*DESIDOC Bulletin of Information Technology*, Vol. 20, Nos. 1&2, January & March 2000, pp. 21-28


# Information Technology—A Force Multiplier Extraordinary

**Dr MS Vijayaraghavan**
*Technology Interface, Secretariate of Scientific Adviser to Raksha Mantri*

## ABSTRACT

The paper highlights the role played by information technology (IT) in civil and military domains in equal measures to place IT in the category of force multiplier par excellence. It describes the various elements that constitute IT, i.e., sensors (for generating data), storage media (for preserving the data for further analysis), and data processing and dissemination of information using various technologies like advanced semiconductors, advanced high-end computers, fibre-optics, photonics, cellular technology, satellite technology, advanced networking, digital transmission and digital compression, etc. It gives an insight into the immense potential IT has as a force multiplier in the battlefield as much as it dominates the social, cultural and economic fabric of a nation.

## 1. INTRODUCTION

The call given by the leaders of our freedom movement in the early part of this century to get political independence from foreign rule, had a widespread impact on the population. People from every walk of life—be it education, judiciary, industry, print media, science and technology, trade and commerce, medicine and politics—responded in full strength to this call. The result was the birth of best of talents of the world standard springing all over in the country in every field of human activity.

The driving force was the motivation to prove to the world that Indians are second to none and therefore, they can manage their affairs without any foreign powers providing governance. Such was the impact of this call that it had a cascading effect on every facet of human life.

## 2. FORCE MULTIPLIER—AN AGENT OF CHANGE

It appears that the term force multiplier originated in defence with a well-defined objective. According to TN Dupuy, it is an item, collection of items or characteristics (such as morale or training) that makes an organisation or ensemble more effective, efficient and capable in combat or in similar situations, through synergy. While no authoritative list of force multipliers exists, the experts frequently refer to non-military variables, such as leadership, morale, motivation, etc. Therefore, ability of an initiative to bring in torrential changes on its introduction into a system, could also be referred to as force multiplier.

From this perspective, the call for freedom from foreign rule kindled the latent patriotic fervor in the people and provided the needed motivation to have the effect of a force multiplier.

Nothing has impacted a system—be it political, social or scientific—as much as the technology to bring in a cataclysmic change.

During the last one decade and a half the world history has witnessed the gargantuan role played by information technology (IT) in civil and military domains in equal measures to place IT in the category of force multiplier par excellence.

## 3. ELEMENTS OF INFORMATION TECHNOLOGY

To understand the far-reaching implications of introduction of a force multiplier such as IT, it would be helpful to know various elements that constitute IT. Four distinct elements together represent IT. The first of these is the Sensors whose role is to generate data in electronic form from perceivable objects. In view of diverse objects, there are multiple sensors. These could be electromechanical, electro-magnetic, electrooptical, electro- chemical, electrothermal etc., depending on the application. Likewise, these sensors are located on the ground in moving or stationary platforms, in air, in space, on sea or underwater.

The next element is storage media. The data received from these manifold sensors is required to be preserved for further analysis. Data storage devices come in a variety of forms. From conventional magnetic disc and tape to semiconductor devices and optical disc in numerous variations, there is a plethora of these devices to choose from, depending on the need and application. Further, these devices come with different storage capacities, access times and shapes to suit specific deployment needs.

Data processing is another element of IT which is extremely crucial. The data received from one or many of these sensors and stored in one or many storage devices, requires to be converted into useful and actionable Information at the end of the value-addition chain. This function of data processing again requires multiple tools, foremost amongst which is computer. From laptop to supercomputers, there are a variety of these equipment catering to a wide spectrum of data processing functions.

The ultimate value addition in the Information chain comes from the capability to disseminate acquired information to the point of use at a remote location. The medium for such a transfer of information from the source to the utility point constitutes the fourth element of IT. This has been possible due to convergence of communications and computers. The field of telecommunication is too well known to attempt any description. However, it must be said that there are four areas of telecommunication which are crucial for its development. These are: transmission, reception, distribution, and communication control. Transmission, reception and distribution ensure transfer of information from one point to another, and networking thereafter, to reach the actual user to meet his needs. The safety of information at the point of generation, reception, during transit and its denial to those not authorised to receive, are addressed by way of communication control.

