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Three Dimensions of Information Technology Applications: A Historical Perspective

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THREE DIMENSIONS OF INFORMATION TECHNOLOGY APPLICATIONS: A HISTORICAL PERSPECTIVE

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ABSTRACT

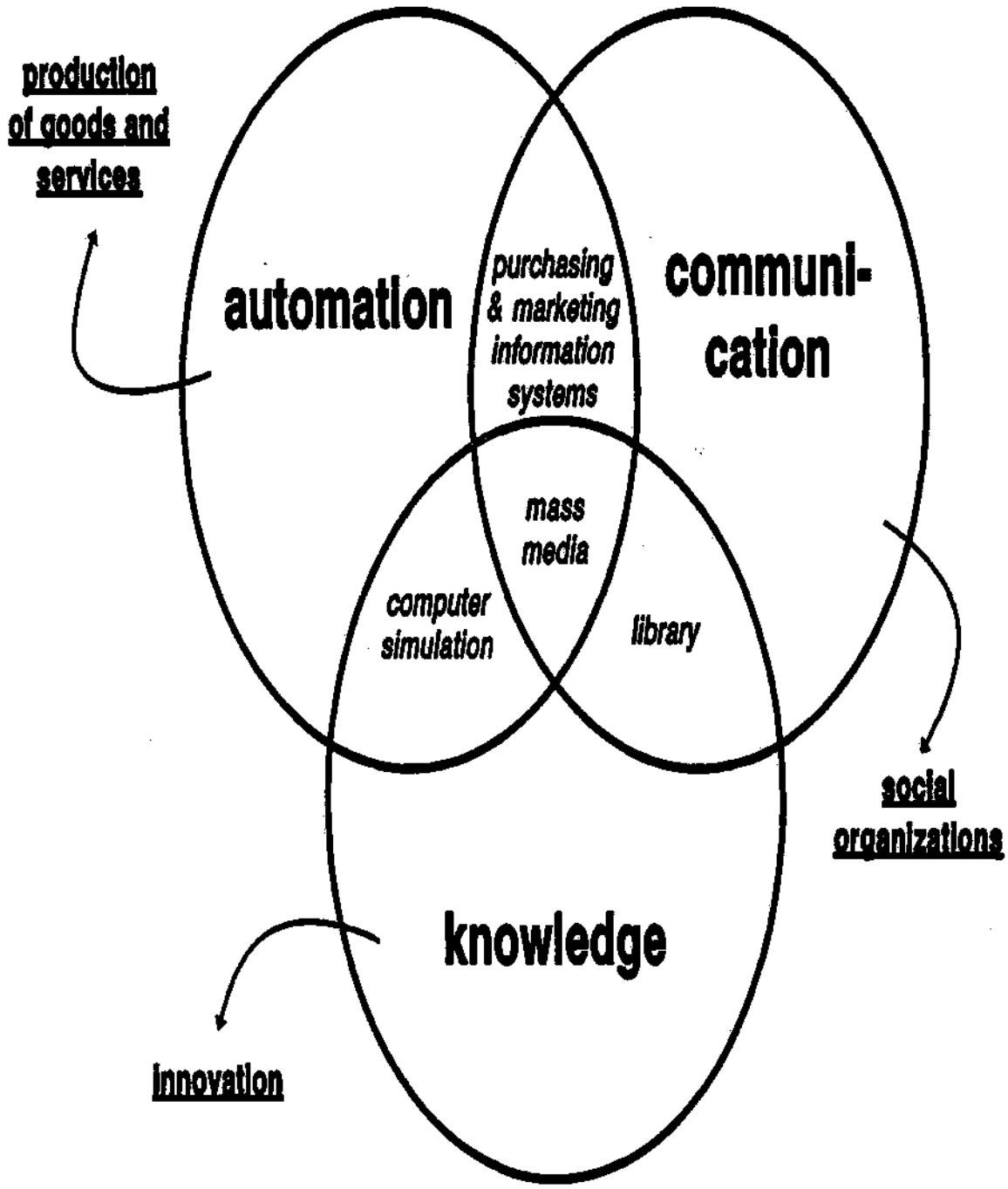
By using a historically oriented study, the paper sees Information technology (IT) as the successor to three important streams in technologies supporting information-related activities, namely, mechanization, communication, and generation and transmission of knowledge. The study aims to show the IT phenomena as something taking place within the context of social and cultural evolution over the past several thousand years. Moreover, it wants to use the historical approach to explain why IT is such a powerful technology. Finally, the discussion wants to show that the communication aspect, and the knowledge-related aspect of IT are under-rated. If history is a guide, then we can argue that these two aspects possess very far-reaching consequences for the individual and society.

keywords: Information Technology, automation, mechanization, data communication, information society, history, written language, printing.

1 INTRODUCTION

The aims of this paper are threefold. Firstly, we wish to show the Information Technology-supported information activities as phenomena taking place within the general context of human social evolution over the past several thousand years. Secondly, we want to use a historically oriented study to explain the fact that Information Technology (IT) is a very powerful technology. Thirdly we hope to reveal certain aspects of current IT applications which are under-rated and, if history is any guide at all, these aspects may prove to possess the most far-reaching consequences on the individual and the society.

