Bibliographic and Technical Problems in Implementing a National Library Network*

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The problems facing the planners of automated library networks are rooted in the complexities of organizing and managing a vast flow of bibliographic information and its interface with users. Telecommunication equipment transmitting data in the form of electric signals, electronic memories holding large stores of information, and computers manipulating the data and graphic displays for human interaction are technological means for performing network functions more effectively than has been possible in the past. They do not in themselves, however, make networks possible.

Becker has listed the following among the problems and obstacles to be overcome: the development of acceptable criteria for determining what is to be placed on the network, clarification of the roles of network participation, agreement on network organization and operation, and the investigation of its social, legal, financial, and technical implications.1 The designers and operators of a network must understand the need to cooperate and to compromise in determining objectively and rigorously which areas are most susceptible to cooperative action and which will have the greatest benefit in the shortest possible time. At the very least, library networks require common languages and common procedural conventions.

The underlying concept of library networks is well-established. For many years, libraries have been cooperating to make the greatest

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possible use of available information resources by sharing them through arrangements of varying degrees of formality. In a comprehensive survey of the development of library cooperation, Esterquest mentioned twelve types, including interlibrary loan, union catalogs and lists, regional bibliographic centers, cooperative storage, cooperative acquisitions, and cooperative cataloging. Each of these efforts has been regarded, in its time, as providing the solution to a pressing problem. Nevertheless, the difficulties in making such cooperative relationships work effectively have led to the downgrading of some and to the abandonment of others.

A major impediment to the success of library cooperation has been the difficulty of maintaining a regular flow of up-to-date bibliographical information among libraries. In the last several years, however, two developments have given hope that this situation might be alleviated. The expanded operations of the Library of Congress under the National Program for Acquisitions and Cataloging have helped to speed the production and distribution of catalog records for current publications. In the technical domain, the MARC Pilot Project and the MARC Distribution Service have demonstrated the feasibility of distributing catalog data in machine-readable form.

The second of these developments has taken place in a climate highly favorable to automation in libraries all over the United States. The possible applications of the computer to library operations are being explored in the belief that their efficiency will be enhanced. Using the new technology, libraries should be able to attain greater speed and flexibility in creating, updating, and disseminating bibliographic information. The anticipated success of this effort has, understandably, rekindled enthusiasm for sharing resources through immediate access to a common bibliographic store and rapid transfer of information within a network of libraries.

Experience has already shown, however, that even automating individual libraries requires solutions to many difficult problems. Establishing a workable automated library network involves difficulties of still greater magnitude. This paper takes a broad view of problems involved so as to identify and to analyze basic issues that tend to be glossed over in our eagerness to approach the goal. Inevitably, the discussion may overlap topics covered in other papers in this issue. The parts, functions, and attributes of a library network are so inextricably related that the examination of any element must impinge on other elements.
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The Concept of "Library Network"

The literature in the past few years is rich in discussions of future international networks, national networks, state networks, regional networks, etc. Many network plans have been put forward. Nevertheless, the lack of a generally accepted definition of a library network causes confusion. Becker and Olsen defined a network as "an interconnection of things, systems, or organizations. Adding the adjective information to network allows the concept to be defined with greater precision. In an information network, more than two participants are engaged in a common pattern of information exchange through communications for some functional purpose." Within this definition, the authors described the ideal information network as exhibiting the following characteristics: formal organization, a communications system, bi-directional operation, a directory look-up system to identify the unit that must be able to respond to a query, and a switching capability to determine optimum routes.

On the basis of this definition, a single library can be shown to be an information network for its staff and users. The library has a formal organization governed by established policies and procedures. The staff is grouped into divisions with distinct functions (e.g., cataloging, reference, circulation). The interfaces among divisions through individual staff members using common files and the interaction of staff and files with users constitute the communication system. The directory look-up is provided by the bibliographic control apparatus which comprises all of the files for locating items in the library collection. The main catalog affords the most complete coverage; some of the other files are tangential to it; the contents of others overlap.

The library staff serves the function of a switching mechanism to determine optimum routes for queries. For example, a user seeking an unbound serial will be referred to the serial record instead of the main catalog. The flow of information is bi-directional. A reference librarian responding to a user's query uses one or more of the bibliographic control devices. If he finds them inadequate or incorrect, he notifies the cataloging division (in effect, a cataloger) which may change or add to the information in the files.

