Methods and Research for Design of Information Networks

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THIS ARTICLE CONCERNS questions of research appropriate to the design of networks of library and information services and is organized into four sections. The first section reviews a selection of previous statements on research areas held relevant and important to the design of library and information networks and suggests a derived functional framework into which most of these viewpoints can be accommodated. The second section briefly distinguishes between two basic goals of information network design, and it characterizes their respective design approaches in terms of methodology. In the third part, information networks are postulated which assume the accepted present-day premises of library and information service objectives, and the research effort conducive to the design of such networks is discussed. The last section of the paper attempts to indicate major assignments for research in the design of information networks which extend the scope of current information services and objectives.

With varying degrees of conviction and emphasis, research on information service systems and networks has usually been viewed as a necessary or desirable component of efforts, the goal of which is the design of such systems and networks. If the role and topical direction of such research were to be summarized in a single sentence, it would be difficult to do so more concisely or encompassingly than does the statement made in 1960 in the U.S. Senate: "The most pressing need therefore is for the development of reliable methods for studying and assessing requirements, for determining the role of information and information services in science, and for measuring the value of information and the utility and effectiveness of present and proposed services." [1]

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The following sample of comments on the role and the areas of research relative to the design of library and information service systems and networks represents viewpoints which are consensuses rather than opinions of individuals. These comments demonstrate varying degrees of concern by the profession and by the scientific community, and they impart an overview of problem areas and of approaches to solutions which these groups have considered significant. (No attempt is made in this paper to review or summarize recent and current research on issues relevant to information networks; the reader is referred to several publications [2] which accomplish this task quite well.) Two types of comments are especially indicative: those emanating from reflective deliberations of qualified study groups and committees, and those underlying large-scale experimental efforts in the direction of modern information-sharing networks.

Project Intrex, conceived in 1965, partially qualifies among the latter efforts. Although planned primarily as a program of experiments addressed to the broad problem of access to bibliographic materials and conducted in an atmosphere of a model library, it proposed to "explore a range of ideas designed to promote the integration of university libraries into the national (and, ultimately, international) network of information centers." [3] The suggested direction was to develop a direct, inexpensive interface with any citation retrieval service, such as that of the National Library of Medicine or the National Aeronautics and Space Administration, and to be available to the M.I.T. community as well as to a variety of other users. A supporting program of research mentioned by the Intrex planners was to attack "the primitive state of two critical items: [computer] consoles and interaction languages." [3]

A study conducted by the Interuniversity Communications Council (EDUCOM) in the summer of 1966, began to explore the establishment and operation of information networks with an enumeration of a few key problems or problem areas, including those of formal organization, financial support, standardization and quality control, copyright, evaluation of operation, and the roles of the individual and the community. The study produced a technical plan [4] for the establishment and evaluation of a pilot national information network, implying that the state of the art had sufficiently progressed to permit its design and experimental operation. However, another EDUCOM conference, held in the fall of 1967, discussed the need for more accurate data relating to the decision on the storage medium for textual

portions of library collections; [5] subsequently, EDUCOM announced it would study numerous different characteristics of physical information records prior to considering the design of experimental equipment and conducting experiments, tests, or studies.[6]

The Bolt, Beranek and Newman study for the Council on Library Resources, Inc., on concepts and problems of future libraries [7] urged advancements of relevant sectors of technology through the mechanism of positive interaction among the disciplines of library science, computer science, systems science, and the behavioral and social sciences. Concerned primarily with the incorporation into information services of procognitive functions, the report identified the following needed research efforts: the determination of basic characteristics of the relevant network that interrelates the elements of the fund of knowledge (that is to say, the development of an effective, formal analytical semantics); the development of advanced memory systems likely to come from studies of higher order associative memories; the development of fast processors for manipulating complex information representations and structures; the development of advanced displays and control for man/computer interaction; the development of procedure-oriented, field-oriented, and user-oriented languages with which to control the processing and application of the body of knowledge; an understanding of machine processing of natural languages; and the development of multiple-access computer systems.

