EXPRESSIONS OF TIME IN INFORMATION SCIENCE AND THEIR IMPLICATIONS: AN OVERVIEW

A Neelameghan
Documentation Research and Training Centre, Bangalore-560003

1 INTRODUCTION

1 Definition

Communication. - Charles Cooley defines communication as "...the mechanism through which all human relations exist and develop -- all the symbols of the mind together with the means of conveying through space and preserving them in time..." [1]. George Lundberg considers communication as a subcategory of interaction, namely the form of interaction using symbols -- gesture, picture, plastic or verbal or any other which would serve as stimuli to behaviour [2]. These definitions emphasise the social function of communication and hence pertinent to this essay.

Information. - In a general sense it is that content (message) which is exchanged when an organism reacts with and adjusts to its environment, and as the environment, in turn, is changed by the reaction of the organism. The emphasis in this essay will be on human reaction.

Society. - In general "society is a system of usages and procedures, of authority and mutual aid, of many groupings and divisions of controls of human behaviour and of liberties. It is the web of social relationships and is always changing" [3].

Time. - Time is a basic concept associated with everyday experience. Generally we speak of it in terms of when an event occurred or would occur or how long it takes. We also measure it in terms of, for example, the position of the hands of a clock, readings in a calendar, etc. Ackoff's functional definition of time as a "property of events that is sufficient to enable an individual to individuate any two changes in the same property of the same individual" [4], is helpful.

Human perception of change and of temporal succession of events involves acts of mental organization. Our awareness of the sequence of events depends on the sense with which we perceive them. Therefore, time is not a simple sensation but depends on processes of mental organization uniting thought and action. The mechanism of memory is one of the unsolved problems of the science of time [4a]. Memory is an important subject of study in psychology, and the study of the attributes of memory (human memory) and its simulation is a major subject of interest to information science in building up its foundations.

2 Information Science

Information science covers studies on the theoretical and practical aspects of the following:

- -- generation and growth of information in different environments.
- -- collection, storage, organization, and processing of information to facilitate access to and use of, information.
- -- dissemination, diffusion and transfer of information in different user environments.
- -- use, abuse, and impact of information individuals and communities in different contexts.
- -- design, development, and management of information systems and services, manual and machine-based.
- -- social, economic, political, and legal features of information and information systems.
- -- education and research in information.

In such studies information science has necessarily to draw upon a whole spectrum of other disciplines. For example:

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-- mathematical and other methodological sciences in formulating models, equations, statistical indices, etc., of growth, diffusion, transfer, and organization of information.

-- physical sciences, in considering analogues of the phenomena of movement and diffusion, structure, communication, and entropy in the information field.

-- biological sciences, in considering analogues of growth and ageing phenomena of information; genetic epitemology, modes of knowledge and discipline formation; neurophysiological and biocybernetic aspects of information processing and flow.

-- linguistic sciences, in expressing, structuring, coding, and communication of ideas and information.

-- behavioural sciences, in the study of human behaviour in the generation, search, acquisition and use of information.

-- social sciences, in the study of the sociology of information production and distribution, the economics of information, the socio-political, legal, cultural, and management aspects of information availability and utilization.

In a consideration of the expressions of time parameter in information science studies, three factors appear to be interesting:

-- the qualitative and quantitative expressions of time in the information field based on analogues and models largely borrowed from other disciplines.

-- Time as a unifying and correlating concept among a variety of disciplines including information science.

-- changing patterns and developments in the information field which have a time parameter implicity or explicitly associated with them, and their implications to and impact on individual and group behaviour.

II TIME-BINDING AND COMMUNICATION

1 Social Function of Communication

The social function of communication implied in Cooley's definition (vide I, 1) is the ensuring of continuity in society through access to the experiences and ideas of the past expressed in symbols for transmission across space and through time. This is the "time-binding" function of social communication. In the 1920s, Alfred Korzybski [5], the founder of General Semantics, proposed a theory of organic and human behaviour, based on binding ability which provides an insight into the links and differentiation between plant, animal, and man. During the past decades, studies in cybernetics, thermodynamics, ethology, neurobiology, etc., have provided supporting evidence and data for the theory. "Binding" in the Korzybiskian sense means "tying together", "using", "structuring", and "transforming". The binding attributes of plant, animal, and human species are summarized in the following table.

<u>Binding Ability of Plant, Animal, and Man</u>

Organism	Binding ability	Remarks
Plant	Energy binding or chemical binding	Relatively immobile in space; incapable of complex organization, group behaviour, and communication (symbol usage). No knowledge resources and culture.
Animal	Energy binding and Space binding	Capable of limited movement and of simple group behaviour mainly to satisfy biological needs. Incapable of communication from generation to generation through symbol usage. No knowledge resources and culture.
Man	Energy binding, Space binding, and Time binding	Capable of complex behaviour, communication of information, creation and transmission of culture across space and through time using symbols. Transcends space-binding genetic animal background.

Man's time-binding ability arising from his usage of language, number, gesture, picture, and other symbolic forms enables him transcend the limitations of inherited characteristics and the seemingly insurmountable barriers of 'time' and of 'space'.

The insight, the wisdom, the culture and the arts, the ideals of political, economic, technological, and social structures of the world, and the variety of human values and as cultural inheritance and competition -- that is, competition in, with and for, symbolic forms used in communication. Intra-species competition reduces the chances of survival of the species. Therefore cooperation within species is essential to the physical survival and time-binding culture transmission activity of man. Man is a link in the vast transmission line through time of the culture [7]. As Norbert Wiener points out, the cultural community extends to the extent there is an efficient and usable flow of information.

Knowledge and culture transmission and perpetuation-in-time of society is secured not only through oral communication, but also through various social structures and forms: "... rites and rituals, sacraments, ceremonies, and institutions. Language is itself one such institution and the continuity between speech, writing, print, books, and libraries defines language's time-binding institutional function. Other institutions include the family, the temple, economic, social, and political systems, education, industry, agriculture, art and science, moral codes, legal codes etc, uniting people in co-operating, communicating time-binding civilization" [7].

III SOCIETAL HOMEOSTASIS

1 Information and Entropy

Human society can be looked upon as a dynamic open system consisting of individuals, groups, organizations and institutions of various kinds in continual interaction and interchange of energy and messages (information). Here, we shall primarily consider semantic interchange. Open systems have certain common characteristics, such as the following [8]:

Input. - Import of energy from the environment. Man as a biological and social entity seeks and inputs energy and information necessary to satisfy his biological, emotional, intellectual, spiritual, economic, and cultural needs.

Throughput. - The input is processed by performing work and is converted into the output. Man himself is an information processing system. He has also created various information processing systems to help him.

Output. - Inference, data, ideas, description, information, knowledge, documents, etc.

Cyclic character. - Input, processing, output, feed-back, control, adjustment, and adaptation -- each phase supports the next in a cyclical way. From this succession of events in time arises the interrelationships of the pasts of the system and of their functions.

Negative entropy. - According to the second law of thermodynamics the universe is running down. The energy loss or increase in entropy corresponds to the positive direction of time. This time's arrow [9] or probability vector, affects the physical, biological and communicative patterns in the universe. Norbert Wiener points out [10]:

> "As entropy increases, the universe and all closed systems in the universe, tend naturally to deteriorate and lose their distinctiveness, to move from the least to the most probable state, from a state of organization and differentiation in which distinctions and forms exist, to a state of chaos and sameness ... Order is least probable, chaos most probably. But while the universe as a whole ... tends to run down, there are local enclaves whose direction seems opposed to that of the universe at large and in which there is a limited and temporary tendency for organization to increase."

Some of Korzybski's time-binding agents, man in particular, constitute these local enclaves trying to maintain order. The commands through which man exercises control over his environment are a kind of information imparted to it. Increase in the supply of information increases negative entropy, helps to reduce uncertainty, imposes order, and prevents the system from tending towards chaos and disorganization. Leslie White comments in a similar vein from the zoological standpoint [11]:

> "...culture is the means of carrying on the life process of a particular species, Homo-sapiens. It is a mechanism for providing man with subsistance, protection, offence and defence, social regulation, cosmic adjustment, and recreation. But to serve these needs of man, energy is required. It becomes the primary function of culture, therefore, to harness and control energy so that it may be put to work in man's service. Culture thus confronts us as an elaborate thermodynamic, mechanical system."

Information input, negative feedback, and coding. - Negative feed-back is the information on what is wrong, if any, with the system, necessary for making adjustments and take corrective action. Signals received may be expressed as codes. Man has evolved elaborate coding systems to facilitate communication.

Steady state and dynamic homeostasis. - The change in the attributes of the parts of the system over a time period t_1 to t_2 may not be drastic (steady state). On the other hand, information received may cause substantial impact, even cognitive dissonance, on the individual.

Just as the human body is kept in dynamic equilibrium -- that is, homeostasis -- through cell cooperation and communication, so also human societies depend upon cultural communication for their homeostasis. Therefore, cooperative behaviour patterns and the resulting meaningful effective human relations have a high survival value. And these behavioural patterns are based on the act of symbolic communication.