The requirements for the ideal "single library" network include accurate and up-to-date information. The network communications function efficiently when they provide an "immediate" answer to a query even if the answer is negative. (The word "immediate" in this context means within the required response time, whatever that may
be.) A negative answer is hardly satisfactory, however, particularly if it results from a failure to generate information rapidly enough (as might be the case when there is a cataloging arrearage). An even more common difficulty arises when the information is somewhere in the network but technical or organizational shortcomings inhibit its flow to the desired point. This situation occurs frequently when the bibliographic control apparatus comprises many separate files.

This concept of a “single library” network can be projected into a national network of libraries, using virtually the same framework with additional hierarchies or levels, and increased bi-directional capability. The switching mechanism no longer depends on individuals but rather on well-defined nodes or centers that transmit requests to the appropriate information resource by the most expeditious route and transmit the relevant material back to the source of the query.

If a network were organized with major regional centers as the intermediate nodes, it might seem that to avoid traffic congestion when those centers access the national bibliographic store, the entire data base would have to be entirely duplicated in several places. This could be avoided if each intermediate node assumed national responsibility for a subset of the total information base; that is, records that could be specifically categorized by language, date, subject, or type. A hypothetical network for sharing cataloging data might have regional nodes that maintained union catalogs for their respective areas and also served as distribution centers for particular segments of the national data base. The national center would distribute its output to every regional node which would keep all records for a prescribed period. As records were supplied to libraries in a region, they would be posted to the regional union catalog and to the national bibliographic store. At the end of the stated retention period (say, a year), the regional node would delete all records outside of its national responsibility if they had not been added in the regional catalog. This procedure would reduce the file in the regional nodes. The rapid flow of information in the network would be facilitated by the ability of a regional node to satisfy many requests from its member libraries and to route others to another regional node known to be responsible for a given category of record. In addition to being the primary distribution point for newly generated records and possibly a regional center in its own area, the national bibliographic store would serve as the court-of-last-resort for requests outside the scope of any regional center.
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As long as the network designer is using paper and pencil and hypothesizing without constraints of cost, organization, legal implications, etc., there is practically no limit to the kinds of networks that can be created by assigning different values to the building blocks and assembling them in different ways. In practice, however, the success of a library network will depend on the extent to which it satisfies certain basic requirements.

Requirements for a Library Network

The preceding section was not intended to provide a blueprint for a library network. Its main purpose was to show that many of the problems of a library network and those of an individual library differ in degree but not in kind. Thus, it is not surprising that difficulties that have plagued libraries for decades still persist in the age of the computer. In this section, some of these problems will be explored in more detail in two main categories: 1) standardization of the bibliographic record and 2) technical considerations.

A third element which is not considered in this paper is the need for sufficient information in the network. In absolute terms, the information store depends on the level of financial support of the libraries comprised by the network. If they are unable to acquire and catalog the materials to satisfy the needs of their users, the amount of information available will be below the required level. In relative terms, however, the solution lies in the adequacy of the links among the libraries. The dominant purpose of standardization of the bibliographic record and the provision of means of rapid communication is to facilitate the pooling of bibliographic information. If these conditions are met, the amount of information in the network will tend to equal the sum of the information in all of the individual libraries.

Standardization of the Bibliographic Record. It is easy to minimize the difficulties in creating a bibliographic record that is standardized in format and content. To achieve the ideal result, agreement must be reached on four major points.

1) There should be a standard set of rules for describing and analyzing bibliographic items. Great progress has been made toward this goal by the formulation and general adoption of the Anglo-American Cataloging Rules for the creation of catalog headings and the description of bibliographic items. The situation with respect to subject analysis is somewhat less clear. Library of Congress subject headings,
LC classification schedules, and the Dewey Decimal Classification are widely used in American libraries. In practice, however, the application of classification schedules and subject heading lists may differ from library to library (or even cataloger to cataloger) because there are no generally accepted procedures for analyzing the materials being cataloged. The development of clear guidelines for subject analysis is highly desirable, particularly if local records are to be posted to a national data base. The task is formidable, but any success in accomplishing it will contribute significantly to the consistency and manageability of the data base.

It is obvious that equally difficult problems must be solved before international standardization is possible. Nevertheless, it is encouraging to note the International Meeting of Cataloging Experts held in Copenhagen in August 1969. The purposes of the meeting were to review cataloging developments and to examine the prospects of cataloging advances through standardization and mechanization and, in this connection, to consider the national bibliographies, the Shared Cataloging Program, and the production of cataloging data in machine-readable form. The aim was to arrive at conclusions of practical value which will further international uniformity in cataloging. It is to be hoped that this meeting has set the stage for further progress in international cooperation and provided the climate for the advancement toward the ultimate goal of a true “sharing” of information resources.