The Carter report provides a brief review of the feelings on research by those groups and individuals who concerned themselves with the issues and plans of national document systems. Summarizing the discussions of further needed research in fifteen such plans offered up to 1967, the report states:

> The most frequent recommendation was to develop "standards" of one kind or another (e.g., standards for indexing, abstracting, communications, hardware, cataloging). A notable feature of these recommendations was that the plans called for *what* was to be standardized, but made no recommendations about *how* this was to be accomplished. The next most frequently mentioned areas for additional research were those of developing educational curricula and of studying the needs for better equipment and facilities. Other important topics proposed for research and investigation included: (1) Informal communications. (2) User needs and characteristics. (3) Inventories of libraries and other information resources. (4) Improvement of publications and technical writing. (5) Copyright and patent problems. (6) Classified and proprietary information.[8]

The Carter report itself was concerned primarily with organizational issues; it did, however, recognize research as an important function of the "capping agency" (which would manage the design and operation of the national document system), and called in its basic propositions for a "balanced program that will give appropriate weight to all aspects of the necessary research and development." It proceeded to single out the following among the areas of most pressing current needs for research: user studies to determine both the recognized and the unrecognized needs of users; document representations by both manual and automated means; evaluation tools and techniques for assessing the adequacy of information systems; communication of information to clarify the role of documentation and other media of information transfer; and equipment for the storage, manipulation and transmission of information to users.

The most recent consideration of research needs relative to the pressing national problem of scientific and technical communication was offered by the Committee on Scientific and Technical Communications (SATCOM) of the National Academy of Sciences—National Academy of Engineering. (Of the previous policy milestones in science communication, the 1963 report of the President's Science Advisory Committee, the Weinberg Report, avoided specific recommendations on needed research areas, aside from urging all organizations concerned with technical information to investigate the new techniques and ideas and giving its approval to "practical tests of new modes of technical communication." [9] In the 1965 report on a national information network in science and technology issued by the Committee on Scientific and Technical Information,[10] COSATI was particularly concerned with indexing and abstracting costs and effectiveness.) The SATCOM study,[11] which concerns itself with many of the issues of the Weinberg Report, repeatedly harped on the lack of understanding concerning communications research and of data on various systems aspects of the process of scientific and technical communication. As for desirable areas of research, SATCOM recommended several areas of study, research and experiments, including the following: comprehensive analyses and experiments on the functioning of different parts of the scientific and technical communication network and on its overall operation, the development of measures of the value of information services and ways of overcoming user apathy or resistance, experiments involving the use of the computer in conjunction with human workers for the preparation of indexes, the development and evalua-

tion of languages for describing the formats of files and other types of digital communication systems, and the development of standard structures for each widely used bibliographic documentary information element. SATCOM further urged scientific and technical societies to participate in research, recommended large-scale experiments, and suggested that the federal government establish a single group to plan a unified program of critical experiments of operational scale.

It would be unfair to expect from any of these well motivated and knowledgeable quarters a definitive discussion of research requirements: some were concerned with narrower, usually political, aspects of information networks, and a few with the broader problems of scientific and technical communication. In addition to these eclectic consensuses, numerous personal opinions on research stand recorded by individuals from diverse walks of life. Predictably, they are uneven in both purpose and content, ranging all over the research map (and even rejecting it as either irrelevant or resolved). Jointly, however, these discussions strongly imply that there has been no attempt made so far to provide a reasonably detailed outline of the social, technical and management problems whose solution is necessary and sufficient for the design of advanced information networks.