## 4. TECHNOLOGIES OF INFORMATION REVOLUTION

Late 1980s witnessed the dawn of yet another revolution–the information revolution. While the defence spending by nations played a significant role in bringing about this new revolution, private companies and individual entrepreneurs were also a driving force behind many emerging technologies. Many analysts predicted that the effects of this new revolution would dwarf those that had come earlier. Indeed, it was at this point in history when many analysts began to describe the rapidly approaching 21$^{st}$ century as the information age.

Many technologies are part of the contemporary information revolution. Among these, nine stand out as unique. These are: (i) advanced semiconductors, (ii) advanced high-end computers, (iii) fiber-optics, (iv) photonics, (v) cellular technology, (vi) satellite technology, (vii) advanced networking, (viii) improved human-computer interaction, and (ix) digital transmission and compression.

Semiconductors are arguably the technology that has contributed the most to our current ability to store, process and communicate information. With the invention of semiconductors, the rate of advance in a host of computing capabilities (including expanded memory, faster speed, improved reliability and overall performance) increased dramatically, often approaching exponential growth. Further, semiconductor technology explosively increased information storage capacity in a memory chip as well as functional density

achievable on a silicon semiconductor chip. According to Gordon Moore, the co-founder of Intel, the logic density of silicon integrated circuits has closely followed the curve (bits per square inch) = 2 ^($t$ - 1962) where $t$ is the time in years. That is, the amount of information storable on a given amount of silicon has roughly doubled every year since the technology was invented. These advances have simultaneously resulted in decline in the cost of semiconductor chips to one-hundredth of its original value in just about a decade.

Enabled through improved and cheaper microchips and propelled by ever-increasing functionality of these chips, today's computers—the backbone of the modern information revolution—coming under the category of supercomputers, can not only perform computing at one trillion mathematical operations per second, but are also available at prices unimaginable only a few years ago. These advances in computers have helped permit messages, data and information to be transferred globally in fraction of a second. With computers also becoming lighter, compact and cheaper, IT has become truly ubiquitous with far-reaching impact.

Extremely thin glass fibers carry light pulses from the sending source to the receiving destination. These fiber-optics cables can carry information 1,00,000 times more than conventional copper pairs, to enable build information superhighway which would be unthinkable using existing telephone infrastructure. This explosion of bandwidth, as a consequence of introduction of fiber-optics technology, has resulted in increased capacity to transmit information.

To fully harness the potentials unfolded by fiber-optics, the end devices and systems must be small and compatible with high speeds provided by fiber- optics. Here, the photonics technology plays a significant role. The photonic devices, such as light emitting diodes (LEDs), blue lasers, laser diodes, miniature optical components etc. that have been developed and are available in the market, have been singularly responsible for propelling fiber-optic technology to levels of use that one sees presently. The future would only see better, efficient and cheaper photonic devices to push IT even further.

Until recently, the locations from where one could transmit and receive messages were tied to technology that could be transported only with difficulty. The advent of cellular technology is rapidly cutting through the knot that tied telephones to wires, limiting the flexibility of communications. In essence, cellular telephones are mobile radio transmitters and receivers that look and act like traditional telephones using radio waves to send and receive messages from remote non-wired locations. The shrinking size of these cellular phones coupled with portable computers and modems, allow people to exchange information to and from virtually anywhere in the world in real time.

Another technology that has revolutionised the quality of life is satellite technology. Theoretically, a global satellite communication network could employ as few as three satellites, but in fact, many satellites make up the present-day satellite communication network, both in geo-synchronous and elliptical orbits. With rapid developments in communication technologies, modern communication satellites allow for both store-and-forward and direct broadcast services. In a direct broadcast satellite, often employed by commercial broadcasters, the information from the broadcast site is sent to the satellite to be redirected to the point of use anywhere in the world. The store-and-forward satellite allows information sent to it to be stored before transmitting the information to authorised recipients. This type of satellite is often used by governments who have sensitive data to protect from unauthorised recipients. As the marriage of computers, digital and cellular technologies with satellite communication takes place, a global seamless information infrastructure that will significantly enhance the value of the connectivity, is provided. This enables satellite technology to tie the world more closely together than ever before to truly realise a global village.