Differentiation. - Division of labour and specialisation of functions and roles of the different parts of the society necessitated by the growth in time of the size of society and complexity of its demands as it evolves from one stage to another adapting and adjusting.

Equifinality. - The possibility of attaining the set goals of the system starting from a variety of initial conditions, by adopting suitable alternative means.

The different phases of the system's working are time-dependent and processes/events such as entropy and steady state are referred/defined specifically in terms of time and information communication.

2 Societal Cohesion and Communication

Human civilization and culture, organizations and institutions are held together over time in a network of mutual dependence and responsibility and the sustaining transactions carried on by myriads of messages communicated over this network. These messages form the basis as well as the regulating, organizing and time-binding influence in social evolution and progress. A failure in communication could lead to misunderstanding, misinterpretation and confusion of the import of the message [12]. In turn, these may cause alienation, aggression and detraction from human progress. Here, communication connotes a deep dynamic and complex series of processes operating together -- the whole range and cycle of perception, memory, information analysis and processing, symbolic transformation, delivery and feedback -- that guide human behaviour towards and transactions with, the physical and social environment. The blending of the resources of cybernetics, information theory, general systems approach and general semantics with those of science and technology has extended human foresight, predictive capacity, and planning capability to guide social intervention and reform. Man, thus, appears to be moving toward influencing the future and directing his own evolution.

IV TIME IN COMMUNICATION PROCESS AND KNOWLEDGE GROWTH AND DIFFUSION

1 General Systems Approach

As an approach to the organization of general systems theory Kenneth Boulding suggested "to look over the empirical universe and to pick out certain general phenomena which are found in many different disciplines, and to seek to build up general theoretical models relevant to these phenomena" [13]. Examples of such common phenomena are: population dynamics, growth-in-time, relative growth, entropy, competition, information diffusion, etc. Selected models of growth-in-time and of communication of information and knolwedge are mentioned here.

2 Growth-in-Time: Exponential and Logistic Patterns

Patterns of growth-in-time showing isomorphism of law in different fields are the exponential and the logistic [14]. For example, growth of science and technology, increase in the knowledge of number of animal species, yeast cells in a controlled environment, publications on drosophila, of manufacturing companies, etc. Isenson [15] has shown that the rate of growth of knowledge over time can be expressed as an equation embodying various limiting factors such as the upper bounds imposed by natural law, political and social constraints, the contemporary level of scientific and technical understanding and the ability of the scientific and technical communities to communicate their new findings. The equation is: $dk/dt = p(t)*Q*bNi(t)[1+Ni(t)]$

where

- $p(t)$ is the probability that a given scientist will make a contribution during an increment of time t, and is a function of the state of the art relative to limits imposed by natural law; $p(t)$ may be thought of as a function of $(1-K(t)/K^o)$, in which $K(t)$ represents the current state of the relevant art and K^o some natural limit such as the velocity of light.
- Q is a measure of the mean productivity factor per scientist or engineer
- $Ni(t)$ is the number of scientists and engineers actively engaged in the i^{th} and related fields.
- b is the communication factor, a measure of the ability of each scientist to keep up with all the developments in his specialisation, and takes a value between 0 and $\frac{1}{2}$.

As several studies have shown, the size of recorded knowledge (literature) in many of the scientific fields doubles, on an average, about every ten years. But exponential growth must have ceilings because of various constraining factors. Otherwise, the growth would reach absurd conditions in the future. And this results in the familiar logistic pattern of growth.

Examples of such logistic functions and curves are:

$$\frac{p(t)}{Po} = 1 - \exp\left(-\alpha T \exp \frac{t}{T}\right)$$

$$\frac{p(t)}{P^o} = 1 - (1 + \beta t) \exp\left(-\frac{t}{T}\right)$$

$$\frac{p(t)}{P^o} = \left[1 + \gamma \exp\left(-\frac{t}{T}\right)\right]^{-1}$$

p being the number of papers, the real parameters α, β, γ permit appropriate adaptation to concrete distributions. The logistic growth curve may not be a normal S-shaped ogive. Historical time series analyses present variants of the curve as seen for example, in the growth of science and technology. Hunting fluctuations and the escalating curve are two examples. The constraining factors causing the variant shapes and the implications to the sociology of science have been the subject of study by De Solla Price [16].

Paul Weiss presents a knowledge growth model on the analogy of the growth model of an organism [17]. Various models of the growth of knowledge over time and their social implications have been examined by Diana Crane [18].

In an investigation of the nature of scientific literature, Price considers it as a network which shows some interesting properties such as the formation of "research front", factor of "immediacy", and growth and decay (obsolescence and half life). The study of such characteristics help to explain, in some measure, the patterns of communication, and cumulation and transfer of scientific knowledge over time [19].

3 Technology Growth: Boltzman Equation Model

Hartman found an analogy between chain nuclear reaction and technology growth. He has suggested that a model for the technology forecast can be derived directly from Boltzman equation [20]. Scientists and engineers are pictured as being immersed in a sea of information, the information being a necessary input for the generation of new information (technology). His thermodynamic model simulates authors by stationery atoms and information carriers by electrons accelerated by an electrical field. A bit of information may collide with a researcher and trigger a new idea or it may not. As it is not possible to predict what piece of information will collide with which researcher and whether a particular collision will be "elastic" or "inelastic" the process is only statistically definable -- providing an acceptable parallel for forecasting technology growth.

4 Information Diffusion: Heat Conduction Model

Avramescu describes [21] a mathematical model for scientific information transfer on the analogy of heat diffusion laws. The information flow equation is similar to Fourier's. The information diffusion process is a multiple chain, one scientific paper stimulating another. The elementary space elements are papers linked together by references and citations in a natural time sequence. Fourier's law, written in linear form $q = - \lambda \partial u / \delta x$, expresses information in space and time as function of growing interest directed from source papers to affected new ones. If λ = constant, the flow is 'linear' and the superimposition principle of single chain would hold. The space coordinate x marks the successive generation of papers p beginning with any selected initial time $t = 0$. Thus, x is proportional to the cumulative number of papers P.

Extending the heat diffusion analogy, information flow would also exhibit another attribute -- accumulation capacity. Thus, $q = k. \partial u/\partial t$, where k is a capacity factor, that is, accumulated information flux per time and space unit, which increase the interest of a user in proportion to his own "capacity" for receiving and processing new information. Using Fourier's homogeneous partial differential equation, it may be shown that diffusion becomes easier when the space elements are more conductive or permeable and when the greater absorbing capacity of the receivers does not reduce the available information. The parabolic differential equation implies: time variations of scientific interest are proportional to the interest variations around any space point, eg. a scientific paper. Discussions about a paper or interlinking between papers enhance interest, concentrate citations and raise the value of any true creative activity.

5 Communication Process: Epidemic Model

Communication, like other processes, is a time-dependent phenomenon — a sequence of events resulting in the transmission of information from a source to a recipient. William Goffman and V A Newill [22] in formulating a generalised mathematical model for the communication process and its associated information systems, consider three problem areas: behavioural, representational, and technical. The mathematical theory of communication developed by Claude Shannon and others [23], deal mainly with the technical problem. Siegfried [24] has dealt with the close parallel between the transmission of disease and the transmission of knowledge. Goffman points out that "because the principles underlying the spread of infectious disease also govern the diffusion of information and the spread of knowledge, a communication process can be represented as an epidemic process". Thus, in developing a mathematical theory of the communication process, the Goffman-Newill model defines the process in terms of a set N (population of objects) together with an agent i (information) which is conveying ideas (infectious material) among the members of N; the members of N pass through a set of states s (susceptible, infective and removed) and the entire process through a set of states S (stable and unstable) with respect to time t. Control system theory is applied to study the growth, decay and stability of such processes. Information retrieval corresponds to processes that enhance the spread of infection by increasing the contacts between infectives and susceptibles. A communication process C can, thus, be formaly expressed by $C = \langle N, i, s, S : t \rangle$. Goffmann has shown the use of the mathematical model to establish relative importance of existing lines of research to the development of a given scientific topic, forecast their future behaviour and forecast the emergence of new important lines of investigation. Fairthorne, in a review [25] of the empirical hyperbolic distributions used in bibliometric description and forecasts, such as those named after Zipf, Pareto, Bradford, Willis, Berger-Mandelbrot, and others, most of which are samples or instances of a family of statistical distributions studied by Paul Levy in 1925, points out that the Goffman-Newill model is, perhaps, the only one involving time explicitly.

6 Idea Diffusion and Social Structure

The usual logistic model of the process of diffusion/growth of ideas in a field could be considered as a simplified contagion model. It assumes seeding and contains only a contagion part. In deterministic form, it may be expressed as:

$$\frac{dn}{dt} = \beta . n(N-n)$$

where N is the population size, n the number of people who have the idea at any time (the haves), N-n the number of havenots, t the time and β the interpersonal diffusion parameter.