To understand the reason for the absence of a research plan and schedule, or even of a research manifesto, it is helpful to consider the dual form in which research can exist. These two forms are perhaps best illustrated by an analogy which contrasts the self-directed, sporadic and spontaneous research in the aerospace and aerospace materials sciences before 1960 and the defined, planned research effort in these sciences under the Apollo program of NASA. The distinction lies, of course, in the degree of definition of the research purpose and mission. The absence of a comprehensive research schedule for the design of advanced information networks thus infers a lack of technical plans to implement such networks.

What is the range of the research areas which bear on the design of library and information networks? Table 1 attempts to suggest a framework for placing social, technical and administrative considerations into a functional, discipline-oriented relationship. While nearly all calls for research fall into this framework, there is less agreement on the relative value of individual areas and topics.

A *plan* to design and implement an advanced network of library and information services is actually a statement expressing known relations and dependencies of significant component activities and pro-

cesses of the task. Once such a plan has been drawn up, it is relatively easy to identify what problems, if any, should or must be researched. In the absence of a plan, however, discussions of proposed or necessary research should at least outline the concept or form of the information network to which they refer; without such an outline, the question of research need and value often remains open.

For the purpose of our discussion, a generalized concept of library and information networks may be given in terms which are reasonably familiar. As its basis, we assume the existence of a physical network of information processing devices communicating in a machine-to-machine mode. This network forms a physical substratum which provides a switching capability permitting people and machines to access a variety of partially compatible information and data banks. The content of these banks then can be maintained and manipulated by means of instructions stored in programs, or conversationally from local or distant inquiry stations, to provide a range of information products and services. Since commercial as well as military data communications networks are under advanced development in the United States, mechanized library and information networks are undoubtedly technically feasible.

Table 1. Research Areas Relating to Design of Networks for Library and Information Services

A. *SOCIAL SCIENCES*

1. Environment
   - Functions and relations of component agencies in the network
   - Identification of new services
   - Political, legislative and legal considerations
   - Effects on man, society, science
2. Market
   - Identification and description
   - Information requirements and uses
3. Manpower
   - Personnel requirements and characteristics
   - Education and training
4. Management
   - Organization
   - Management: planning, operations, control

B. INFORMATION SCIENCES

1. Theory of Information
   - Semiotics (syntax, semantics, pragmatics of natural and artificial languages)
   - Information processes (generation, collection, coding, organization, transmission, transformation, storage, use)
   - Information measures
2. Human Engineering
   - Man-machine communication
   - Man as information processor
3. Information Processing Technology
   - Hardware design and operating characteristics
   - Software languages, systems
   - Communications engineering
4. Information Systems Engineering
   - Information systems properties (structure, behavior)
   - Information systems analysis and synthesis
   - Methodologies of complex systems design evaluation
   - Economics of information systems and networks
   - Management of design and operations

The development of advanced networks of library and information services can proceed via two principal approaches. If services and systems of services already exist whose objectives and functions are acceptable, the development of a network amounts to a transition from the present-day state of these services to a higher level. The primary goal of this development is then an improvement in the *efficiency* of the system processes and performance.

The extreme of the alternate approach begins with a formulation of new objectives and functions for a system yet to be designed. The designer follows a procedure which embodies rigorous elements of the scientific method. For systems of information services, this procedure contains the following sequence of three phases:

1) Assessment of the market
   - definition of market
   - identification of information uses
2) Design of information services
   - standard products
   - special services

3) Design of the information system
   information store
   process and operations design
   quality control

In contrast, the redesign of systems of services which retain their basic objectives and functions involves the second and more often, only the third phase.

Using this distinction of approach, we can conveniently identify and distinguish between design efforts which propose (and are restricted to) the improvement of efficiency of existing information services, and those which seek new objectives as the basis for their services and systems. The thesis elaborated in this article is that the two goals and approaches impose different roles and challenges on research.

When reviewing the methodologies utilized in present-day ongoing designs of library and information networks, it becomes apparent that they are primarily concerned with redesigns of systems of existing services. While these redesign efforts frequently entail an upgrading of some parameters of existing services (e.g., speed, comprehensiveness, etc.), the consideration of new services and especially of new markets is conspicuously absent from ongoing activities in library and information networking.