The perspective identifies three important dimensions of IT applications. Firstly, IT applications in the area of automation may be considered as a continuation of mechanization which began in the Industrial Revolution. Secondly, the vast avenue opened up by IT in the area of communication may be considered as a successor to the talking drums, smoke towers and light house. This has sometimes been referred to as the communication revolution. Thirdly, IT has given a boost to knowledge related activities which are a continuation of the written word and printed book. This has been sometimes referred to as the information revolution. The three dimensions are inter-related. In fact, the second dimension (communication revolution) and third dimension (information revolution) are so closely related that both of them can justifiably claim to have common ancestors. (The impacts of IT can be felt very deeply in the library which is an information system related to knowledge generation and dissemination.) We prefer to discuss the three dimensions, each under a separate section for both clarity of presentation and convenience in elaborating their distinctive features.



examples of a major emphasis of each sector are underlined; examples of IT-supported systems common to 2 or 3 sectors are in italics print

relationships between the 3 sectors of IT applications

Of the three dimensions of IT applications, automation has been receiving the most attention and the term automation has sometimes been taken to be synonymous with computerization. New means of material production open up a new avenue of new products, thereby enriching our material and cultural lives. This is what automation has been offering us and more, for example, by releasing us from the drudgery of monotonous work. However, the potentials of IT applications in the area of communication and knowledge intensive activities are likely to be greater. New means of communication allow us to organize our companies, hospitals, and even society in very different ways. IT's contributions to the knowledge enterprise enable us to create, store and disseminate knowledge on a scale hitherto unknown. Given the propensity of the modern society to *actively use* knowledge in economic, social, cultural and political life, IT's applications in this area are likely to be more important in years to come. We would like to plead for more research effort in the second and third dimensions of IT applications. If we may offer any deep reason for this, it is that these applications have a sort of closer "coupling" with the human being as a *social* animal and a *thinking* animal. If we may use a crude analogy, the effect of rice on our human body is to enable our muscle power to do work more efficiently and accurately, while the effect of vaccine and drugs are going to affect our bodily functioning at a different level. The effect of rice is likened to the role of IT in automation while the effects of vaccine and drugs are likened to the roles of IT in communication, and knowledge creation and dissemination. This theme is dealt with in greater length in (Heng 1993).

The paper is organized as follows: sections 2, 3, and 4 discuss the automation enabled by IT, IT-based communication revolution, and the IT based information revolution respectively. These are followed by the concluding section which examines the implication of such historical perspective for our current use of IT and research efforts in Information Systems.

2 AUTOMATION AS A CONTINUATION OF MECHANIZATION

IT applications in the area of automation are most widespread, and the list of possible applications is almost endless. See for example (Forester 1980). As long as a task can be

well understood, and the steps for executing it well specified, it can be automated. The task may be continuous, or boring, or complex in which case it can be "divided and conquered" to a level of complexity capable of being well understood by the human mind. This discussion of a task that can be automated is strikingly similar to a task that can be mechanized. And it is so, for there is much relationship between mechanization and automation. In this section, we would discuss how the latter may be seen as a continuation of the former.

The technical origin of the computer may be traced to the mechanical clock. Before that, in all the handicraft-related technologies, the control component was totally taken care of by the human. The mechanical clock represents a device that is machine-controlled, or self controlled. From the introduction of the clock to 19th century, control of the machine was however still kept as human activity. The introduction of the convey belt techniques in the 19th century was to alter that: it allowed semi-automation of biscuit making and meat packing, and eventually the assembly line concept of production. Some of the control which had hitherto been a prerogative of the human, was transferred to the machine; and in the case of the convey belt, the human was forced to work at the pace of the machine. From the perspective of control, a more important event was the invention of the weaving loom by Joseph-Marie Jacquard at the beginning of the 19th century[1]. The Jacquard loom was controlled by information coded on punched cards. Its introduction and diffusion transformed the weaving industry, and represented a significant milestone in the Industrial Revolution. Hence it comes as no surprise that the Jacquard loom was an intellectual inspiration of Charles Babbage, the father of the modern computer.

Apart from a technical root, there is an economic root or background to the phenomenon of automation. At least from the beginning of the industrial revolution, there appear to be certain patterns in the use of technologies. Two of these have been relatively well identified in the literature: progressive exploitation of latent scale economics, and

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[1] Jacquard might have obtained the idea from the late eighteenth century musical instruments which operated under the control of rolls of punched paper (Beniger 1986).

increasing mechanization of operations that have been done by hand (Nelson and Winter 1977). While the first pattern is not often followed by the applications of IT (some would claim IT can reverse or at least reduce the advantages associated with economics of scale), the second pattern is quite apparent. Mechanization seems to be construed both by the designers of equipments and their owners as an effective and efficient way to reduce costs, increase reliability and precision of production, gain more control over operations, etc. This point has been highlighted by Rosenberg (1976) in his study of innovation in the American industry of the nineteenth century. This economics-motivated tendency to mechanize is now boosted by IT. The main economic returns of automation are efficiency, flexibility and cost-saving (taking the form of labour saving, time saving, material saving, lower operating and maintenance expenditure). The input data and output data are well defined and well-structured. The technologies used are more traditional such as database technology, process-controlled technology and number crunching computing though of late artificial intelligence-base technologies such as image processing and expert systems are being introduced.