Social diffusion process is usually too complex to be reduced to a mechanical contagion process. The diffusion occurs through : (a) scientist-scientist direct informal contact; (b) scientist to scientist contact through an intermediary such as information scientists, scientific editors etc; and c) combination of (a) and (b). The assumption of an inter-mixed population implies that each person has equal number of contacts with each other person. This may not hold good, it is not a random process. The diffusion may take place only in a tight little in-group: for example, the group of haves which may be people who have a great many contacts with each other, but few with the havenots. This aspect of social structure preventing complete intermixing shows the diffusion process. Generally, the slowing down rate is different at different stages of the process [26]. Investigations in progress for some types of incomplete social structure occurring in scientific communication (eg. the invisible colleges, and partially interpenetrating interdisciplinary research groups) has been reported by Le Coadic [27]. Le Coadic points out that the "formal part of the process requires structural measures and the mathematical model characterising such a process must somehow take into account the varying degree and kinds of connectness in the social structures they are meant to characterise. It is necessary to determine the timing, sequence and diversity of the formal information flow and the characteristics of the dissemination (scientific libraries, scientific journals ...) and of the users of each element of the information system in order to identify those elements which are critical and to establish the functional characteristics of the system as an entirety. Consequently, a general formulation of the differential equation that describes this social diffusion process is:

$$\frac{dn}{dt}(x, y, t) = \alpha(N-n) + \beta . n(N-n) + \gamma . \sum n + D . \Delta n$$

where α is the constant source diffusion parameter, β is the interpersonal diffusion parameter, γ is the inter-group diffusion parameter, which measures the degree of inter-penetration, $\sum n$ is the number of persons who have already adopted in the total system, is the spatial diffusion parameter and Δn is the Laplacion of n.

$$\Delta n = \frac{\partial n}{\partial x^2} + \frac{\partial n}{y^2} = \text{dir}\ (\overrightarrow{\text{grad}}\ \underline{M})$$

x, y are spatial coordinates.

7 Idea Acceptance: Time-dependent Models

Related to the concept of diffusion of ideas is the concept of acceptance of ideas by a target group. Morphet [28] has presented a probabilistic model of time-dependent factors governing the acceptance of innovative ideas by industry. Within this framework is analysed the timeliness factor that partially governs the receptivity to innovative ideas of industrial organizations.

The model is based on the assumption that: (a) Even the best innovations do not diffuse by themselves; (b) The commitment of an organization to existing practice will only favour innovation when existing practices become obsolete. The occurrence of such obsolescence is identified with the concept of the New Idea Point (NIP), the point in time at which the organization must have assembled a portfolio of innovative ideas in order to maintain continued existence. The reaction of firms to new ideas between NIP, is associated with the organisational ambivalence - a tension between action and reaction, between need and conservatism - which must be periodically resolved in order to meet the imperatives of the NIP.

The pattern of variation of the attitude of a firm between NIPs is portrayed as a variation in the probability that the firm will incorporate new ideas into its portfolio. To express this, the concept of Idea Collection Curve (ICC) is used. On the assumption that an idea-source can probabilistically locate imminent NIPs in potential users, an optimum timing for the approach to the organisation is derived in the model.

8 Innovation Diffusion Models and Sociological Implications

Everett Rogers and others have attempted generalization of the mode of diffusion of research results in the "market" over a period of time. An innovation is defined as an idea that is seen as new by individual. Thus, innovations include 2, 4-D weed spray among farmers, a new drug among physicians, the IUCD birth-control technique among peasant women in India, a new education technique among teachers, and so on. The crucial elements in the diffusion of innovations are deemed to be (1) the new idea; (2) the communication channels; (3) the particular social system; and (4) time. The element of time distinguishes the diffusion studies from other types of communication studies. Time is involved in the following ways: (1) the innovation decision period through which an individual moves from first knowledge of the innovation to persuasion of its usefulness, to its adoption, and continued use; (2) the rate of adoption of the innovation in a social system, measured as the number of adopters per time period; and (3) the innovativeness or the degree to which an individual is relatively earlier than other members of his social system to adopt new ideas. Factors helpful in accelerating the diffusion and adoption of new ideas/innovations such as, altitudinal type variables, social relationships and strategies adopted by change agents, have also been studied [29].

Other similar models of innovation diffusion over time are those of Clark and Guba and the CASTASIA Model. The diffusion studies of the Centre for Research Utilization of Knowledge, Michigan University, are also relevant [30]. Some of the barriers to the communication of new ideas/innovations are mentioned in section VIII.

Findings of diffusion research have implications to technology transfer programmes, new product marketing, educational innovation spread etc.

9 Acceleration of Innovation and Knowledge Obsolescence

World War II and the events that followed it provided a great impetus for scientific research, innovation and technological change which, in turn, contributed in a large measure to socio-economic change. For example, research in the field of electronics lead to radar and improved communications, computers, early warning systems, control systems, space explorations, and new commercial materials and products. Some of these innovations, particularly in communication and information technologies, enabled greater interaction among researchers and innovators which, in turn, further accelerated the scope and pace of scientific and technological enquiry and innovation. It is estimated that half the total of scientific research conducted in the United States has been done since 1965. Similarly, in UK more than 50 per cent of all new products have been based on scientific and technological discoveries and innovations since World War II. Illustrative data are presented in another paper [31].

In addition to the expansion in the scope of scientific inquiry, there has been an appreciable acceleration in the rate at which new knowledge is put to use. This has resulted in an acceleration in the rate of knowledge obsolescence. The Department of Commerce (USA) estimated that prior to World War I, there was an average wait of 33 years between invention and its application. By World War II, the time lag had dropped to 10 years; and now it is even less. Illustrative data on the rate of obsolescence in different fields are presented elsewhere [31].

Killingsworth, Lynn, and others [30] claim that, in general, considerable acceleration has occured in the rate of diffusion of new knowledge between the early part of this century and the inter-war period with a further acceleration after 1945, although the time-lag from invention to innovation may vary from one field to another. The reasons for the acceleration of diffusion of technology are said to be:

(a) Development of a variety and improved channels of communication of information;

(b) Development of more sophisticated methods for determining the time at which equipment should be replaced, and

(c) Greater receptivity for newer ideas and techniques.

Other findings of the Lynn study include that:

(1) The time lapse between innovation and its utilisation in industry is much shorter for consumer products than for industrial products;

(2) Time lapse is shorter for invention developed using government funds than those using private funds; and

(3) The technology diffusion and transfer time is reduced if the innovator himself undertook the development.

What are the implications? A major change which might have required 5 years to implement a decade ago must now be completed in a shorter time period, if an organization, particularly an industrial or commercial organization, is to remain competitive. On the one hand management reaction time is constantly shrinking, while on the other each decision may involve more risk (because of a large number of variables internal and external, to be taken into account), and is valid only for a shorter time span. Therefore, as reaction time diminishes, opportunity for gainful action may be lost, because preoccupied managers and policy makers may fail to reach out and grasp them.

V TIME AND INFORMATION SYSTEMS

1 Zipf and Bradford Distributions

Since 1960 in the field of bibliometrics two classes of empirical laws have been used fairly frequently. These are the Zipf and Bradford laws [32] both of which are hyperbolic distributions. One of the other laws is used depending upon whether one's interest is in vocabulary or in periodical literature, or physical access time, in the rate of diminishing returns in bibliographical search or in the cumulative yield from a given input. The hyperbolic behaviour, that is, the product of fixed powers is constant, has been noticed for over a century in widely different fields.

In 1916, Estoup [33] noted an empirical relation between the rank of a word in order of frequency, and the frequency of its appearance in a fairly long text. The scope of this observation has been considerably developed and extended by Zipf. The rank of a word r is the number of words, including itself, that have at least the same frequency, f(r), of occurrence. The Zipf distribution can be expressed as:

$$f(r) = k/r \text{ (k approx 0.1)}$$

The time factor involved here is in the explanation of the observed relation in many fields on the basis of the general principle of Least Effort. Two derivatives from the Zipf distribution may be mentioned as illustrative examples.

The equation $n(u) = Ku^{-2}$ derived by Parker-Rhodes and Joyce [34], gives the number of words n(u) in a given vocabulary that occur in a long enough text with relative frequency u. This relation is the same as the Lotka's distribution equation for literary output of authors [35] in a given period of time. Parker-Rhodes and Joyce derivation is based on the assumption, among other things, that "words in the vocabulary are stored and scanned in order of decreasing frequency, that the duration of scansion is proportional to the number of words scanned, and that the language concerned evolved so as to give maximum variety (information) for a given duration of scansion". The maximum liklihood methods is used to derive the equation. The Zipf distribution of exponent unity is arrived at by using information theoretical or statistical methods.

A D Booth [36], assuming a Zipf distribution of book usage, supported by empirical evidence on library borrowing, arrived at the optimal least-frequent most-distant arrangements for the layout of bookshelves and arrangement of books in libraries to optimise access time. He inverted the Parker-Rhodes and Joyce argument. Booth suggests the possibility of some equivalent mechanism for average minimum access time in human cognitive process.

Fairthorne expounded and applied the Least Cost Principle to several problems in documentation and retrieval, from coding through the power required by different alphabets, to the arrangement of books on shelves.