2) Bibliographic records should be prepared in relation to a standard data base. The principal aims of descriptive cataloging as commonly practiced by libraries are: a) to provide a unique description of each item, b) to bring together the works of an author, and c) to bring together editions of a work. The first point can usually be resolved by rules alone. The second and third, however, require the establishment of a consistent form of name for a particular catalog and the coordination of each new record with existing records. It is obvious that both a file of name authority records and a known data base of bibliographic entries must be readily accessible to the originators of catalog records to insure consistency. Without a method for distinguishing items as being unique or for relating them to other items in the file, bibliographic control becomes a Tower of Babel for the librarian and, in turn, the user.

The problem becomes evident when the experience of the National Union Catalog (NUC) is examined. Reports for the same bibli-
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graphic item are frequently received in widely different forms. In a
discussion of the NUC, a recent study concerned with the conversion
of retrospective catalog records to machine-readable form states "that
wide variations in bibliographic description would make it difficult
to identify many of these records as being for the same item." 5

Some of the confusion among catalog records is attributable to
differences of interpretation of the rules and information on the publi-
cation. Much of it, however, occurs because outside libraries cannot
conveniently obtain up-to-date information about the preferred form
is often time-consuming and sometimes yields a heading in an obsolete
form. Ready accessibility to a current source of established names is
one of the benefits that an automated library network should provide.

The records being disseminated by the MARC Distribution Service
constitute an acceptable body of standardized bibliographic data for
English language monographs. It is not yet a complete source of
cataloging data for subscribing libraries, however, because it does not
provide information about see and see also references for the headings
used in the records. The Library of Congress is aware of this draw-
back and plans to distribute reference control information as soon
as possible. When this is done, the MARC data will become a subset
of a true national bibliographic store.

The body of standard cataloging data in machine-readable form
will be enriched as retrospective records are converted. The RECON
Pilot Project now under way at the Library of Congress promises im-
mediate benefits through conversion of approximately 69,000 English-
language records. Expansion of the MARC Distribution Service to
cover other languages and a large-scale conversion project for retro-
spective records are other possibilities in the foreseeable future.

3) There should be a standard set of rules for structuring machine-
readable records for all forms of material and labeling their data ele-
ments. There is a growing acceptance of a basic structure for a format
that prescribes the physical layout, leader, directory, control fields,
and variable fields. This structure was designed in collaboration with
many groups and is being considered as a national standard by the
United States of America Standards Institute upon the recommenda-
tion of its Section Committee Z39 (Library Work, Documentation,
and Related Publishing Practices). The format has been adopted by
the American Library Association, the Special Libraries Association,
the National Libraries Task Force on Automation and Other Coopera-
tive Services, the Association of Research Libraries, the Committee on Scientific and Technical Information (COSATI), the Federal Library Committee, and the British National Bibliography. The MARC II format used by the Library of Congress conforms to this proposed standard.

Progress is also being made in the definition of content designators that explicitly identify data elements for different forms of material. Both the Library of Congress and the British National Bibliography are using essentially the same format for bibliographic descriptions of monographs. The Library of Congress has issued a recommended serials format to elicit comments from the library community. The Library of Congress has also designed and is using a format for single-sheet maps and is making progress toward definition of content designators for audio-visual material. COSATI has defined content designators for technical reports to be used by executive agencies in the federal government. All of these formats have the same basic structure.

Agreement on a common format has made possible the exchange of machine-readable bibliographic records between the Library of Congress and the British National Bibliography. The potential advantages have led Coward to assert that "a MARC record service must transcend national boundaries; it must have an authority which makes its records acceptable to librarians anywhere in the world; and it must strive to be as complete as is humanly possible. I do not think that there is any future in attempting to produce a national service unrelated to other national services." The growing international interest in the transmission of bibliographic data in this form is also exemplified by a French translation of The MARC II Format.

4) There should be a standard degree of completeness of the data elements in a machine-readable record. Within the basic structure, records can vary in two respects: content designators can be simplified and data elements can be omitted. For example, a name entry could be identified simply as a name rather than defined by type, or, the bibliographic description could be streamlined by omitting notes. The Library of Congress and the British National Bibliography have taken the position that the records they distribute should be as rich in detail as possible. Their premise is that, on the basis of present knowledge, it is impossible to define rigorously every potential use of a machine record. Therefore, the difficulty and cost of augmenting a record make it prudent to provide a full record even if unwanted
items may be deleted later. On the national level, it seems unwise to do less than is now being done.