Of many early works concerning the economic history of automation and mechanizations, the book *Economic Consequences of Automation* by Paul Einzig published in 1957 can count as one of the best. Though dated and inadequate in several aspects, Einzig has rightly argued that automation can bring a range of advantages such as saving labour, and the provision of better and quicker information. He sees automation as a very *advanced form of mechanization*, as a continuation of the trend towards mass and flow production systems.

To have a deeper appreciation of the historical continuity a brief detour into the history of mechanization may be necessary. For this we shall draw from Karl Marx whose eminence as a student of technology is related by Rosenberg (1982). In using manual implements man performs two functions, namely, (a) providing mere motive power and (b) providing the operation or the control function. For example, in spinning wool, the foot is the prime mover of the spinning wheel, while, the hand, working with the spindle, and drawing and twisting, performs the real operation of spinning. Long before the Industrial Revolution, the function of man as a mere motive power had been taken over by animals, water and

wind. Marx (1867) notes that long before the period of manufacture, and also to some extent during the period, implements such as the windmills attain the status of machines, without creating any revolution in the mode of production. It is the operation or control function which is first seized by the Industrial Revolution. Seen from this perspective, the steam engine itself did not give rise to any Industrial Revolution. On the contrary, it was the invention of the machines (which were able to take over the operation or control function of man) that made a revolution in the form of steam engines necessary. Here we quote a few passages from volume 1 of Karl Marx's *Capital*:

> The machine, which is the starting-point of the industrial revolution, replaces the worker, who handles a single tool, by a mechanism operating with a number of similar tools and set in motion by a single motive power, whatever the form of that power. Here we have the machine, but in its first role as a simple element in production by machinery.
>
> An increase in the size of the machine and the number of its working tools calls for a more massive mechanism to drive it; and this mechanism, in order to overcome its own inertia, requires a mightier moving power than that of man, quite apart from the fact that man is a very imperfect instrument for producing uniform and continuous motion. Now assuming that he is acting simply as a motor, that a machine has replaced the tool he was using, it is evident that he can also be replaced as a motor by natural forces.

This replacement of human power by mechanical power brings with it what James Beniger (1986) calls the *control crisis*. According to him, every production process may be generalized to have a physical component and a control component. Prior to the Industrial Revolution, the physical component was performed by human and animal muscle power *at slow speed; the control component* was taken care of by modest bureaucratic structures. There was parity of speed in the two components, thus attaining a kind of harmony. The Industrial Revolution was to increase immensely the speed of executing the physical component of a piece of work. The harmony of the speeds in the two

components was disrupted, resulting in a bottle neck in the control mechanism. Even huge bureaucracies could not cope with the forces unleashed by the Industrial Revolution. The first signs of the crisis appeared in the form of rail safety in the early 1840s. By the 1860s the crisis had assumed the form of a continuing struggle to control the vast railway system to maximum efficiency. And in 1870s, railway companies delayed constructing large systems because they lacked the means to control them. Other sections of the economy, such as production, distribution and consumption, were confronting crisis of a similar nature. Mass production and distribution require a means to communicate information about goods and services to a national audience in order to stimulate or reinforce demands for these products. At the same time it requires a means to gather information on the preferences and behaviour of this audience. As this crisis grew from 1840s to 1860s, it evoked a response in the form of innovations in information processing, bureaucratic control, and communications. By the turn of the century, the crisis of control had ceased. Solution of the control crisis of 1840-1890 paved the way for a new wave of economic activities which called for new innovations. This continued into the twentieth century and IT represents the latest phase in the continuing development of the control techniques of the Industrial Revolution. Hence the title of Beniger's book, *The Control Revolution*. Viewed in this light, the so-called Information Society is not so much the result of recent social changes as of the changes brought about by the Industrial Revolution.

Of the almost countless books and papers written on the economic aspects of IT Beniger's book deserves special mention. It is a serious application of scholarship to analyze the origin of the pervasive application of IT in the changed structure of economic production. In doing so it provides the missing link between mechanization associated with the Industrial Revolution and automation associated with the so-called post-Industrial Society. Furthermore it explains why automation is the continuation of mechanization in a truly new way.

IT's contribution to the control aspect goes far beyond the extraction, production and distribution environment of industries. IT has found application in business and commerce. The most obvious example of this is office automation. Very much related to it is

accountancy, which is not surprising because accountancy has management control as one of its main functions. (Again, the ability of IT to support control function.)