2 Document Life Parameters

It has been observed that if all the citations in a single issue of a periodical or a volume of it for a particular year, are sorted according to the date of the cited documents, then the number falls off rapidly as we move back into time. Since 1960 several studies of this type in different subject fields have been done [37]. From these studies several time-related parameters of "periodical's life" have been isolated. The following are examples.

Half life - the time period, actual or expected, during which half the total use of an individual item constituting a literature has been or is expected to be, made.

Item half life - The time period, actual or expected, during which half the total use of an individual item constituting a literature has been or is expected to be, made.

Median citation age (Apparent half life) - The time period during which half the citations in a citations study occur.

Corrected half life - the half life as estimated by removing the growth element from the median citation age.

Obsolescence - The chance of an item being currently used declines with age. Obsolescence rate is the rate at which liklihood of use declines with age

Obsolescence factor - The factor by which the active life of a literature of a subject field appears to decay annually, as calculated from the number of articles cited in successive years.

Corrected obsolescence factor - The factor by which the active life of individual items in a literature tends to decay annually

Annual ageing factor and Utility factor are other similar useful concepts.

Formulae for determining the above parameters of documents have been worked out and applied by Maurice Line, Brookes, Vickery, and others. The values of the parameters can be used for guiding library management decisions: for example, maintenance of library collection (periodicals, books etc), withdrawal of documents from active circulation, planning of acquisition programmes within a hierarchy of library systems, and identifying significant research in a field.

The Goffman-Newill epidemic model has been mentioned in section IV.5. Fairthorne has reviewed empirical hyperbolic distribution of the Bradford-Zipf-Mandelbrot type used in bibliometry [25]. An interesting use of the Bradford distribution is to check on the completeness of a bibliography. For any subject it is necessary to analyse the productivity of only the most productive periodicals as determined by the Bradford ranked series in order to estimate the complete bibliography. This helps to save time and effort in estimating the size of the literature in the field and the cost of covering the whole or any specified portion of the literature.

Avramescu [21] reports on the deduction of the Bradford's law from the main solution of the heat equation.

3 Waiting Time

In the management of any system including an information system, ensuring receipt of the item sought by the clientele with minimum delay and cost, is an important consideration. The 'waiting time' - the subjective or psychological time - is of special concern here. For users of an information system this may arise in one or more of the following stages: (1) Physical/communication access to the system; (2) Identification and access to the appropriate data base; (3) Use of the tools and techniques to search in the data base to select and retrieve the relevant information/surrogate; (4) Document information delivery; (5) Document/information usability.

Delay in physical access to the system may arise from inadequacies of the transport and/or telecommunication system. Delay in the access to the data base may arise from defective organization or from restrictions on access, or inadequacy in the user capability. Information systems and the tools and techniques used tend to become complex and unless the user is familiar with the sophistications, the use of tools and interaction with the system may involve more time and delay in getting the desired output from the system. Physical access to document and translation into the language of the reader are other familiar delay factors. There have been some discussions of the time factor in library and information management.

A variety of improvements are being progressively incorporated into information systems, manual and mechanized, to secure quick access to relevant information and documents at reasonable cost [38].

4 Temporal Dimensions of Classification

In Fairthorne's interesting paper Temporal structure in bibliographic classification and Phyllis Richmond's commentary on it [38a], attention is drawn to relation of each text to a fan of earlier texts and to later ones, a factor which the classifier uses in assigning a document or discourse to a subject class. From the internal characteristics (subject treated) of two documents, it is possible to discuss whether one is a descendent of the other. "A documentary corpus has a distinct order which is in bibliographic time, not necessarily the same as physical time. Bibliographical time is the time in which the documents presented themselves to the reader or author. This time has no relation to the time of publication." The lapsed time between the two events may be due to communication delay.

One can see the relation of Fairthorne's fan history idea to Kessler's concept of "bibliographic coupling" [38b], bibliographic search using citation indexes [38c], and automatic classification of documents or discourses using citation clusters.

VI RESEARCH COMMUNICATION: SOCIOLOGICAL AND BEHAVIOURAL ASPECTS

1 Overemphasis on Speed?

Timely availability of relevant and reliable information and data is important to the researcher, the production engineer, as well as the manager and planner as an aid in solving problems, making gainful decisions, minimising the chances of unnecessary duplication of effort, and triggering of new ideas [39]. With the increasing demand for information and data, there has been a phenomenal growth in primary information sources, such as books, articles, reports, conference proceedings, etc In finding ways and means of moving information from the point of generation to points where it will have use, the need for speed of communication has been emphasized. For instance, reducing the time-lag between submission of a paper to a periodical and its publication Growth in the number of primary periodicals, publication of short communications, minimising editorial and referring work, adoption of fast printing techniques are some of the results of such considerations. There have been salutory as well as undesirable effects of the ever-increasing quantity of information that hits the researcher at an apparently ever-increasing speed.

Ziman points out that in the pure sciences the supposed wastage of resources through duplication of effort is somewhat exaggerated. Simultaneous discovery arising from concurrent work on the same problem by different researchers is not a bad thing in itself. It provides for a good means of confirmation of the findings or discoveries; the routes taken to the discoveries by the different researchers may be different Experiments may be repeated to improve techniques, increase accuracy of data, etc Also, "the speed of research" varies at different stages, from discipline to discipline and the "speed of supply of information" should correspond to this variation in demand. Ziman writes [39]:

> "What are the time constants of research? These have not been studied in great depth; and probably vary greatly from one discipline to another At the peak of a revolution, for example, as depicted by Watson in "The Double Helix", a few days or weeks may see the breaking of the wave; on the other hand in the formulation of the question to be answered, a decade may not be too long for successful rumination and significant progress. In general, I would confirm the observations of Garvey, who found that the various stages of hypothesis, design of apparatus, experiment,

testing, confirmation, critical analysis, informal discussion, writing up and so on, take months or years to complete, so that the interval of about four months between the receipt of a typescript and its publication in a reputable journal is not a significant proportion of the time required to 'make the discovery'."

Fundamental formulations and important research results which amount to a breakthrough or set a new paradigm in a field, should, of course, be disseminated as quickly as possible. Such starling discoveries are, however, few and far between so that existing quick reporting means may be adequate. What is deprecated is the overemphasis on speed of communication of "research" results leading to a mushrooming of primary publications, and publication of unreferred and poorly edited papers The information seeker's time and effort are wasted in wading through a flood of redundant and not-so-reliable information and data to select those that are really important contributions to the field.

In spite of these depreciations, the rate of proliferation of documents and information exchange media has gone on unabated The 'publish or perish' syndrome is bound up with many questions in the sociology of science (e.g. achievement of a scientist, especially the newcomer to a field, being estimated on the basis of the number of papers published by him, the economics of research and the ratrace for grants, the behavioural aspects of researchers to "scoop the field" as if in competitive business to ensure priority of "discovery" which, in turn, could bring more projects and grants), the economics of the information industry etc.

De Solla price remarks that

"Colleges demand that scientists publish or perish; payment of research funds entails the production of research reports as something more than a fiscal document Publication becomes a responsibility consequent upon the spending of time or of money rather than a privilege consequent upon finding something worthy of the noble archive and the attention of one's peer's .. In the new situation scientists will tend to grasp at all devices to facilitate publication even at the cost of archival value or research communication efficiency. "At the research front the pay-off of rapid communication becomes so great that traditional formal mechanisms for broadcast dissemination are increasingly restrictive and new solutions are found to facilitate information and highly selective insect-borne pollination by the busy bees of the invisible colleges" [40].

The sociological and human aspect of science also throws some light on the motivations of the scientist for quick announcement and speedy communication of his work. The motivation is to establish and maintain intellectual property. Robert Merton from his study of such priority claims and disputes over intellectual property over the past four centuries, finds them a fairly common feature in the history of science. Duplication of discoveries is a widespread phenomenon [41]. The nearly concurrent discoveries resulting from several persons in different parts of the world simultaneously working on the same problem may be a result of quick communication or absence of it. Duplication may be particularly frequent when a research area becomes nearly saturated, another reason for the flattening of the exponential growth curve. Price infers that "First, scientific communication by way of the published paper is and always has been a means of settling priority conflicts by claim-staking rather than avoiding them by giving information. Second, claims to scientific property are vital to the make-up of the scientist and his institutions. For these reasons, scientists have a strong urge to write papers but only a relatively mild one to read them" [42].

The issues discussed above relate to communications in "pure" sciences, the situation is somewhat different in the applied and development research areas. Here one seeks the best available solution to a particular problem, and the rewards of success or cost of failure may be measured in thousands of dollars [38]. Timely information and data helpful in making gainful decisions is vital in competitive industrial research. Speed of movement of information through documentary and nondocumentary media is obvisouly essential in this context. Here too, however, (perhaps even more so than when the users are researchers in the pure disciplines), when users are research managers, production managers, etc, the information system should not only be capable of picking out quickly the most relevant data and information, but also present them in a manner -- eg, digest, technical note, trend analysis with charts and graphs -- which will immediately show the relevence of the information to the activities of the organisation in general and to the special interest and activities of the individual concerned, in particular. Such repackaging of the information and data would facilitate reaction of the individual to the perceived situation in the context of a rapidly decreasing management reaction time to environmental changes.

