to effectively use these infrastructure and contribute contents that are localized and relevant appropriate investments, at least half of the 70 billion dollars must be invested in training top quality scientists and engineers.

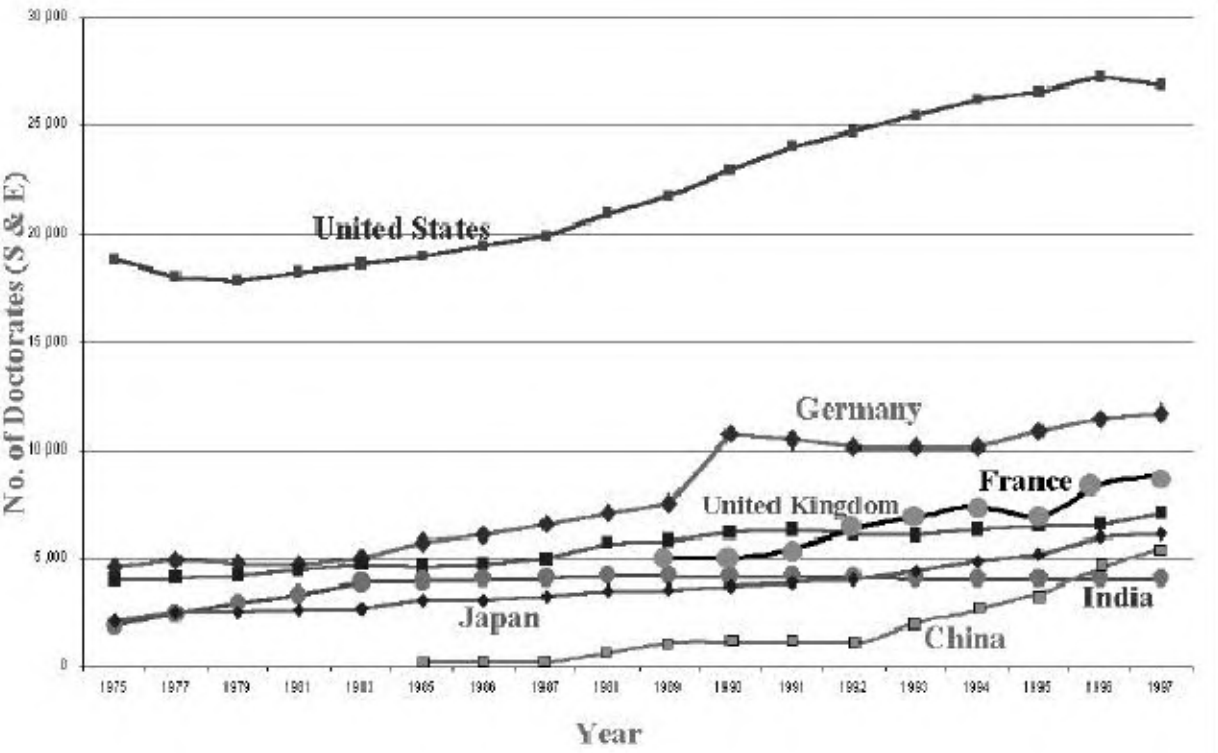

Figure 4. Number of doctorates produced in a few typical countries[19].