The technological pursuit to enhance connectivity by scientists and engineers throughout the world, has resulted in

capabilities that enable various elements of IT to communicate with each other and to enhance the speed at which these communications take place. The effort to progress the reach, variety, utility and penetration of IT resulted in local area, metropolitan area and wide area networks (LAN, MAN and WAN) which finally led to the birth of the network of networks—Internet. Though originally developed for military use, Internet heralds the advent of cooperative effort by the world scientific community to build mother of all networks. Despite the network providing for bandwidth as large as few tens of gigabits per second, the reach, spread and utility of Internet is already threatening to clog the superhighway to the extent of mounting development efforts for next generation Internet.

While computers no doubt perform a variety of complex functions at speeds beyond human capabilities, it is the human-computer interface technologies that are responsible to open the world of computing to millions of people who avoided computers because of real and imagined barriers associated with the user interface. Development of better operating systems and software, such as Macintosh OS and Windows has reduced the level of this fear. Today, interface systems and softwares that utilise voice recognition and handwriting identification are available, thanks to technologies such as neural net. These advances, in turn, make more people to exchange, manage, manipulate and use information.

Finally, the *coup the grace* to information proliferation is given by the type of transmission used in the transfer of voice, data, graphic, or picture. The advent of digital compression technology has facilitated faster, better and efficient means of information transfer. Digital signals in binary digits are accurate and form the language of computers. Using mathematical approach, digital compression makes possible immense data files to be drastically reduced in size, and thereby increasing the amount of information that can be sent over a line at high speeds. Furthermore, the integration of voice, text and video through Integrated Services Digital Network (ISDN)—possible mainly due to digital compression technologies—has made the traditional concepts of time and distance irrelevant.

## 5. IT—AN ENGINE FOR SOCIO-ECONOMIC DEVELOPMENT

From the preceding sections, it can be easily inferred that IT heralds the death of time and distance. While transportation technology led to shrinking of physical distances by orders of magnitude, telecommunication technology made terrestrial distances irrelevant. Thus, IT brought about revolutionary changes rivalling those of industrial revolution to culminate in bringing radical changes to physical, social and economic infrastructure of a nation. The world has thus started beginning to feel the power and potential of IT in every aspect of human activity. This telling impact of IT on the socio-economic development of the country leaves little doubt on the role of IT as the *numero uno* force multiplier that can metamorphize the nation and galvanise all its activities towards wealth generation.

Economic development of a nation takes place due to a number of factors. High industrial growth, high productivity in industry and agriculture, increased trade and commerce, better population control, better heath care and sanitation, efficient and effective transportation, reliable and effective communication and mass media, high growth rate for science and technology, and above all, the spread of quality education all contribute significantly to economic growth and therefore national development.

Information technology has changed the way most companies do business. Innovations in IT are having such wide-ranging effects across numerous domains of society that the policy makers are acting on issues involving economic productivity, intellectual property rights, privacy protection and affordability of access to information, among other concerns. IT is being used by industries for many purposes, both operational (e.g., accounting, logistics, scheduling etc.) and strategic (changing competitive positioning or providing totally new services). IT has radically changed services,

both in service-sector industries and in-service activities that are integral part of goods-producing industries. The service industries are primarily transportation, communications, wholesale and retail trade, financial services, insurance, real estate, utilities, personal and professional services.

Telecommunication has been literally built on IT and is now pervaded by IT. The use of IT can bring about changes in the boundaries and definition of an industry. Deregulation and new technologies have allowed new players to provide services that were once the exclusive domain of traditional telephone carriers. Today, private carriers and value-added carriers handle voice and data long-distance traffic for paying customers. IT has been used to alter existing relationships among wholesalers, retailers, manufacturers and end users. For example, to eliminate intermediaries and enable direct sale, a manufacturer can directly go on net to perform retailer function towards spawning a new business model. Thus, inventory-based model of doing business has been replaced by an information-based model. Different industries are moving into areas untreaded by them before. For example, insurance companies are moving ever deeper into the business of healthcare management and the lines between the two are already getting blurred. Likewise, different industries are moving into banking, thus threatening the traditional understanding of what constitutes the banking system, primarily due to opportunities unleashed by IT. For example, banks will have to develop relationship with software developers or risk the probability that software developers and other non-financial institutions will come between banks and their customers.