Ziman points out that "hindrances to the immediate spread of new knowledge (in applied and development research) are not then so much in the machinery of publications, but rather barriers of secrecy deliberately raised around industrial and military research. The communication system of technology is quite different from that of pure science, having different ends, different norms, and altogether different standards of morality".

2 Behavioural Aspects

The expose in Watson's Double Helix presents a part of the human side of research workers in hot pursuit of an idea which is known in advance, to be a breakthrough. In a recent study, Ian Mitroff [43] among other things, examines the changes in the attitude and behaviour of scientists in relation to particular hypothesis, held by them, due to the availability of information and data at different points of time on the object of their hypothesis. The scientific issues considered are: Origin of the moon, temperature history of the moon, origin of mascons, and lunar and terrestrial tektites. Information available on the issues in relation to point in time: before Apollo Mission 11, after Apollo Missions 11, 12, 14 (Now) and after Apollo Missions 14 and 15 (Later). It is shown that "for each issue, the spread of the statistical difference between the various competing hypotheses continually increases over time".

Mitroff also considers the shift in scientific attitude as a problem in information transfer over a time period. Using Henri Theil's equation [44] it can be shown that in a system of mutually exclusively events E_1 ...... E_n with prior probabilities P_1 ...... P_n the expected information of the message which transforms the prior probabilities to the posterior probabilities q_1 ... q_n is given by the expression.

$$I(q:p) = \sum_{i=1}^{n} q_i \cdot [\log_2 (q_i/p_i)]$$

In the case of the hypotheses about the moon, the hypotheses are taken as the events (E), the attitudinal judgements on the various hypotheses as judgements of their respective probabilities, and the Apollo Missions as evidence messages that transform the probabilities. Using the equation, the information transferred between the time periods as a result of the Apollo missions can be computed.

In an approach parallel to the moon hypothesis studies, Kenneth Arrow and others, have been examining how the amount of information processed by businessmen, consumers, stockholders and other 'economic actors' influence their behaviour on the stage of the economic system. It is worth nothing that Theil's equation mentioned above comes from a paper on the use of information theory concepts in financial statements analysis. Such considerations and looking upon information as a key resource, the "information revolution" is influencing the pattern of thought in several fields -- economics, political science, government, sociology etc. Economists are attempting to formulate a new economics of information and over the past decade it has ranged over a wide spectrum of activities in the information field -- from the study of specific activities of libraries to a reconsideration of the role of information in the economic system [45], the welfare economics of symbol manipulation as Jacob Marschak calls it [46].

VII THE EMERGING INFORMATION ENVIRONMENT

1 Fusion of Computer and Communication Technologies

The combination of innovations of the communications field, such as CATV, CCTV, satellite, digitised transmission of graphic and audio inputs, image technology, holography etc. with information technology portends a quantum jump in information transfer [38]. Already in less than a decade, a service industry that was based on relatively short telegraph messages and person-to-person telephone calls has been transformed into a data pipeline that is carrying more and more information. The new technology of communications makes possible a flow of digital data that bursts over electronic circuits from computer to computer, streaks through the air between microwave relay stations and is bounced off satellites from continent to continent. Imperceptably, perhaps, the new capabilities arising from the fusion of these technologies reshape our perception of society. The emerging information environment is characterised by:

1 Exponential increase in volume of information flow.

2 Time and distance no longer being constraints upon communication.

3 Global shrinkage (of time and distance)

4 Decrease in 'time cushion' between socio-technical changes, their impact and consequences

5 Increase in dependence upon information and communications services.

6 Growth of complexly linked systems for basic societal services.

7 Increased interdependence of previously autonomous institutions and services due to feed back required for common information.

8 Abrupt changes in perception of socio-physical environment.

9 Radical conceptual changes induced by increased information and communication.

Conscious use of an elaborate scheme of symbolism (information processing) in his interpersonal and inter-environmental transactions has not only provided man with a survival mechanism and dominance role, but has secured cohesion and reality of human society. In an increasing measure the information processes are being externalized and built into hardware tool systems, which perform various types of information processing for man, at greater speeds, with greater precision, handling vast amounts of information.

The value of the uniquely human operation (thinking) at a computational level has changed by a factor of 10 in the past two decades. Developments in programming such as preprogramming of mathematics and other functions into the computer for routine use is a significant development. The rapid increase in the growth and interlinkage of large computer networks and their control capabilities also represent a significant change, not only in magnitude, but in the qualitatively pervasive impact on human society -- as it begins to rely more and more on cybernetic control systems for myriad routine production, service and maintenance functions. "Rather than machines dominating man, however, this growing interdependence begins to resemble his other symbiotic relations with the natural environs. It is, in effect, a new symbiosis". Time needed for accessibility and processing of information would be considerably reduced in the future as indicated in the illustrative examples mentioned below:

2 Impact of Education

The impact of advances in communication, computer and information technologies hold promise of improving educational facility, and its quality, reducing its cost, and making it more widely and conveniently available. Educational facility is likely to move out into research centres, service centres, communication centres and other off-campus locations including industrial organisations, thanks to the newer information transfer devices, such as television casettes, audiovisual media, computer data banks, etc. This implies a one-time capital expenditure than on expensive teaching tools/faculty. While the new input/output devices would interconnect and bring closer together people of similar interests located in different departments and centres, it may result in less communication, because a large part of the faculty time may have to be devoted to the preparation of audiovisual and other materials for use in the system.

Traditional methods of transmitting knowledge and information through books, blackboards, face-to-face lectures is likely to be replaced by electronic classrooms, automated network linked libraries, and computer-supported pupil oriented instruction. These advances coupled with the automation of copying facilities will accelerate document delivery system. Networking of library and data centres would facilitate access to specialised data files -- demographic, economic and scientific data

As a result of improved services and with people attaining skill in using information technology, the demand patterns are likely to change and consequently the very nature of education may have to change. This will have considerable impact on the management of education.

3 Impact on the Medical Field

The impact of the developments in communication and information technologies in the medical field may be summarised as follows :

(1) Computer-assisted collection and retrieval of medical data; (2) Utilisation of computers in clinical chemistry; (3) Computer prediction of the outcome of reconstruction surgery; (4) Computer support of medical decisions in ambulatory care; (5) Computer-based diaries for the assessment of subjective symptomatology; (6) Augmentation of the decision-making capabilities of physicians; (7) Development of interactive information systems, clinical information systems, ward management information systems, patient data bank, etc.

The remote access possibilities at global distances would facilitate the quick access to specialist consultants. The systems would be designed for on-line interactive mode with the practitioner in the field closely in mind, and with the capability for using natural language, facility for error compensation, video display, etc.

4 Impact on Business and Management

Forecasts on the future of computer-based management information systems indicate: (1) A shift of concentration away from hardware and clerical automation to improved systems design for managerial use; (2) Acceleration in the speed of real-time processing for management planning and business applications The manager of the future will be able to make decisions based on real-time access to data banks and library of easily retrieved programs and mathematical models; (3) Time-sharing developments necessitating the reorganisation of multi-divisional companies; (4) Dedicated services and special data processing bureau for use of the customer; and (5) In general, vast improvements in Management Information Service, but the critical factors would be the manner in which the equipment and software and supporting services are used.

The improved Management Information Service, would provide a wider range of choice for the management and the movement from one area of operations to another (diversification), will be easier and entail a lesser degree of risk Availability of relevant information would reduce the time-lag between the identification of problems and finding solutions to them. The quality of staff functions would be improved with greater certainty of productive and gainful results The management will also be able to draw upon and interact with experts and widely dispersed groups in real-time tele-conferencing mode.

5 Impact on Society

The acceleration of the pace of life (eg. speed-up of production through automation) means that every minute of 'down time' costs more in lost output than ever before. Delay is increasingly costly. Information must flow faster than ever before. At the same time, rapid change by increasing the number of novel, unexpected problems, increases the amount of information needed to cope with those problems. This combined demand for more information at faster speeds is cracking the rigid vertical hierarchies of a typical bureaucracy

New knowledge either extends or outmodes the old. In either case, it compels those for whom it is relevant to reorganize their store of images. It forces them to re-learn today what they thought they new yesterday. Robert Hilliard, a broadcasting specialist for the US Federal Communications Commission, comments: "At the rate at which knowledge is growing, by the time the child born today graduates from college, the amount of knowledge in the world would be four times as great. By the time the same child is fifty years old, it will be thirty-two times as great, and 97 per cent of everything known in the world will have been learned since the time he was born". The tremendous expansion of knowledge implies that on the average, each book contains progressively a smaller fraction of all that is known.

Max Weber points out that the remarkable increase in the speed by which public announcements as well as economic and political facts are transmitted exerts a steady and sharp pressure in the direction of speeding up the tempo of administrative action. Information surges through society rapidly, drastic changes in technology come fast that newer forms of organization that would be instantly responsive, are needed

In the information-rich and technologically fast developing world of tomorrow the pace and direction of social change is likely to be set and guided by those individuals, institutions, and nations having the capabilities for optimal use of information in making gainful decisions in all areas of human endeavour [47].