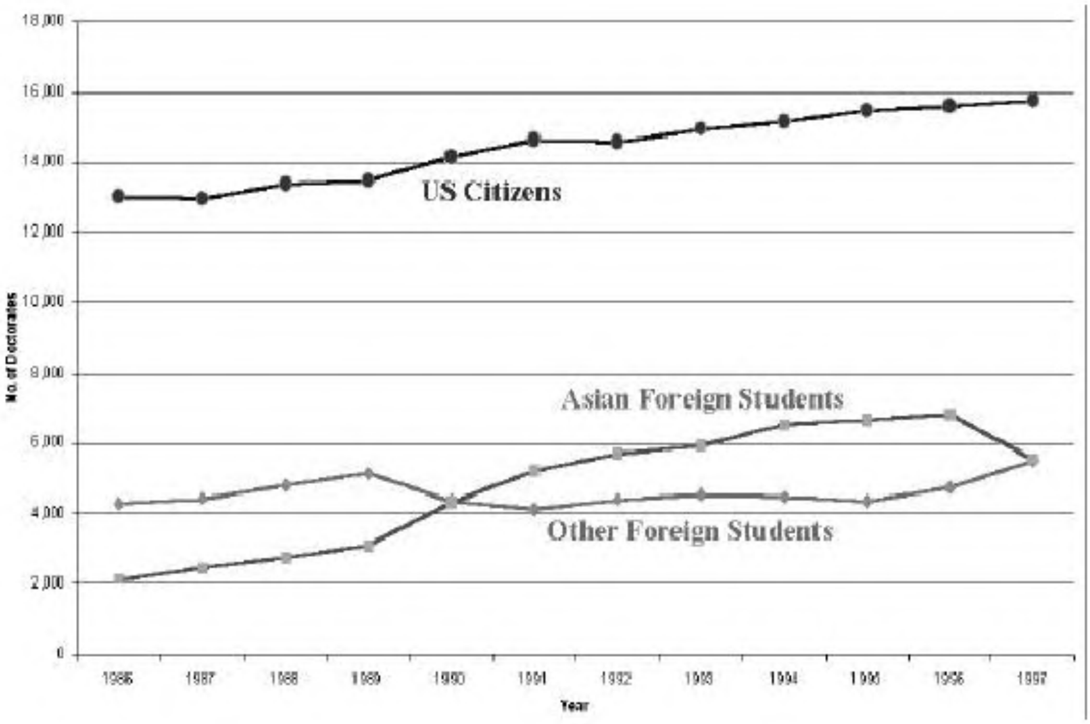

Figure 5. US doctoral degrees in S&E earned by US and foreign students[19].

The digital revolution in the developed countries has been possible due to their sustained investments in education and research. The OECD countries with 14% of world's population accounted for 86% of the 8,36,000 patent applications filed in 1998, and 85% of 4,37,000 scientific and technical publications published worldwide. These countries invest an average of 24% of their GDP in research and development compared with the