IT succeeds mechanization in yet another way. By automating a process, IT generates information about it which sheds light on the process itself. This capacity of IT is given the term *informating* by Zuboff (1988) and it forms the cornerstone of her book *In the Age of the Smart Machine.*

Because of the newness of the term informating, it is worth citing two examples to illuminate what she means by it. Consider computer-based numerically controlled machine tools or microprocessor-based sensor devices. They not only execute programmed instructions to the equipment but also convert the current state of equipment, product, and process into information. Another example is provided by scanner devices in the check-out points in supermarkets. These devices automate the check-out process and simultaneously generate information that can be used for inventory control, warehousing, scheduling of deliveries, and market analyses. By virtue of the informating capability IT provides a deeper level of understanding and insight into activities and processes hitherto partially or completely opaque. "In this way information technology supersedes the tradition of logic of automation." (p. 10). She argues that the informating potential of IT is a much overlooked and under-utilized aspect; people tend to pay almost all the attention to the traditional automation aspect of IT. To correct the bias, it may be useful to see that automation and informating are related. In fact, they are hierarchically integrated. "Informating derives from and builds upon automation" (p.11).

3 SOCIETY, COMMUNICATION AND INFORMATION TECHNOLOGY

The importance of communication is underlined by the simple fact that no social unit, either a small organization or a whole society, can exist without communication. Communications of many types have been recognized by political scientists and economists to lie at the heart of the regularities of social order. The reasons are not too obscure to find. Social systems consist of relatively autonomous components - individuals, families, groups, organizations - that can act for different and even cross-purposes. Actions at societal level must necessarily depend on exchanges among these individual

components. This implies the need for information exchange and processing. The complexity of exchange depends on factors such as population size, spatial distribution, technological infrastructure, social organizations and economic development (Beniger 1986). It stands to reason that an important subject matter of social sciences is the information phenomenon among social actors: its gathering, storage, possession, processing, retrieval and transmission. Much of this vision has been expressed and we shall quote a few. The zoologist E.O. Wilson (1975): Reciprocal communication of a cooperative nature is the diagnostic criterion of a society most generally defined. The observation is based on studying thousands of social species from colonial jellyfish and corals to the primates, including the homo sapiens. In the opinion of Norbert Wiener (1948, 1950): The social system is an organization, like the individual, that is bound together by a system of communication. Society can be understood through a study of the messages and the communication facilities which belong to it. And in the view of the sociologist Niklas Luhmann: "The system of society consists of communications. There are no other elements, no further substance but communications (quoted in Beniger 1986)". The German philosopher and scientist Wolfgang Goethe sees communication as the basis of human community. He envisaged a Panama Canal, a Suez Canal, and a canal linking the Rhine and the Danube as the means to link the human community decades before others seriously thought about these projects (Bell 1979).

These assessments accorded to communication, though weighty, are superseded by that provided by some historians. The historian William H. McNeill employs the theme of cultural diffusion as the central idea to understand and to explain the emergence of various civilizations. In his award-winning book *The Rise of the West* McNeill argues that the various civilizations have fundamental inter-relations with one another. From the Neolithic beginnings of grain agriculture in the Middle East to the present, he finds that major social changes are usually triggered by new or newly important stimuli of a foreign source. The Canadian economic historian Harold Innis identifies the modes of communication, rather than modes of production and property relations as Karl Marx sees it, to be the key concept to understand the transition of society from one stage to another (Innis 1972). He argues that Western civilization has been profoundly influenced by communication and can be divided into periods in relation to media of communication. In the

organization of large areas, communication occupies a vital place, and it is significant that there is a correspondence between a historical period and the media of communication. For example, papyrus, the brush and hierographics to the Graeco-Roman period; the reed pen and the alphabet to the retreat of the Roman Empire from the West. The following passages from (Innis 1972) are worth reading:

> ... Man's activities and powers were roughly extended in proportion to the increased use and perfection of written records. The old magic was transformed into a new and more potent record of the written word. Priests and scribes interpreted a slowly changing tradition and provided a justification for established authority. An extended social structure strengthened the position of an individual leader with military power who gave orders to agents who received and executed them. *The sword and pen worked together.* Power was increased by concentration in a few hands, specialization of function was enforced, and scribes with leisure to keep and study records contributed to the advancement of knowledge and thought. The written record signed, sealed, and swiftly transmitted was essential to military power and the extension of government. Small communities were written into large states and states were consolidated into empire. *The monarchies of Egypt and Persia, the Roman empire and the city-states were essentially products of writing.* Extension of activities in more densely populated regions created the need for written records which in turn supported further extension of activities. Instability of political structures and conflict followed concentration and extension of power. A common ideal image of words spoken beyond the range of personal experience was imposed on dispersed communities and accepted by them. (emphasis added, p. 10)

> ... With printing, paper facilitated an effective development of the vernaculars and gave expression to their vitality in the growth of nationalism. The adaptability of the alphabet to large-scale machine industry became the basis of literacy, advertising, and trade. The book as a specialized product

> of printing and, in turn, the newspaper strengthened the position of language as a basis of nationalism. (p. 170)

It must be stated parenthetically here that communication technologies cannot by themselves explain the changes of society. Rather, the rudimentary elements of a communication technology were obtaining in a society which might or might not provide the favourable conditions for them to develop further. If the development did occur, then the technology, with a fortuitous convergence of other forces, would usher in a new form of society.