6 Impact on the Individual

The emerging information environment may prove to be a turbulent one, with shortened lapse time between developments and changes. Many an individual may find it difficult to adapt and adjust if he is not prepared. The positive and negative impacts may occur concurrently or disparately on different individuals. Some of the anticipated impacts are as follows:

Positive Impact. -

1 Extension of sensory ranges through technological developments

2 Increase in higher personalised information and communication exchange.

3 Enhancement of the capability and more frequent inter-personal inter-group dialogues and conferencing through sophisticated media.

4 Better accessibility to a larger proportion of people to available knowledge.

5 Ability to use information process to:

(a) Become more aware and more self-conscious;

(b) Make more free and voluntary choices;

(c) Incorporate more variety into social process; and

(d) Avoid avoidable hardships and costs and expenses through simulation, i. e. social experimentation can be carried out without being tried on people.

6 Individuals may be enabled to play their roles in their peculiar ways.

7 Provide for and encourage personal growth.

8 Higher levels of knowing, caring and achieving self-determination.

Negative Impact: -

1 Information overload

2 Invasion of privacy of various forms.

3 Adverse manipulation of means and media to control news and mould opinion

4 Increased surveillance and monitoring of personal data

5 Decrease in social cohesion with greater fragmentation of attitude and motivation.

6 Increased discrimination via inequable access to advanced skills necessary to use information and communications effectively.

7 Information available in quantitative terms may be given exaggerated significance as easier to incorporate into technology.

8 Collapse of time in information process may burden human adaptation.

9 Illusion of certainty may supress values of voluntary action, eg. displacement of responsibility from man to machine.

Toffler comments [48]:

> "We are witnessing an historic process that will inevitably change man's psyche. For across the aboard from cosmetics to cosmology, from Twiggy-type trivia to the triumphant facts of technology, our inner images of reality, responding to the acceleration of change inside ourselves, are becoming short-

lived, more temporary. We a. . creating and using up ideas at a faster and faster pace. Knowledge, like people, places, things, and organisational forms, is becoming disposable"

7 Leisure Time and Information Services

"Taxes may tower, workmanship grow shoddy, goods inferior, prices outrageous, politics more corrupt, but the one thing that we fear most is boredom. We cannot stand time on our hands. Yet we demand shorter work hours and more time to be bored, an unwholesome cycle wherein senses have replaced the soul". This is an extract from a talk attributed to Sententius Galbo, an olive merchant, to his wife, Cornelia in 462 A D in Rome [49].

The engagement of the individual in worthwhile pursuits, particularly when his time is not used in activities germane to his personal and social interests, has been a concern of various social agencies including libraries and information services, for centuries. This concern is looming larger and larger as the individual finds more and more time, leisure time, on hand, to be occupied. History tells us that the introduction of machinery during the first Industrial Revolution, led to more production, fewer working hours, and more leisure time for the workers; and that the libraries rose to the occasion by providing the workers with such reading material as would help them learn while they earned, to develop their knowledge of and adjust their skills to t.. productive use of the machines and of their own leisur~ time.

Today the 'leisure industry' is geared to providing the individual almost all kinds of experiences he desires. Yet the book, the information services, and communication media have an important role to direct the individual's attention and interests on socially and personally ethical pursuits without at the same time restricting his freedom of choice. The design of information services and knowledge transfer mechanisms optimally suited to this purpose, is an important issue.

VIII BARRIERS TO COMMUNICATION: TEMPORAL DIMENSIONS AND SOCIAL CONSEQUENCES

1 Information and Goal Achievement

In designing information systems a basic premise is that economic, social, and political systems will perform better and more efficiently if a mechanism be provided to ensure that decision-making points have timely access to relevant, reliable, and adequate information. Therefore, obstacles to convenient access to information and absorption of ideas, for example, barriers to communication, can lead to temporal delay in the achievement of social goals. In this section, some of the constraints to communication and their socio-cultural implications, particularly at the international level, are briefly considered.

2 Influencing Factors

Communication of ideas, the basic behavioural act of man, has helped to accelerate change in almost every sphere of activity designed to satisfy his wants of one kind or the other In fact, the technological achievements since World War II have been so dramatic that people have been able to share the hope that they need no more go hungry, ill-clad, or unsheltered due to ignorance -- that is, inaccessibility or delay in the access to knowledge and the means of its utilization. Yet it is apparent that vast numbers of people are living close to misery, fear, tension, and conflict. Programmes for the sharing of the affluence and misery between the haves and havenots have, in many a case, failed to produce the desired result. Here again, inadequate information, delayed information, misunderstanding of information, or misuse of information, have been among the principal causes of the failure.

Attributes of the social system. - The attributes of the social system as a whole that may influence the effectiveness and speed of transfer of ideas and, therefore, of culture among people, include the following:

1 Whether the situation involves one-to-one, or one-to-many, or many-to-one, or many-to-many communication.

2 Whether the communication takes place within the national boundaries or across national boundaries

3 Whether the transfer of culture is attempte among equals or non-equals. For example, between economically advanced and economically less advanced countries; or between an information-rich country and an information poor country; or between a governing country and the governed country; or among a group of economically more or less equally developed countries; or among politically equally powerful countries; or among less developed countries with more or less the same GNP level.

4 The total scientific, social, political, and economic environment during the period of transfer of culture

5 The total scientific, social political, and economic environment of the past in which the participants in the transfer process have been respectively placed, and the expected change in these factors as a result of the communication and transfer and exchange of ideas.

6 The noise, the garbage, the resistance, and the adaptability characteristics of the infrastructure already present in the recipient social system.

Attributes of Communicator and Communicatee. The attributes of the communicator and communicates (participants) that may affect the communication process and the transfer of culture include the following:

1 The objectives and motivations of the participants involved.

2 The degree of difference in the religious, educational, economic, social and cultural background among the participants.

3 The intimacy of contact between the participants.

4 The prior experiences of the participants in similar contextual situations.

5 The degree of difference in the information richness between the participants.

Attributes of Medium and Mode of Communication. - The attributes of the medium and mode of communication that may affect the idea transfer process include the following:

1 Whether the communication is directly between any two of the participants or whether an intermediary is involved.

2 If an intermediary is involved, then whether it is an individual, an institution, or a machine system.

3 If it is a human intermediary then some of the attributes of the communicator/communicatee mentioned in section 55 are applicable to the intermediary.

4 If it is a machine system intermediary, then the particular characteristics of the machine system used.

5 Ability of the participants to use effectively the intermediary -- whether human or machine -- to achieve their respective objectives

6 Tools and techniques of communication: Verbal, non-verbal, language (natural and code) used, recording medium, etc.

Taxonomy of objectives and Communication Across Cultures: Time parameter. - In a scientific inquiry of an object (a system, a phenomenon, or an artefact in general) the usual question to which an answer is sought is 'What is it?' This is a question of identification. This generic question is paraphrased or divided into several questions such as the following:

- What are its interesting attributes?
- What is it for? How does it serve our needs?
- How did it arise?
- What is it made of?
- How does it work?
- Where did or does it occur?
- When did or does it occur? } Time associated questions
- How long did or does it last? }
- Which time-slice is of particular interest }

The answers to these questions are expected to increase the inquirer's understanding of the object under study. These parameters are also used in developing a taxonomy or classification of objects and to organize information about the objects. Such a taxonomy and organization of information are deemed to assist effective communication with those who seek information about the object. However, one needs to be aware of the different cultural contexts, framework, or paradigms in which the objects might have been originally studied and the framework that the enquirer may be using. And this difference can affect cross-cultural communication. For instance, in most of the modern information classification systems "time" is used as a parameter for categorization, together with all the relevant and related qualitative and quantitative expressions of time, eg, past, present, future, early, late, two o'clock, 1975, Gregorian calendar, etc. But there are cultures whose concept of time may be in complete variance with this sort of conception. For example, some of the Amerindian cultures (Navajo, Pueblo, Sioux), some of the South Sea island cultures, some of the Latin American cultures. The question is often raised how compatibility can be achieved between two different taxonomies of time such that cross cultural communication of information can be made effective.

The 'silent language of time' used in different cultures in different ways to communicate a person's or a group's reactions to environmental situations has been eloquently and analytically dealt with by E T Hall [50].

Particular taxonomies arise according to needs. For example, in some of the South Sea Island communities all the seven colours with which we are familar are not recognized, for they do not need all of them for the conduct of their daily activities. It is also known that as some of the community members became 'modernized' and shifted to another cultural context, their communication repertoire absorbed additional colour concepts and vocabulary.

The following list gives an overview of the "barriers to communication"[51] which adds a temporal dimension to communication of and access to, information.