It is not difficult to find an explanation for this phenomenon: there are already in existence complex systems consisting of bibliographic information banks, products and services, vendors, and of generators and users of information. It is also not difficult to find a justification for the redesign or continued development of these systems. Although some parameters of their services are admittedly suboptimal, their improvement appears feasible via applications of newer technologies and organizational approaches. The justification for further investment in these systems can be argued even in the face of the difficulty of assessing the temporal economic value of their services since they are a significant component of the process of codification of human knowledge in that they create an external memory for mankind to aid in the carrying out of numerous human functions and activities. The bibliographic function clearly belongs among those which appear very desirable for society to sustain.

The currently attempted and planned networking activities in the library and information professions have as their goal an introduction

of greater efficiencies in the existing and assumed functions of bibliographic control and services. These efficiencies are to be derived through the sharing or networking of various selected processes and of data in existing systems. The emerging networks will thus provide for centralized bibliographic record-keeping on a geographical and/or subject basis; cooperative acquisitioning and technical processing of materials; cooperative, coordinated production of various types of bibliographic aids; and optionally, for a capability of decentralized inquiry against compatible record files. While efficiency improvement of existing library and information services can be a desirable goal by itself, it is apparent that in accepting the objectives and premises of these services, the current networking designs are not concerned with fundamentally new approaches to improve the *effectiveness* of information communication in society.

Since it appears that for the next several years we shall be committed to a networking of existing library and information agencies and services, it is appropriate to ask what research is necessary or desirable to assist in this effort. The methods being used to induce efficiency are of two types: technical and organizational. The technical approach rests primarily in the mechanization of physical processes and their elements; the organizational method employs coordination, cooperation, and partial centralization. To the extent that the success of the current efforts at networking of services will be reflected by the efficiencies attained, the necessary or desirable research can be expected to relate principally to these two methods. The following few paragraphs briefly discuss indicated areas of research.

The frequently stated design desideratum [12] that the information service systems accommodate the information communication process contiguously, exposes that a serious lack of knowledge lies at the interface of two system components. There is at present a discontinuity between these two components—the physical store or inventory of information and the media of access or directories to the store—which prevents a smooth and convenient transition and interaction between directories and documents or full-text information. (The mechanization of directories tends to stress this discontinuity; whereas previously I had to walk from a card catalog into the stacks, the possibility of having a library catalog on microfiche in my office or on loan at home is a frustration like having a telephone book in a city without a telephone service.) In technical terms, the unresolved problems are the relation, roles, and the consequent development of the analog and

the digital technologies and their optimal symbiosis in a library and information network. There appears little doubt that for some time to come the two information forms, analog and digital, shall coexist in our information systems; there is a lack of clarity at the present time concerning the nature and boundaries of this relationship, and of the methods for viably tying both into our systems of services.

A second area of technical research concerns the characterization of the traffic of information in bibliographic networks. Data are lacking on the types of communication which such a system can anticipate and on the distributions of the traffic between generators, vendors and users over various parameters. The actual configuration of the networks is very much dependent on such assessments, as are reasonably accurate transmission requirements and the choice of transmission media (mail, cable, microwave). The doubts of the EDUCOM 1966 study on information networks as to the "ability to produce anything meaningful without firm specification to traffic loads" [13] remain warranted.

Another broad problem area is that of compatibility and standardization. Although we must constrain both the system operator and user by rules, there clearly exists some freedom in slanting these constraints one way or the other. It might be asserted that constraints on the system input are less dangerous, technically more desirable, and in practice easier to implement than a stringent stifling of the users' options and of their not-so-consistent behavior patterns. What is not so clear, however, are the necessary minimum levels of standardization for either the system or the users.