It is difficult to deny the fact that communication technologies serve as a means to transmit various kinds of information so necessary for a society to function and to develop. On this point, even the rather one-sided model of Innis has its validity. An application of the ideas of Innis from the beginning of civilization up to the present day world would give us the following figure:

Technology	Social Organizations
Oral Tradition	Tribes
Written Language	Cities (City States)
Printing	Nation State
Telephone, Radio, etc.	Modern Nation States
I.T.	Integrated "Nation States" e.g. EEC

Social Organizations Made Possible by Various Communication Technologies

For organizational designers, it is useful to recognize that the communication capacity of IT can help us design new organizational forms. A cogent example is provided by transnational companies (TNC) which would not have been able to operate without IT. These corporations make *direct* investment all over the world, involving the establishment of foreign subsidiaries. A characteristic of a TNC is the existence of a parent company and a cluster of daughter companies in various countries with a common pool of mana-

gerial, financial and technical resources. The whole operation is guided by a global strategy, orchestrated by the parent company. It organizes and coordinates the purchasing, production, marketing and research in order to attain its short-term and long-term goals. Such globally based activities would simply be impossible to co-ordinate without the use of IT. The impact of TNCs to new global economic and political relations is too glaring to need further comment here and has been the subject of countless papers and books.

3.1 TRANSMISSION OF KNOWLEDGE AND INFORMATION

In this sub-section, we would race through history to take a quick look at how writing, and later on printing had contributed to the transmission of information and knowledge. According to sociologists and historians, this was to help transform the older versions of the society beyond recognition.

Oral culture refers to a period in human history when human memory served as the means of recording events, and direct face-to-face communication was the way to transmit ideas. The invention of the written words is to transform all these. We began to write around five thousand years ago (Olson 1990). Recording media included cave walls, tree barks, bamboo slabs, animal skins, stone tablets, and so on. Records were more permanent and could reach a greater public[2]. In other words, writing provides us with an ability to preserve and transmit knowledge, information and culture through *time* and across *space*. As an example of how written language can function as a tool for communication, consider the dialogue possibilities created by it for two deaf persons who can read and write. In his standard work *What Happened in History*, the eminent historian Gordon Childe makes the following observation (p. 140, 141):

> The distinctive achievements of civilizations that differentiate them from barbarism

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[2] It is known that a written text can produce a dramatic effect on people living in an oral culture. In her autobiography *Out of Africa*, Isak Dinesen describes the response of the Kikuyu tribesmen to their first exposures to the written texts: "I learned that the effect of a piece of news was many times magnified when it was imparted by writing. The messages that would have been received with doubt and scorn if they had been given by word of mouth were now taken as gospel truth."

> are the invention of writing and the elaboration of exact sciences. In Sumer, Egypt, and India the new economy had required and elicited conventional systems of writing and numeral notation, of weights and measures and of time-keeping. It has thus revolutionized the methods of accumulating knowledge and transmitting experience, and produced sciences of a new kind. By the written word a man can accurately transmit his experiences to correspondents in another city and to generations yet unborn - provided, of course, they use the same conventional symbolism.

It was to last a few thousand years before the revolution of written words was to be succeeded by the art of printing in China before 700 A.D. and in Europe in 1455 A.D.[3] The effect of the printing in Europe was the most profound change in the diffusion of knowledge and ideas since the invention of writing. In the words of the Oxford historian John Roberts (1987), it was the greatest cultural revolution of these centuries, and no single change marks for clearly the ending of one era and the beginning of another. To the best of my knowledge, the most comprehensive study on the effects of printing is *The Printing Press as an Agent of Change* by Elizabeth Eisenstein, published in two volumes in 1979. She explains how printing made the Italian Renaissance a permanent European Renaissance, how it implemented the Protestant Reformation and reoriented Catholic religions practice, how it affected the development of modern capitalism, implemented western European exploration of the globe, changed family life and politics, diffused knowledge as never before, made universal literacy a serious social and intellectual life.

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[3] Incidentally the case of printing technology illustrates once again the importance of wider societal conditions in determining the fate of a technology. Paper had been invented in China at about the end of the first century and its introduction into Europe followed the later Crusades (Dampier 1961). Printing was invented in China and it consisted of rubbing the impressions from stone into paper or other media. Printing from wood blocks was taking place before 700 A.D. under the T'ang Dynasty and moveable type appeared in the eleventh century. Large number of books soon appeared but the state of China society then did not have the favourable conditions for the printing technology to exert such impact as in the West a few centuries later (Roberts 1987). The conditions were also not there to spur the printing technology to rapid development.

To appreciate the import of Eisenstein and Roberts' assessment of printing it may be worthwhile to digress into a brief societal background of Johannes Gutenbergs' invention. The period was at the dawn of rapid colonial expansion (some call it "great discoveries"). The economic world was one of high level of production and exchange attained by the Italian republics, the German trading leagues and the Flemish cities. The landed aristocracy was on the decline while the urban mercantile bourgeoisie was on the rise. These important changes were reflected in the world of ideas. Printing was in part a response and in part a stimulus to this socio-politico-economic transition in Europe. It was a response to the needs of the new bourgeoisie who aspired for a political role to promote their growing economic ambitions. The first major function of the printed book was to spread literary and the general knowledge among the new economic powers of society.