With more study of the effect of different levels of content designation in MARC records, it may be possible to simplify encoding bibliographic records without detriment to a cohesive library network. The minimum degree of completeness of bibliographic data will be determined by what is required for uniqueness in the master data base (see item 2 above) if there is to be a bi-directional flow of data. Where data flows only in one direction (for example, from regional center to a local library), records at the lowest echelon in the network (local library) may be less complete than those at the national level. Levels of MARC records and their implications will be studied during the RECON Pilot Project.

Technical Considerations. Many problems must be solved and questions answered before a true national library network can be created. In a recent review, Bregzis stated:

Although the concept of a central bibliographic data file has lately become quite popular in library automation plans, the problems arising from the massive size of such a file, the complex logical structure of records, multidimensional interrelationships among records, and technical constraints associated with data storage, access, and telecommunication have generally been overlooked or dismissed. . . . Whether library technical processing, as it is presently known, permits large-scale consolidation even under computer control is an open question and not beyond doubt.8

Although it is impossible to discuss every technical consideration vital to the creation of a successful national network, this section will mention some important factors that are often ignored by network planners.

1) The dynamic characteristics of bibliographic records are frequently underestimated and as a result not enough weight is given to the requirements for updating. Not only does the increased growth rate of printed material affect the problems of the initial control of library holdings, but maintenance of the bibliographic records themselves becomes increasingly difficult, albeit indispensable. A recent analysis of the extent of changes in Library of Congress catalog cards in the RECON study9 provides convincing evidence that ignoring changes made to records in an active catalog would result in a significant loss of the quality of the cataloging information.
The MARC Distribution Service does reflect most of these changes. Any substantial change in the LC Official Catalog (e.g., a change in main, added or subject entry) triggers a revision of the machine-readable record and this updated record is, in turn, distributed to the subscribers as a "change" record. However, some "housekeeping" changes are not distributed to the user. For example, the Library does not update the MARC record of an incomplete set as volumes are added unless the record contains a content note; the change is made only when the set is complete.

This experience stimulates many questions in the context of a formal network. What is involved in maintaining bibliographic quality and accurately reflecting holding information? Would the records of every node in the network be updated? If every "change" record distributed by the national center has to be inspected by regional nodes to determine if the original record is in the regional system, there is a cascading effect throughout the network structure. What are the cost implications of the additional flow of information through the system? Would failure to update at every level of the network result in the problems of inconsistency that exist today?

Assuming files will be organized in the same fashion as they are today (i.e., an in-process file, and a catalog record file), regional nodes will be required to store MARC records in a separate file until they are required in the regional system at least for some period. Any change record received might have to be compared against all files since at any point in time, there is no way to know where in the system the record resides. An alternative scheme could be the maintenance of an index by LC card number which would have an associated communications field to indicate in which file the record is presently located. This index would require updating in its own right as the record moved from one status to another. The problem is compounded many times when one begins to envision the maintenance of authority files, the required links back to the bibliographic records, and the complicated machine procedures required to implement what really can be considered a "network" in its own right.

2) The method of data organization for the storage, retrieval, and maintenance of machine-readable files is highly dependent on the requirements of the users of the system, e.g., optimum retrieval capability must sometimes be sacrificed to achieve a balance between maintenance and search efficiency. The size of the files and the computer hardware and storage media available are other variables that must be considered in system design.
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The question of how best to structure information is not unique to the planners of automated library systems. A number of techniques have evolved, e.g., direct, random, inverted, indexed sequential, multilist, ring, tree, etc. Depending on the scheme chosen, there are associated problems such as space management, dynamic storage allocation, nesting, paging, address calculation, etc. It is not the purpose of this section to give a detailed presentation on file organization, but rather to emphasize the need to understand the complexity of data organization when library networks are being considered. The interested reader will find more detailed exposition in several excellent articles (See Additional References).

Assuming the existence of a suitable computer and storage media, the designer must ask himself early in the planning stages, "What are the elements in bibliographic data that are frequently used as search arguments and therefore should be selected as keys?" Beyond the commonly accepted elements of author, title, and subject (and not necessarily in that order), there is little agreement among librarians as to a rank order of importance of other descriptive items. And, so far, catalog-use studies have failed to provide this type of substantive data. Even if this information were available it would probably not be possible to design a system that would provide 100 percent satisfaction for all users. To do this would require making available every data element as a key. If the system to be designed was an inverted list structure, the use of every data element as a key would require a dictionary of attributes and machine addresses which might be as large or larger than the data file itself. Although this technique satisfies the retrieval requirement, the problem of maintenance of a large dictionary is difficult and costly. Other file organization strategies could be employed, but without sufficient knowledge of the most useful access points, there is little basis for evaluation of one technique over another and planning cannot be accomplished with confidence.