The basis of the problem of compatibility lies in the behavioral patterns of humans with respect to their uses of information, and more fundamentally, in the properties and in human use of natural language. Ultimately, the criteria for the standardization of all system elements must be derived from studies of these areas at research levels which are only now being unfolded (e.g., semiotics). Meanwhile, it is desirable to ascertain the dimension of the actual need to switch automatically from one information file to another; to investigate authoritatively the several methods through which file convertibility can be implemented within and among information networks; and to propose, as a minimum, the design specifications for a file-description and inquiry language or languages.

A second category of desirable research concerns questions of political and organizational nature. It is clear that major efficiencies in the

existing library and information systems can be realized at the level of cooperative networking. The types, sizes and characteristics of these networks are subject to an interplay of a variety of factors—political, economic, geographic, and human. Thoughtful analyses of the possible, desirable and permissible categories of networks and network nodes should yield another element of the data necessary for the systematic development of a national network.

A major threat of delay to the networking of library and information services appears to be the less-than-enthusiastic attitude of the decision-making echelons of the library profession. It is improbable that this attitude can be dissolved solely by standard management techniques which apply political pressures or through financial incentives which may encourage divisiveness. We must recognize the serious social overtones inherent in this resistance to networking and mechanization, as well as the symptom of a profession in crisis. It is perhaps here, in the area of social science research in librarianship, that a most urgent effort is vital in order to find new directions for a profession in transition.

It should be observed, concomitantly with the identification of several areas of propitious research, that the state of the art is sufficiently advanced to warrant the development of existing library and information systems in the direction of networking their services. Impressive information processing and communication devices are available; the techniques to store and manipulate information are given, although not in anything near an adequate supply; progress exists in the development of machine-readable resources; encouraging agreements are recorded on common formats of principal elements of the bibliographic inventory. The principal question to be asked and answered today then must be the following: What level of network design and implementation is presently justified?

In part, this is a technical question, and research in the areas described above should be formulated so as to provide the required answers. To the extent that the question is related to the possible levels of efficiency in existing information services, it is a question of cost and of return on the investment. To give meaningful answers, it is necessary to ascertain and make known the operating costs of existing library and information services; the design and operating costs of alternate designs of several logical levels of service networks; and a plausible assessment of the apparent desirability and value of the service improvements which such designs make available to users.

Given such cost analyses and continuing to accept the assumed premises of the social and economic value of our information services and of their objectives, the direction and level of further development of our library and information systems can be indicated with authority.

The incentive for this further development of information systems is attractive: the possibility of greater efficiencies in the inventory and distribution of information, in the maintenance of these repositories, and in the less tangible but positively favorable effects on information users.

The relative intangibility of the effects on information users has, however, lately raised questions concerning the justification of proposals to implement information networks other than those of cooperative libraries. These questions point to the lack of consistent evidence that networking of present-day information systems will improve the *effectiveness* of their services. More fundamentally, they question implicitly some of the premises which underlie the objectives of existing information services in that the objectives appear to be based on a "lack of knowledge and objective data about requirements, about the parameters of the problem, about the value of existing services and systems, about the effectiveness of these systems, about suitable techniques for measurement and evaluation, and about suitable criteria of effectiveness and value." [14] The result is an impasse; while it seems probable that the physical communications platform being developed in the United States is technically capable of sustaining a nationwide network of library and information services, the would-be designers of this network are finding it difficult to justify its implementation.

The inquiry into the objectives of present-day library and information systems and into the bases of their future development is founded on one searching issue—their value. The concern is a proper one since all of the parties involved—the users, the funders, and the designers—must desire that the further large-scale development of our systems of services be justifiable not only in terms of operating efficiency but also in terms of the effectiveness with which it meets its objectives. Apparently the value parameter of our design objectives must ring more convincingly. (The faint hope that the evidence of the low exploitation of library and information materials and services is perhaps inadvertently in error, or that better techniques of system evaluation might reverse the negative conclusions, are not well founded.)