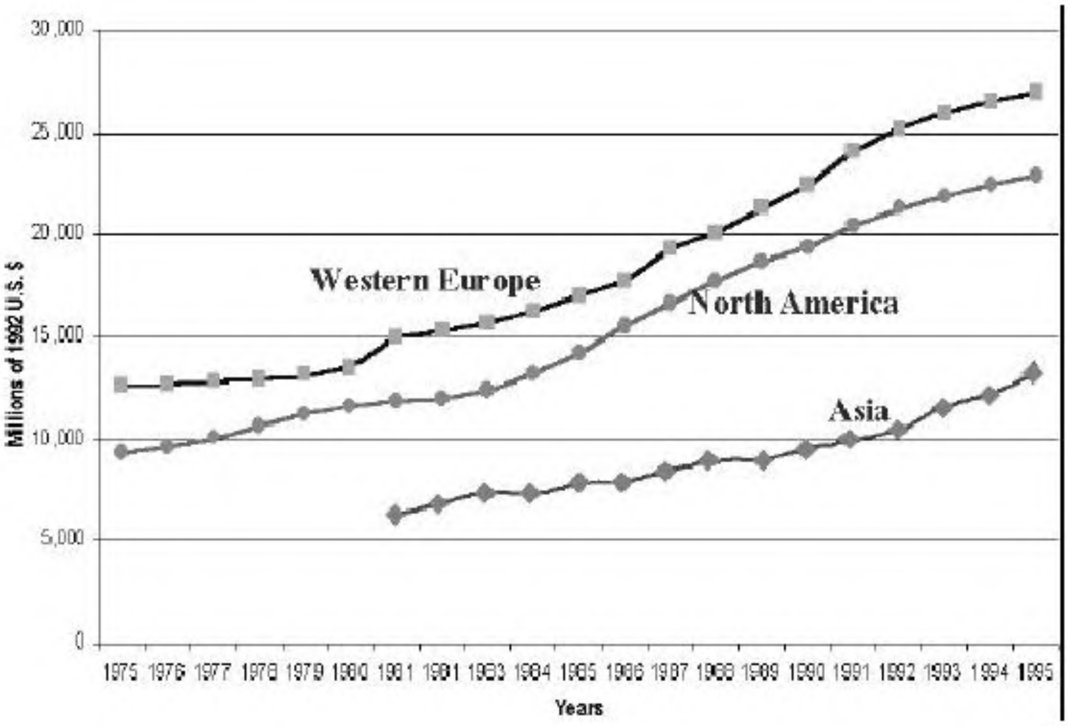

Figure 6. R&D investments in universities.

0.6% average in South Asia and much lower figure for the entire Third World. Patents and publications are indicators of the intangible assets of the corporates and are often strongly correlated to the Ph D's produced by a nation. The fact that the education level, the income, the internet access and hence the digital dominance are strongly correlated is not accidental but an indicator of that primary ingredient for the explosive growth in the education level of the population and this drives innovation, creates wealth and infrastructure which further combine in a non linear way and lead to knowledge and wealth explosion[16,17].

The number of doctoral degrees in Science and Engineering in a few selected countries is presented in Figure 4. The United States that leads the digital dominance is also the largest producer of Ph D's, closely followed by other developed countries in Europe and the Asian leaders like Japan, China, Korea, India and others. What is shown in Figure 4 are absolute numbers. The per capita production of Ph D's would show even wider gaps between the United States and India and China. What is noteworthy is that while the Ph D's produced by India has stabilized around 4000, China has overtaken India and shows continuing upward trend – a point that would put China ahead of many countries in the knowledge economy.

The systematic planning of China in capacity building and that of Korea through collaboration with the United States is worthy of emulation by many of the Third World countries including India. China expanded the number of graduates produced within Chinese universities and within US universities has more than made up for the initial dormancy that it had in the pre-liberalization era.

The United States has been a major outside source of training for the Asian Ph D's as seen in Figure 5. However, the Third World has not taken any major advantage of this as much as India and China. The impact of the Indian and Chinese diaspora on the ICT and their assimilation in their parent country has been distinct and effective. India and China could capitalize on the avenues of training in US since their basic education systems are sound. This may not be the case with many Third World countries. A major attempt must be made within the Third World to invest heavily in college and university education at levels comparable to the investments in ICT for them to close the digital divide.

The digital divide has also been reflected in the continued R&D expenditure made by the United States, Europe and Asia. It is seen from Figure 6, that in 1995 the Western Europe and North America invested around 20 billion dollars annually in R&D in the universities as compared to around 10 billion dollars by Asia. The copyright laws in the developed countries have been tailored to protect the innovator and reward and encourage private investors. This has lead to the major part of the R&D investments coming also from the private sector.

The Third World countries could invest in collective research and development avoiding duplication and capitalizing on the fact that research and development are effective only through collaboration. The latter fact is vindicated by the success of the European Union in many major initiatives including aerospace and ICT.

The Third World countries could collaborate in using ICT to create a firm base of educated and skilled manpower. ICT can be very effective in reducing the cost of education. The Third World could start with sharing of published and bibliographic material and create its own digital library like the 'Universal Digital Library' (www.ulib.org). It could then frame standardized curricula for distance learning through the web. The content creation efforts for distance learning could be shared amongst the Third World. It could also attempt to use the web to conduct quality research using shared laboratories and library. This would automatically fuel the need for STARTAP like connectivity between and within the Third World countries.

In brief, the Third World countries while planning to invest in enhancing their basic infrastructure for communications and content development, should plan also to invest equally in developing its basic and higher education to produce a top quality manpower base and in creating a framework for high end collaborative research amongst the Third World. This will enable the ICT advantages to result in their economic prosperity and smoothen the digital divide.

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