Printing participated in and gave impetus to the growth and accumulation of knowledge. In each succeeding generation there were more and more men who were able to assimilate the knowledge available to them and to augment it with their own contribution. At the same time, printing facilitated the spread of ideas that helped to shape the alterations in social relations made possible by industrial development and economic transformations. In fact the widespread availability of books transformed the European consciousness. People were not longer dependent on the Church as the main source of knowledge, and in 1501 the Pope suggested to the Bishops that the control of printing might be the key to preserving the purity of the faith (Roberts 1987).

The roles of writing and printing are currently succeeded (but not superseded) and supported by IT whose contribution in the area of collection, preservation/ storage and transmission of knowledge and information is exemplified by the library. The proper functioning of library as an Information System is very much enhanced by the advantages IT provides to the users and functionaries of library. Via the computer terminal, the library administrative can check if a book requested for acquisition is already in its possession, enter the data about the latest acquisition, instruct the automatic mailing out of reminder to books due, manage reservation, etc. The users on the other hand can consult the library database to know if a book is available for loan, to place reservation, to scan through related titles or authors, and he can have easy access to the database of

other libraries through the computer network. Moreover, he can copy abstracts of papers from scientific journals onto his diskette.

3.2 INFORMATION TECHNOLOGY AND BUSINESS ACTIVITIES

The value of telecommunications systems to companies is gradually being taken for granted. It is just as basic as electric power and water. Some go further to use it as a strategic weapon for competition. They see telecommunications as the thread that enables them to pull everything together and to reach out for new markets. An executive vice-president of American Express (a leading US financial service company in travel related services) described his company this way: "The business we are in is really the communications and information-processing business" (Forester 1985).

Because so much of the activities of different functional units of a big company has to do with exchanging information in order to co-ordinate their work, IT offers the possibilities to integrate their work while providing a greater degree of organizational independence. Perhaps what is even more significant is the capability to support business re-design. Of the various components of IT, the data-communication aspect plays the most important role in re-organizing business architecture. It is therefore not surprising that most of the important cases of IT application of strategic value are data-communications based (Runge and Earl 1988).

4 IT APPLICATIONS IN KNOWLEDGE INTENSIVE ACTIVITIES

A method for recording knowledge and information not only facilitates their storage and transmission. It can also support the thinking process. The written language provides a powerful medium to articulate thoughts, as anyone involved in writing an article or solving a mathematical problem on a paper can testify. The value of the written language as a tool for communication and knowledge acquisition is obvious to anyone who is deaf, or dumb or blind.

The tremendous advantages made possible by writing and printing have been bolstered by

IT. Ong (1982) sees writing, printing and the computer as ways of technologizing the word. Each technology has its own role, its own strengths and weaknesses[4]. Just as printing has not replaced but rather supplanted writing, IT has not replaced but rather supplanted writing and printing. Seen in this light, we can perhaps grasp better why all the predictions about a paperless society have been proved wrong.

4.1 INFORMATION TECHNOLOGY HELPS TO GENERATE KNOWLEDGE

Computers have given human beings the means to build models and to simulate experiments and tests (sophisticated computer-based simulation has been given the exotic name virtual reality), to carry out massive numerical calculation, to process very large databases. In fact, modern econometrics and the use of empirical data in the formulation of government economic policy would not have been possible with the computer (Bell 1973). All these have yielded new human knowledge hitherto not possible.

We would like to illustrate the contribution of computer-aided simulation to natural sciences with an example. Before the advent of powerful computers, scientists developed idealized models to make predictions which were to be verified or otherwise by experimental observations. However in complicated systems simplifications may well end up in leaving out some of the most interesting phenomena which emerge from the unforeseen combination or amplification of small effects. This is where computer can lend a hand. By building computer models of such complicated systems it is increasingly possible to work out the consequences of simple theories in complex situations, as well as to

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[4] Plato's criticisms of writing, formulated in *Phaedrus* and *Seventh Letter*, bear surprising similarities to current criticisms of the computer:

1. Writing is inhuman, pretending to establish outside the mind what in reality can only be in the mind. It is a thing, a manufactured product.
2. Writing destroys memory. Those who use writing become forgetful, relying on external resource for what they lack in internal resources. In other words, writing weakens the mind.
3. A written text is basically unresponsive.
4. The written word cannot defend itself as the natural spoken word can. Real speech and thought always exist essentially in a context of give-and-take between real persons.

determine the consequences of a theory without undue approximations or simplifications. In the words of Hut and Sussman (1987) advanced computing is drastically changing the way science is done. One result is a shift in the balance away from such reductionist methods to analysis by synthesis[5]. The synthetic approach is appropriate when the fundamental processes of the interactions among the parts of a system are known, but the detailed configuration of the system is not. One can attempt to determine the unknown configuration of the system by synthesis: one tries out the possible configurations and work out the consequences of each. The winning configuration is one that best accounts for the observable details. "Analysis by synthesis has recently shed new light in an old friend of astrophysics, gravitational dynamics, for here the increased speed of computers has enabled investigators to tackle problems that have long eluded other approaches (Hut and Sussman 1987)."