Indeed, it appears that possibly the only way to proceed is to direct serious and conscientious research toward a category of design para-

meters which until now have been assumed or ignored, i.e., the definition of information markets, and the description of the information-using processes in these markets. The measure of effectiveness and the design of effective information services and of their nationwide network are predicated on this research mission of primary significance.

The identification and description of markets is an early step in the design of any information service; the objectives and the functions of information systems are both dependent on an assessment of the target markets for their services. To be successful in the present-day climate which asserts that information is a resource having a significant utility potential, the information services should be directed at markets whose characteristics include at least one of the following: high volume or frequency of use, or high value of information used.

Apart from the library cataloging and inventory-keeping functions, virtually all present-day systems of bibliographic services have a single market: the community concerned with scholarship, research, development, and production of either knowledge or goods. These systems dispense scientific and technical information to the scientific and technical community, whether it be found in the university, government, industry, or the professions.

The design of information services by the library and documentation professions is predicated on the concept and model of scientific and technical communication as a process of continued information metamorphosis by a Gargantuan organism—the scientific and industrial establishment—which thrives in proportion to its ability to digest its own product, information. It is logical to infer from this model that "new science and technology rest firmly on the base of information generated in the past," [15] and easy to accept as axiomatic the conclusion that the need for information services in this establishment is one of crucial importance and enormity of proportion. To the dismay of nearly everyone, however, this axiom has been found most difficult to uphold whenever it was put to the test. Much of the evidence produced by our professional studies of "information use" is actually contradictory to it. Why this perplexity?

A British librarian, W. L. Saunders, recently made this observation:

> Much of our professional activity in university libraries is based on certain assumptions about the role and the significance of information and libraries in one very important branch of creative activity

—namely academic research and scholarship. It could well be that library services and "information" in the librarian's sense make a very much smaller contribution to the creative process than we librarians like to believe.[16]

Let us suggest why this could well be. Knowledge, or information, exists in two "memories"—one internal to the human mind, the other external to it. Man's interaction with information can draw on both of these banks. The crude evidence we have about this interaction suggests that the researcher or engineer—in short, the creative man—draws very heavily on his own information bank (memory) and, often, on the internal information banks of the visible or invisible college of which he is a member. If we reflect that he automatically stores the information he produces in his internal memory, and that his subject areas of interest or activity remain largely contiguous, it indeed becomes quite plausible that our creative man needs to resort to the external information bank only seldom, and that his need for our present forms of information services is far less frequent than we like to believe. The confusion between the reasonable axiom and the evidence contradicting it is one between the need for and the use of information (which *is* there, voluminous and frequent) and the need for and the use of extra-memory information services (which is there only at times).

There are other factors at play, of course, such as motivation. However, if we accept the evidence that the a priori expectation of an overwhelming, continuous need and necessity in the creative elements of society for present-day information services is somewhat mythical, significant implications apply to our past and current activities, and serious assignments arise for our impending directions of research.

A considerable research effort of the recent years has been motivated by the growing volume of disturbing data which suggest that the users of scientific and technical information are rather immune to both new and old information products and services. It was quickly accepted that the apparent low exploitation of these products and services must be a property of their design, to which assumption research responded vigorously with submolecular analyses of every imaginable variation on the format of information products and services, and on the techniques of their derivation, use and evaluation. The literature attests to hundreds of studies of cataloging, classification, indexing, abstracting, and retrieval theories, techniques and products, and to extensive investigations of precision and other measures of ap-

parent system performance and behavior. It is not intended here to deprecate the quality of the hundreds of man-years of research effort so invested, or to minimize the insights gained into information processing techniques, operating efficiency, and into the qualitative and quantitative relations among various system elements. At the same time, the inference is obvious that if the assumed characterization of the science information market incorrectly represented its process of information use, much of this research must be suspected of being irrelevant and redundant to the issue of information service effectiveness.