Language

Man-Man
Man-Machine

Jargon

- Neologysm
- Synonym
- Acronym

Presentation

- Level
- Style

Media problems

- Comprehension difficulty
- Perception difficulty
- Aliennes to reality
- Misunderstanding
- Misinterpretation
- Differential role perception

Culture

Over population

- Primary papers
- Rehash
- Abstracts, digests, extracts etc

Pollution (Noise)

- Propaganda
- Redundant data
- Error

Information handling delay

- Publication
- Translation
- Processing
- Searching and accessing
- Document delivery
- Feedback

Economics of information system

- Direct cost
- Overheads

Therefore, attempts to introduce a new idea or an innovation without a proper understanding of these socio-cultural and psychological characteristics of the target group, and also the attributes of the communication system can not only delay socio-economic change in the desired direction, but the cure may even prove to be worse than the disease. Two decades ago, Margaret Mead [52] warned:

> "... how destructive contact has been in the past between technologically developed and technologically less developed cultures, how often the price of progress has been to turn proud aristocratic nomads into pitifully limited factory workers shorn of their own tradition and provided with no new values. What is the cost of technological change in terms of the human spirit? How much destruction of old values, disintegration of personality, alienation of parents from children, of husbands from wives, of students from teachers, of neighbour from neighbour, of the spirit of man from the faith and style of his traditional culture must there be? How slow must we go? How fast can we go?"

IX FUTURE

1 Role of Tomorrow's Information Worker

The new information technologies resulting from the fusion of computer and communication technology were mentioned in Section VIII.

The machines with properties of superior perception, computation and retention faculties will grow to be partners in progress in human endeavour. They are already more precise and "knowledgeable" than the frail human beings they interface with. This takes us then to the role of tomorrow's information worker. There are, perhaps, essentially two functions which the human users of the responsive machines might perform better than they could now:

1 Conceptualization, that is, the design of patterns correlating many separate data in a meaningful way; and

2 Imagination, which implies the possibility to break through known patterns and devise new possibilities.

Therefore, man would be indispensable, inspite of the technological advances, since his mind can visualise relationships which transcend the rational or what is considered rational at present, and also because he would be able to conceive alternative methods or systems based on different attitudes, surmises and objectives.

Jungk [53] suggests the following five important future roles for information worker:

(a) The first important role of the information worker would be his linking function as a Generalist inspite of the tremendous amount of information produced. This would imply the development of horizontalists (as opposed to verticalists) who would carry out two kinds of synthesis -- synthesis within one discipline and inter-disciplinary synthesis. As a result more and more review articles would be published by libraries and information centres.

(b) Secondly, the information worker should be a Pop designer (Profile of Public designer). He should profile the different kinds of ideas coming from the public so that the decision-makers could see what the needs and desires of public are. This would imply that the public would be much better informed and educated than they are at present, and also that the information worker would create the motivation for learning in the public.

(c) Thirdly, the information worker should be a Sniffer for information. There is considerable work being carried out in laboratories, and information on it often diffuses too late. So there is a need for observers who might build up an intelligence network of ongoing developments.

(d) Fourthly, the information worker should be a Mixer and Modeller of information. This would facilitate creation of models which would enable us to develop more complex concepts.

(e) Fifthly, the information worker should be a Gate-opener. The information worker will have access to more and more proprietary information which would be required by the state as well as the industry. Therefore, there is a need for keeping as many information channels as possible open. The information worker, as a gate opener, will have to work diligently, strongly and even dangerously against the growing tendency to close up information, to own information and not let other people have it. This is exceedingly important as the future will be influenced not only by technological, but even moral change, which might imply new responsibilities to mankind as a whole, transcending order, and more parochial loyalties of today. These future roles of the information worker would become essential in order to prevent further alienation and disaffection of modern man, which stems from the deepening ruptures between the individual and his world caused by technology and its shattering impact.

In various ways these roles of the information workers of tomorrow highlight their participation in and contribution to alongwith other agencies, the "education for survival" of humanity as a whole.

2 Some Research Issues

In an increasing measure, it is being realised that peace and prosperity in the world requires the creation of a new international economic and social order — something different from the order that obtains now marked by dichotomies, distinctions and discriminations, of haves and havenots, rich and poor, advantaged and disadvantaged, privileged and underprivileged, developed and underdeveloped. The creation of this new economic and social order depends on the cooperative and collaborative action among nations institutions of all kinds, and different social groups, so as to bring about the appropriate changes in attitudes of people as well as in social structures in the hope that it would lead to a reduction in the gap between cultures, between nations, and between social groups. Knowledge is the principal instrument of social and economic change, and the sharing of knowledge could be an effective means of reducing and bridging the gaps – spatial, temporal, cultural – in and between societies. The capability for knowledge transfer and information handling is both the potential for change as well as the indicator of achievement in material wealth. As the Club of Rome second report puts it: "All contemporary experience points to the reality of an emerging world system in the widest sense which demands that all actions on major issues anywhere in the world be taken in a global context and with full consideration of multidisciplinary aspects. Moreover, due to the extended dynamics of the World system and the magnitude of current and future change, such actions have to be anticipatory so that adequate remedies can become operational before the crises evolve to their full scope and force. If actions are to be anticipatory and effective, they must be based on a supply of information which is as complete and accurate as it can be made to be." The emerging trends in the information field — for example the new economics of information based on the concept of information as the major non-depleting reasource of society, the profound mutual impact of society and information, the shifts in the loci of decision making and exercise of power — would these lead to the new economic and social order the United Nations hope for? Or, will the changes merely create a shift in the balance of power, new cultures, and precipitate new disparities in society? It is prophesied that everybody will benefit from the coming change propelled by increased access to information; it is a non-zero sum game. Will the reduction of gaps in society lead to a uniformisation and averaging out? Or, will there be adequate scope for the development of the individual, his personality and creative ability? Will the creativity be achieved through better use of the "grey cells" of the human brain – use of a larger proportion and for a longer period of time of the individual's life-span? Will this be accomplished by genetic engineering, or by an alternative technology, such as transcendental meditation? Will these be alternatives or complementary technologies useful in different contexts? The increased creativity, will it result in less or more use of information per individual on the average?

Whether the kind of society that will emerge say in the next twenty-five years would be the most desirable kind remains to be seen. In any case, in the coming decades a good part of the world's efforts will be directed towards devising means and methods of quicker access to and use of a larger volume of information at all levels. Will the developing countries benefit from these efforts? Should they use the same technologies that are now being developed in the technologically advanced countries? Or, should they look for complementary and alternative methods to achieve the goals they set for themselves?

Given the fact that whereas the totality of production, storage, organisation, distribution, and utilisation of information is a long range and expensive business, but that information is the basis of gainful decisions, planning, and control at all levels of human activity, there are several questions the correct answers to which could provide the elements for formulating an objective and integrated information policy. Such questions include the following:

--What are the criteria and guiding principles for apportioning national resources to information activities on the one hand and other sectors -- science, technology, economic, political, and cultural activities -- on the other?

--What are the returns and the social cost of the investment on information and how are these to be measured and evaluated? What are the criteria, means and methods for the purpose?

--How do we judge and allocate resources for the production, processing and distribution of transient but, perhaps, immediately useful data (eg. commercial information) vis a vis the more permanent information but which gives a deferred return, such as educational materials, scholarly works, and the classics?

--Is there a difference in the degree of urgency and accuracy of information needed in different areas of activity -- eg, information for business decisions and information for research?

--What is the trade off between search and utilization of existing information and the production and utilization of the needed information?

--How would one place differential weightage on different modes of information transfer -- eg, documentation services, education, mass media, etc. ?

--In the interest of maximal benefit to society, how do we distribute the controls over the existing stock and the new flows of information science several participants may be involved in the whole process -- the generator, the recorder, the collector, the distributor, etc.

NOTES AND REFERENCES

[1] COOLEY, Charles: Social organization: A study of the larger mind, p 61. New York, Scribner

[2] LUNDBERG, G...ge: Foundation of sociology, p 253. New York, MacMillan. 1939.

[3] McIVER, R M: Society: an introductory analysis, p 5, London, MacMillan. 1963.

[4] ADKOFF, Russell L: EMERY, Fred E. On purposeful systems. p 5 London, MacMillan. 1965.

[4a] WHITROW, G. J: What is time? London, Thames and Hudson. 1972. Chapter L.

[5] KORZYBSKI, Alfred: Time-binding: The general theory. Presented before the International Mathematical Congress 1924. Toronto, Canada.

Idem. Second paper: Presented before the Washington Society of Nervous and Mental Diseases. 25 June 1925.

Idem. Manhood of humanity: The science and art of human engineering. New York. 1921

Idem. Science and sanity: An introduction to non-Aristotelian systems and general semantics. 2nd ed. Lancaster, Pa., The Science Press Printing Company. 1933. (International non-Aristotelian library).

[5a] Cf. works of A L KROEBER, Edward L Sapir, Clyde Kluckholn, Ashley Montague, Leonard Bloomfield, George L. Traeger, Henry Lee Smith.

[6] McGARRY, Kevin J: Communication knowledge and the librarian. p 46. London, Clive-Bingley. 1975.

[7] EVICA, George M: Times arrow and the world's order. A reevaluation of Korzybski's binding theory, etc: A review of general semantics, vol 20, No 4, May 1963, p 421-437.

[8] BERTALANFFY, Ludwing von: General systems theory - A critical review. In: Buckley, Walter (ed). Modern systems research for the behavioral scientist. p 11-30. Chicago. Aldrine Publishing company. 1968.

[9] EDDINGTON, Arthur: Time's arrow and evaluation. p 5-6 Princeton, N J.