4.2 INFORMATION TECHNOLOGY AFFECTS OUR CONSCIOUSNESS

Though remarkable in themselves, the knowledge generation activities enabled by computers are less profound than what artificial intelligence has done to our consciousness. It is generally accepted that the artificial intelligence has two aims: (1) to understand the nature of (human) intelligence, and (2) to build intelligent machines, or machines which exhibit intelligent behaviour. With computer-chess program we come to understand better the mystery in the grand masters' mind. And we know that the winner of the "brain of Britain" quiz context was not the most brainy British man or woman. He or she can be easily beaten by a powerful computer with a large enough database and rapid search algorithm, but the computer cannot cope with the range of ordinary day questions that an average 15 year old can handle with ease. The superior computing power of a computer

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[5] It must be pointed out that the synthetic approach can be used with or without the aid of computer. A well-known example of using it without computer is the discovery of the planet Neptune in the 19th century. It was the end point of a journey to understand the observed but unexplained perturbations in the orbit of Uranus. By adding a hypothetical planet to the solar system and adjusting the parameter of its orbit scientists could provide a re-construction to satisfactorily resolve the perturbation problem.
However, the synthetic approach without computer is limited to simple situations.

has nonetheless led some people to compare themselves or others to the computer, both in the positive and negative sense. Viewed from this perspective, Herbert Simon (1977) is right in asserting that perhaps the greatest significance of the computer lies in its impact of Man's view of himself. And this is precisely what is happening, if we refer to the work of Sherry Turkle (1984). She finds that children, in particular, often see themselves not with respect to their differences from animals, but how they differ from computers. Her studies of computer scientists, students, and children lead her to the observation that the machine may be thought of as a *second self*. Another aspect is the way our language has been influenced by IT. Hofstede (1991) refers to culture and organization as the software of the mind in the title of his book. Some people even refer to God as the most creative and sophisticated programmer. We read of programmable procedure, and bugs in all kind of technical systems. It is quite common to hear people referring to the brain as the computer, whether in jest or otherwise. In a way this is not surprising. Throughout history, the human kind has been very much intrigued by the questions: How does the brain work? What is the relationship between mind and brain? What is intelligence? And our ancestors had speculated that our brain might be equated to the most sophisticated technological device of the time, such as the clock and the mechanical calculator. And this pattern of thought is but a short step away form our tendency to compare ourselves with the computer, since we humans like to pride ourselves as beings with intelligence, a trait apparently possessed by computer systems (from the behavioral point of view).

That a technology should affect our consciousness is nothing new. After all, technologies form part and parcel of our material world (or society), which influences the way we view the world and ourselves. To quote an important statement of Karl Marx (1859): "The mode of production of material life conditions the social, political and intellectual life process in general. The social being of men determines their consciousness."

Where IT differs from other technologies in this aspect is the profundity. And this is pretty evident in the case of writing and, slightly less so, printing. Writing can be seen as the commitment of the spoken and unspoken word to space. In doing so, writing enlarges the potentiality of language almost beyond measures, restructures thought, and in the

process converts a certain few dialects into grapholects[6] (Haugen 1966, Hirsch 1977). It enhances enormously a capacity of abstract thinking which is evident in the growth of language in the oral tradition (Innis 1972). Writing imparts a grapholect a power far exceeding that of any purely oral dialect (Ong 1982). All thought, including that in primary oral cultures, i.e. untouched by writing in any form, is to some degree analytic: it breaks its materials into their constituting components. However, abstractly sequential, classifactory, and explanatory examination of phenomena or stated facts/truths is not possible without writing and writing. In the words of Ong (1982): Human beings in primary oral cultures learn a great deal, possess and practice great wisdom, but they do not "study". In his book *Orality and Literary*, Walter Ong points out that the thought processes of a literate human being do not grow out of simply natural powers but out of these powers as structured, directly or indirectly, by technology of writing. "Without writing, the literate mind would not and could not think as it does, not only when engaged in writing but normally even when it is composing its thoughts in oral form. More than any other single invention, writing has transformed human consciousness" (p. 78). Based on his studies of traditional societies in Africa, Goody (1968, 1977) furnishes insightful descriptions and analyses of changes in the mental and social structures incident to the use of writing. Here we would like to quote an interesting observation of (Goody 1977, p. 37):

> Culture, after all, is a series of communicative acts, and differences in the mode of communication are often as important as differences in the mode of production, for they involve developments in the storing, analysis, and creation of human knowledge, as well as the relationships between the individuals involved. The specific proposition is that writing, and more especially alphabetic literacy, made it possible to scrutinise discourse in a different kind of way by giving oral communication a semi-permanent form; this scrutiny favoured the increase in scope of critical activity, and hence of rationality, scepticism, and logic to resurrect memories of those

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[6] A grapholect is a transdialectical language formed by deep commitment to writing. An example of grapholect is the (written) Chinese language. Almost any standard language, such as standard Dutch or standard English is a grapholect.

> questionable dichotomies. It increased the potentialities of criticism because writing laid out discourse before one's eyes in a different kind of way; at the same time increased the potentiality for cumulative knowledge, especially knowledge of an abstract kind, because it changed the nature of communication beyond that of face-to-face contact as well as the system for the storage of information; in this way a wider range of 'thought' was made available to the reading public. No longer did the problem of memory storage dominate man's intellectual life; the human mind was freed to study static 'text' (rather than be limited by participation in the dynamic 'utterance'), a process that enabled man to stand back from his creation and examine it in a more abstract, generalised, and 'rational' way. By making it possible to scan the communications of mankind over a much wider time span, literacy encouraged, at the very same time, criticism and commentary on the one hand and the orthodoxy of the book on the other.