Without dispute, the scientific and industrial community is one of the markets for library and information services. Meanwhile, it is a very timely question to ask what other, perhaps more lucrative markets, for science information are waiting to be served. Almost intuitively, such a market must be education. The acquisition of knowledge in an organized, codified form is the objective of education, and it may be viewed as a process of information transfer between the external and internally memories of the learner. The learning process invites advanced information services and systems, and the technology-minded trend of development of this immense market has already brought it within our sphere of concern.

It is probable that other information markets of the magnitude of education are waiting for recognition. If the information-handling profession intends to become a service industry, market research and analysis are necessary to its planning and justification. The immediate and significant task for research is to formulate a program of perceptive studies to identify such information markets, and to analyze their characteristics and their potential as customers of advanced information services and systems.

The identification and description of information market characteristics must be accompanied by studies of the uses of information in these markets; information services and systems can be designed and operated successfully only if they meet well-defined requirements. That this has been recognized all along is attested to by the numerous "user studies" carried out over the past twenty-five years in nearly all parts of the world. Notwithstanding this effort, it is not inaccurate to observe that these studies have failed to define the information-using process of their subjects in a manner meaningful to the information system designer. The unwitting evidence of a discrepancy between presumed needs and actual use of scientific

information produced by these studies reduces, without ruling out, the possibility that existing or proposed information services can be made more effective (that is, that they can have a greater effect on the efficiency of scientific and technical work). What kind of research is then needed to provide better data on the information use requirements by our markets?

The awesome goal—to understand the working mechanism of the human mind—is obviously too formidable for a realistic research mission and unlikely to yield useful data in time to identify reliable design requirements for the next developmental phase of library and information systems. The desirable research level lies between this goal and the collecting of sporadic data on users information habits. Such a level is given, we believe, by a program of information-oriented studies into selected symbol manipulating processes of man. These functional processes are characteristic of our information markets: problem-solving of the research and development community, design of the engineering community, learning of education, decision making of management. The immediate objective of such a program of research is not so much elucidation of the functioning and behavior of the human mind (in the sense attempted by research in neurophysiology, bionics, etc.) as the intermediate sequential description of the functional components principally interacting in these processes: goals, methods, and data.

Of greatest immediate interest in our analysis of requirements for the design of effective information services is the role which external information memories can serve in the interaction of these components of human symbol-manipulating processes. Offhand, certain differences in the process characteristics of various information markets are obvious. For example, the information-based process of learning draws heavily on external information memories. In contrast, the interaction with external information stores may be expected to be less frequent, less linear and, perhaps, less predictable in the case of the problem-solving, creative activity in science. A comprehensive categorization of the elements of information in these processes according to various parameters (form, purpose, function, frequency, dependency, precision, value, and perhaps others) should permit an insight into both the requirements of user markets and the characteristics and structure of our information repositories. Founded on such knowledge, the subsequent phase—the design of information services and systems—will be

able to consider objectively questions on which today there exist only opinions.

The suggested direction of research is also logical and appropriate to the technically and politically difficult question of effectiveness. The present-day lack of satisfactory approaches to the measurement of effectiveness and value of information services is a partial consequence of the relative fallacy of past user studies; it is obvious that the assessment of effectiveness of any service is objectively impossible without the knowledge of the specific requirements which such service proffers to meet. Once these requirements have been assessed, however, the question of information service and system effectiveness becomes technical rather than speculative.

An incidental result of the requirements analysis research could very well be a partial insight into a most difficult property of information measure—its value. The development of a pragmatic measure of information utility must rank as a most important task of information science research in the next decade. An adequate functional description of the major information-using processes of man may, however, shift the responsibility for applying this measure on the information user, and away from the service designer and vendor. This is indeed desirable; the value of information is intrinsic to information processes and goals of users and society, and as such it must be only monitored, not determined, by the information industry.

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