[10] WIENER, Norbert: The human use of human beings: Cybernetics and society. p. 12. Garden City, N Y Doubleday Anchor. 1954.

[11] WHITE, Leslie: The science of culture. p 367. New York, 1969.

[12] NEELAMEGHAN A. Social change, communication of ideas, and library service with special reference to developing countries. Library science with a slant to documentation (Bangalore) 1973, 10(1), 1-29.

[13] BOULDING Kenneth E: General systems theory - The skeleton of science. In: Buckley, Walter (ed). Modern systems research for the behavioral scientist. p 3-10. Chicago, Aldine Publishing Company. 1968, 525p.

[14] BERTALANFFY: op. cit. p 23.

[15] ISENSON, R S: Technological forecasting in perspective. Management science (Providence, RI). October 1966, p. 370-83.

[16] PRICE, Derek J De Solla: Little science, big science. p 23-24. New York, Columbia University Press. 1963. 119p. (The George B Pegram Lectures).

[17] WEISS, Paul: Knowledge: A growth process. In: Kochen, Manfred (ed). The Growth of knowledge. p 209-215. New York, John Wiley & Sons, Inc. 1967.

[18] CRANE, Diana: Invisible colleges. Diffusion of knowledge in scientific communities. Chicago, The University of Chicago Press, 1972.

[19] PRICE, Derek J De Solla: Network of scientific papers. Science, Vol 149, 30 July 1965, p 510-515.

[20] HARTMAN, L M: The prospect of forecasting technology. p 237. New York, MacMillan Co. 1966.

[21] AVRAMESCU, A: Modelling scientific information transfer. International forum on information and documentation. 1975, 1(1), 13-19.

[22] GOFFMAN, William; Newill, V A: Generalization of epidemic theory. Nature, 1964, 204, 225.

Idem: Mathematical approach to the spread of ideas - the history of mast cell research. Nature, 1966, 212, 449-52.

Idem: A general theory of communication. In: Saracevic, Tefko (ed) Introduction to information science. p 726-747 New York, R R Bowker Company, 1970, 751p.

[23] SHANNON, Claude E: The mathematical theory of communication, Bell system technical journal, 1948, 27, 379-423, 623-56.

[24] SIEGFRIED, A: Germs and ideas. London, Oliver and Boyd. 1965.

[25] FAIRTHORNE, Roberta A: Empirical hyperbolic distributions (Bradford-Zipf-Mandelbort) for bibliometric description and prediction. Journal of documentation, 1969, 25(4), 319-43.

[26] COLEMAN. J.S.: Introduction to mathematical sociology. N.J. Free Press of Glencoe. 1964.

[27] LE COADIC Y.F: Information systems and the spread of scientific ideas. R & D Management, 1974, 4(2), 97-111.
1974, 4(2), 97-111,

[28] MORPHET, C.S: A probabilistic model of time-dependent factors governing the acceptance of innovative ideas by industry. R & D Management. 1974. 4(3), 165-75.
1974, 4(3), 165-75

[28] ROGERS, Everett M; STANFIELD, J David: Adoption and diffusion of new products: Emerging generalization and hypothesis. In: Bass, Frank M. King, Charles. W; Pessemier, Edgar. A. Applications of the science in marketing management, p 227-250. New York, John Wiley & Sons, Inc. 1968.

[29] ROGERS, Everett M; STANFIELD, J David: Adoption and diffusion of new products: Emerging generalization and hypothesis. In: Bass, Frank M; King, Charles. W; Pessemier, Edgar. A. Applications of the sciences in marketing management, p 227-250. New York, John Wiley & Sons, Inc. 1968.

[30] NEELAMEGHAN, A: Technology transfer: A system analysis approach to the study of its features. Annals of library science and documentation (New Delhi), 1973, 20(1-4), 1-25.

[31] NEELAMEGHAN, A: op. cit. tables.

[32] ZIPF, George K: Human behaviour and the principle of least effort. New York, Hafner, 1949.

Idem. Psycho-biology of language. Boston, Mass., Houghton-Mifflin, 1935.

BRADFORD, S C: Documentation. London, Crosby Lockwood. 1948.

BROOKES, B C: Bradford's law and the bibliography of science. Nature, 1969 (6 December), 224.

LEIMKUHLER, Ferdinand F: The Bradford distribution. Journal of documentation, 1967, 23(3), 197-207.
197-207

[33] ESTOUP, J B: Gammes stenographiques. 4th ed. 1916

[34] PARKER-RHODES, A F; JOYCE T A: A theory of word frequency distribution. Nature, 1956, 178, 1308.

[35] LOTKA, Alfred J: The frequency distribution of scientific productivity. Journal of the Washington Academy of Sciences, 1926, 16, 317-23.

[36] BOOTH A D: On the geometry of libraries. Journal of documentation, 1969, 25(1), 28-42.

[37] BURTON, R E; KEBIER R W: The 'half-life' of some scientific and technical literatures. American documentation, 1960, 11(1), 18-22.

BROOKES B C: The growth, utility, and obsolescence of scientific periodical literature. Journal of documentation, 1970, 26(4), 283-94.

LINE, MAURICE B: The 'half-life' of periodical literature: apparent and real obsolescence. Journal of documentation, 1970, 26(1), 46-52. Note by E C Vickery. p 53-54.

BUCKLAND M K; HINDLE A: Library Zipf. Journal of documentation, 1969, 25(1), 52-57.

BROOKES B C: The complete Bradford-Zipf 'bibliograph'. Journal of documentation, 1969, 25(1), 58-60.

[38] NEELAMEGHAN A; SEETHARAMA S: Information transfer: The next twenty-five years. Librarianship and information science in 2001. A seminar arranged by the British High Commission, British Council Library, on the occasion of its silver jubilee, Madras, 7-10, October 1975. p 9-37.

[38a] FAIRTHORNE, Robert A: Temporal structure in bibliographic classification. In: Wojciechowski, Jerzy A., (ed). Conceptual basis of knowledge. Proceedings of the Ottawa Conference on the Conceptual Basis of the Classification of Knowledges 1-5 October 1971. Pullach/Muenchen, Verlag Do-Kumentation, 1974 p 404-412. Review of the paper by Phyllis A. Richmond. ibid. p 413-415,

[38b] KESSLER M W: An experimental study of bibliographic coupling between technical papers. Cambridge, Mass., M I T., 1961.

[38c] MARGOLIS J: Citation indexing and evaluation of scientific papers. Science, 1967, 155(3767).

[39] ZIMAN J M: Information, communication, knowledge. Nature, 1969 (25 Oct), 224.

[40] PRICE, Derek J. De Solla. Communication in science: The ends - philosophy and forecast. In: De Reuck, Anthony; Knight, Julie (ed). Communication in science: Documentation and automation. p 203-204. London, J & A Churchill Ltd. 1967. (Ciba Foundation volume).

[41] MERTON, Robert K: Priorities in scientific discovery: a chapter in the sociology of science. American sociological review, 1957, 22, 635.

Idem. Singletons and multiples in scientific discovery: a chapter in the sociology of science. Proceedings of the American Philosophical Society, 1961 (Oct), 105, 470.

[42] PRICE, Derek J: De Solla. op. cit. p 69.

[43] MITROFF, Ian. I: Behavioural view of the moon: Apollo 15. The subjective side of science. A philosophical inquiry into the psychology of the Apollo Moon scientists. p 146-191. New York, American Elsevier Publishing Company Inc. 1974.

[44] THEIL, Henri: On the use of information theory concepts in the analysis of financial statements. Management science (Providence, RI), 1969, 15(9), 459-80.

[45] HIRSCHLEIFER J: Private social value of information and the reward to inventive activity. American economic review, 1971, 61, 561-74.

Idem. Here are we in the theory of information. American economic review, 1973, 63, 31-39.

LAMBERTON, D M (ed): Information revolution. Annals of the American Academy of Political and social science, 1974 (March), 412.

Nobel winner engrossed by balancing act. New York times, 26 November' 1972.

[46] MARSCHAK J : Economics of enquiring, communicating and deciding. American economic review, 1968, 58, 1-16.
1968, 58, 1-16
[47] Conference Board (New York): Information technology. Some initial implications for decision makers. New York, The Conference Board. 1972.

[48] TOFFLER, Alvin: Future shock. p 153. London, Pan Books Ltd. 1970.

[49] Quoted by Boris Pregel in his conference dinner opening remarks, International Conference on Environment and Society in Transition, New York, 1974, Annals of the New York Academy of sciences, 1975 (Sept), 261, 265.

[50] HALL, Edward T: The silent language. New Delhi, Affiliated East-West Press Pvt Ltd. 1959.

[51] Modified version of BASU, R N. Barriers to effective communication in the scientific world. IEEE Transactions on professional communication, PL-15, 1972 (June), No 2, 30-33.

[52] MEAD, Margaret, ed. Cultural patterns and technical change. New York, Pocket Books, 1955.

[53] JUNGK, R: Future developments in information technology: The implications of future technology for tomorrows' information worker. Aslib proceedings, 1972, 24(1), 22-30.