Seen in the light of human development, speech, agriculture, writing, printing, industrial revolution, and now information revolution are momentous events. But in terms of significance, we may say that of all these speech must have been the most important step in *human development* (Dampier 1961). On the other hand, writing was and remains the most momentous of all human *technological inventions*, so momentous that we talk of *written history*, and some historians have used writing to ear-mark the birth of human civilization.

Less momentous than writing, but still momentous in terms of its impact, is the advent of printing. The social, economic, and political effects of printing has been dealt with in an earlier section, and we will concern ourselves here with the subtler effects of it in our human consciousness. In his two major works *The Gutenberg Galaxy* and *Understanding Media*, Marshall McLuhan has commented aptly and unconventionally on many of the subtler ways printing has affected consciousness. Just to quote three observations in *The Gutenberg Galaxy*:

1. Print, in turning the vernaculars into mass media, or closed systems, created the uniform, centralizing forces of modern nationalism.
2. The divorce of poetry and music was first reflected by the printed page.
3. The portability of the book, like that of the easel-painting, added much to the new cult of individualism.

5 CONCLUSION

In a way, this paper may be read as a kind of classification scheme for IT-applications. Applications of information technology are so numerous and so widespread that there are many ways of classifying them. One can classify them according to the domain of applications, e.g. engineering, or according to the type of technology used, e.g. expert systems, and so forth. Each classification scheme has merits of its own, as testified by the journals and conferences perpetuating it. If any reader finds any merit of this paper as a classification scheme, then it is a sort of unanticipated consequence. The intended results of this classification scheme or rather this approach are (a) to offer a way to appreciate the power of IT (which has been accepted as an article of faith in business and management literature), (b) to reveal the relatively under-rated potential of IT in the areas of knowledge-intensive applications and data-communication applications, and (c) to see that the current IT-supported activities do have a historical background dating back to about five thousand years ago. It is hoped that in the course of discussion, it is apparent that the predecessors of IT in the areas of communication and knowledge generation and transmission have helped to transform our consciousness and social structure in a very radical way. Given the fact that we are social beings and beings actively generating and using knowledge, IT is likely to promote the transformation further. The implication of research is immediate: more efforts need to be directed at the knowledge-intensive areas and data-communication areas which possess much greater social and business ramifications.

In the course of writing this paper, it occurred to the author that a historically oriented study of Information Systems may be equally rewarding. There are at least three reasons for it. Firstly, these Information Systems, as representing more or less institutionalised forms of use of information, illustrate the crucial role of information in various forms of

societies, dating as for back as at least two thousand years ago. Secondly, it is obvious that *the importance of information in various facets of our life does not stem from the advent of IT.* Of course the use of IT enhances the importance. Thirdly, we can learn something form them as to the use of information; a study of them may help us see the inadequacy of the standard vision of use of Information Systems, namely to support the cost-effective and efficient aspects of business activities.
We shall here name five of them, namely:

- information system to support the dissemination of orders of tribal chiefs, and later on, of political leaders;
- military intelligence gathering services;
- informal information network within a community to transmit story, news, gossips and values;
- bookkeeping;
- library.

All these information systems have evolved into huge IT-based information systems. We shall review their corresponding counterparts of today:

- The public information services consist of both the government controlled information services and the mass media. The importance of providing information to the public is obvious in the appointment of a minister of information (or propaganda in former socialist states) with cabinet responsibilities in many governments. It is also obvious in the attempt by anyone staging a coup d'etat to promptly seize the radio and TV stations, and to censure the press. Businesses too are conscious of its importance. Nowadays we have a Public Relations Department in almost every big organization, both profit-oriented and non-profit oriented.
- Intelligence services, in spite of their nature, are quite well known. An average schoolboy or schoolgirl would have heard of the CIA, the KGB, the MI5, etc. *What* are not so well known are the foreign embassies which are listening posts of their governments, and industrial espionage activities.

Because of the very secretive nature of the trade, the intelligence community uses very sophisticated and even state-of-the-art IT to carry out their information collection, encoding, transmitting and decoding activities.

- Information network to sustain, perpetuate and mould a community is partly served by the mass media. Informal information exchange supported in an increasing fashion by IT, e.g. telecommunication. The role of the mass media in influencing the life of a community can be both short term in the form of opinion formation, or medium-term in the form of a hidden agenda, or long-term in the form of altering the value system.
- One of the oldest information systems is library which has to do with preservation and transmission of knowledge. Though modern libraries differ immensely from their ancestors in Alexandria which was perhaps the first library in the Western World (more than two thousand years ago), their functions still remain essentially the same. With such a long history, the library can deepen some of our conceptual understanding of Information Systems (Heng and Koh 1992).
- The influence of bookkeeping, or its modern version accountancy, is evident in standard IS textbooks such as (Davis and Olson 1985).

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