In airlines, business innovations using IT have been associated with competitive leadership and survival as complexity has increased. Airlines depend on IT within aircraft and airports, in air traffic control systems, and for sales, marketing, maintenance and safety systems as well as for capacity, load management and logistic planning. IT has engulfed this industry to such an extent that this technology has been a part of the transformation of the industry into one of the largest retailers of perishable goods. Likewise, news content will not remain the exclusive domain of traditional news organisations. Medical informatics is a growing area that deals with the convergence of information and medical technologies. Application of IT to bring medical advice and services directly to the place a patient is located, without doctor physically having to move to the place of the patient, is the realm of telemedicine. Today, like teleconference, operations are conducted on patients under the direct supervision of experts who are physically thousands of kilometers away from the patient, thanks to Internet and several opportunities let loose by IT. These advances are bound to enhance healthcare to levels never realised before. Universities play important role in today's society in providing education. As space and time are overcome by the introduction of IT, distance education or learning will get the much needed philip to provide alternative configuration to traditional universities. Concepts such as global university, virtual library and virtual classrooms are becoming realities today.

IT may well create entirely new sectors for business that will encompass a variety of new and different industries. As IT becomes less expensive, more portable, better integrated and interconnected and embedded in a wide variety of devices offering many types of messages, new applications in these fields and whole new industries—such as interactive multimedia systems for business, home entertainment and communication purposes—are likely to evolve. This would have profound effect on industry structures, employment and economic growth.

Introduction of IT has influenced strategy, altered structures, reshaped communication and learning as well as organisational design. Thus, the role of this technology has shifted from one of operational gain to one of strategic benefit. Investment in IT is often seen as instrumental in sustaining and achieving competitive advantage, and therefore is considered fundamental to enable organisations achieve their strategic business objectives and goals. The emphasis now is especially in terms of productivity due to removing employees

repetitive, time-consuming practices and replacing them with work of a more supervisory nature.

New ways of creating, storing and transmitting information are transforming cultural practices besides changing rules of business. Availability of plethora of information sources coupled with rapid information flow brings in enhanced flexibility to increase tempo of interaction and decrease location-dependence of information. These advances in IT would have far-reaching and unforeseen effects on families, communities, institutions and democratic processes.

The social consequences of these technologies have to be understood by government, academic and corporates through studying the socio-technical systems, media and social science of computing. Impact of IT on the way the affairs of government are conducted, is significant. By its very nature of democratising information through improved access, the technology strengthens the democratic underpinnings of popularly elected governments.

The greater capacity for information transfer across the globe leads to greatly enhanced picture of oneself, the global environment and partners. It would therefore be difficult to control freedom of speech and free expression as IT expands our capabilities to hear and be heard, to see and be seen and eventually, to touch and be touched. This would enable governments to perform better by providing non-governmental organisations and groups, the ability to compete against governments in presenting their viewpoints and perspectives.

Thus across the wide spectrum of socio-economic activities discussed here, IT has the effect of a force multiplier element to significantly alter human activities, life-styles, actions as well as organisational structures and practices.

## 6. IT REVOLUTIONISES MILITARY TECHNOLOGIES

Beyond their impact on socio-economic development leading to wealth generation, information and communication technologies have equal and radical impact on military affairs, towards protecting the wealth generated by their very introduction. Management and control of time-critical information is as much a need for the military as it is to business and commercial worlds. IT as applied to command and control—which characterises any military requirement—is used to access more information about the combat situation, process it rapidly and accurately, manage and distribute it more efficiently on near real-time basis. So much progress has been made in improving sensor devices that a flood of raw information is now becoming available that needs to be sensibly processed, merged and correlated quickly. Coupled with the need to have comprehensive and timely awareness of the situation so that strategic decision makers can determine the appropriate response and implement them, it becomes necessary to deploy a powerful IT infrastructure. This includes communication links, high-performance computing, graphic displays and networking of all elements to provide fused data in real-time for decision making. The composite architecture thus emerging out of this exercise leads to the often-referred computer command control communication and intelligence ($C^4I$) system. It is obvious that for full implementation of a $C^4I$ system, enormous amount of data transmission, processing and storage facilities would be required at each level. The computer system for $C^4I$ should have flexible and adaptable system architecture with inter-operability. Managing a large database for storage and retrieval of data is a key management tool for commanders, which is provided by efficient database management and good communication software. Advances in the field of graphics have improved the situational awareness of commanders virtually on a single screen. With geographical information system providing digitised satellite maps, coupled with advanced computer graphics, multimedia technologies reaching high maturity levels and virtual reality tools making possible three-dimensional viewing having high degree of user immersion, visualisation technologies are in place to broaden the applications, especially in the area of simulation and gaming. This would even

further propel battle awareness technologies to provide real-time brilliant decision support system to aid C⁴I systems. The future battlefield would therefore involve blending of technologies—represented by intelligence, surveillance, reconnaissance, C⁴I and precision strike—with unified strategy and operational doctrine, to gain a dominant battlefield knowledge (DBK). DBK would ensure a transparent battlefield to our armed forces and make the battlefield opaque to the adversary. Thus, it is important that we controlled information to achieve DBK. Control of information also ensures protection of economic infrastructure.

## 7. INFORMATION AS WEAPON

Information warfare (IW) is the weapon of the future as it has the range of an ICBM, speed of a high-power laser and lethality of both. IW will increasingly augment/replace conventional warfare for the reasons of low cost, high damage potential, difficulty of detection and defending against the highest threat to a country's national security, and above all, being borderless. IW is broadly divided into three types: spectrum management, proactive information strategy and reactive information strategy. One can monitor traffic and launch attacks on IT assets from any part of the globe. The rapid movement towards a networked environment coupled with the increasing role of Internet in commerce, as also the inherent vulnerabilities associated with any network in architecture, has only accentuated the need for protecting the national wealth created out of IT initiatives. As software programmes become complex, the vulnerabilities associated with them also grow. As network connectivity grows, portable programmes lead to vulnerable services which become the target of attack. In addition, the researched information capability will increasingly become a negotiating instrument between nations.

Drastic changes are taking place in military affairs that combines technological changes with operational and organisational innovation. This military doctrine, called as revolution in military affairs (RMA), is now being extensively touted by the West as the emerging art of warfare of the 21st century. This concept is brought about primarily from the intersection of precision strike, dominating manoeuvre and joint operations made possible only by profuse utilisation of IT. Precision strike will hold an enemy at a distance and blind and immobilise him by destroying operationally and strategically crucial, time-critical targets. Use of IW will deny an enemy the critical knowledge of both his own as well as our forces, and turn his *fog of war* into a wall of ignorance. Satellite technologies will enable force projection overseas to distant locations at dramatically increased speeds in response to contingencies while denying the enemy the ability to do the same.

Thus IT revolution that has swept across the world during this century is a force multiplier in the battlefield as much as it dominates the social, cultural and economic fabric of a nation. No wonder, people across the world refer this impact of IT in every facet of human activity as entry into the 'Information Age'.

## REFERENCES


1. International Military and Defence Encyclopedia Vol-II, 1993, *edited by* TN Dupuy. Brassey's U.S. Publications, p. 975.
2. Integrated Strategies, Technologies and Missions for Comprehensive National Security.

## Contributor

**Dr MS Vijayaraghavan** obtained his MSc (Materials Science) with distinction and PhD in Physics from the Indian Institute of Technology, Chennai. He was involved in the development of electronic warfare technologies, while serving at the Defence Electronics Research Laboratory, Hyderabad for almost two decades. Presently, he is the Director, Technology Interface at the Secretariat of Scientific Adviser to the *Raksha Mantri*. He is dealing with the national security issues that have a bearing on technology. He is also involved in conceptual planning and technology linkages. He has published more than 24 research papers in national and international periodicals and holds a few patents. He was awarded *Bapu Seetaram Memorial Gold Medal* instituted by the Institution of Electronics and Telecommunication Engineers (IETE) for his outstanding contribution leading to production of electronic components.