Another important question is whether the file structure for library networks will be the same for all forms of material. For example, posting holdings information for serials is a problem of far greater magnitude than the related task for monographs because serials frequently change titles, merge, and undergo other transformations. The very nature of serials appears to demand an organization of the files that will allow linking of one record to another so that regardless of the title or issuing body requested, a query will be satisfied or a new item posted.

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How will we organize the subject heading file and the name reference file and guarantee that any addition, deletion, or change to one of these files will manifest itself in the main bibliographic file when applicable? What is the complex organization that will provide linkage from element to element and record to record within a file, and element to element and record to record from one file to another or perhaps to several?

If the National Union Catalog of 7.5 million records is considered as an approximation of the size of the bibliographic data base at the national node and each record is estimated to be 500 characters in length, the storage capacity at the national level would have to accommodate 3.75 billion characters. Added to this already voluminous count would be name reference records and the subject heading records plus the characters required to provide the linkage or the overhead of the system. Needless to say, the technique chosen for the organization of bibliographic files must undergo a careful evaluation of cost of overhead versus the advantages of potential retrieval.

Even if the decision were made to plan library networks based on current cataloging only, the problem, though not quite as formidable to start, would still fall under the heading of “large files” with the same complex relationships and would present the same perplexing technical considerations to the designers. (The Library of Congress catalogs approximately 200,000 new titles per year and it is estimated that the growth rate is 5 percent.)

Because of the great size of the files, one is forced to question whether it is necessary to store the entire bibliographic record in digital form or whether it would suffice to store a select number of data elements in digital form with linkage provided to the record in a slower microimage storage (this concept was suggested to the author by Allen Veaner in a different context than this article). This is still another facet of the problem that is deserving of careful evaluation, measuring need against cost.

3) A related but unsolved problem is that of the composition of a search code. A search code is a string of characters made up of selected characters from one or several data elements, e.g., author, title, imprint, date, etc. A search code may serve several purposes: a) to shorten the character comparison required between the search argument and the records in the file (assuming the search code is a key associated with each record and the same algorithm used to develop the search code key is used to develop the search code for the search
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argument), b) to calculate an address in computer memory where pointers exist to the bibliographic records that contain the data elements from which the search code was derived, c) to cope with name variants caused by misspelling, transcription errors, name on title page not identical with established form of name, change of name due to inversion of the name, etc., and d) to cope with title variants caused by misspelling, transcription errors, lack of definite knowledge of the title, etc.

Some interesting work is already in progress in this area. It might well behoove the investigators in personal name searching in the library community to explore what already has been accomplished elsewhere. The problems of searching files where a principal access point is by personal name is not limited to bibliographic work. A great deal of effort and funds have been expended to develop methods to search other large machine-readable files. Insurance companies, airlines, and the Social Security Administration face this problem and the problem of variant names is a severe one in the Immigration and Naturalization Service, the Federal Bureau of Investigation and, in fact, all intelligence activities.

Assuming storage capacity, some optimal file organization, the development of search codes, etc., does the operation of a library network imply that the same hardware configuration with the same software is implemented at all major levels in the network? What is the price tag to fulfill a national responsibility?

4) If networks are to become a reality, the coded representation of symbols required for the encoding, storage, retrieval, display and transmission of bibliographic records must be standardized. A review of the work performed during the last decade indicates not only the awareness of the need for standardization of codes for the representation of characters, but also the need of the associated hardware devices to input and to display these characters.

Progress in the development of data input devices has generally lagged behind the technical development of other functions in automated systems. Therefore, data input tends to remain the slowest and least efficient function and the one most prone to error. This condition is exacerbated by non-numeric processing where the data may contain virtually any symbol.

The Library of Congress designed a character set for the representation of Roman-alphabet languages and it includes many special characters and diacritical marks for those languages. The MARC Dis-
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Distribution Service utilizes this character set. It was recognized that no print train/chain or terminal device existed that could display this character set at present. The philosophy at LC was not to design tomorrow's systems constrained by today's technology. Therefore, for some time to come, the recipient of MARC tapes will have the burden of translating the MARC character set into the character set available to him at his installation. This may mean printing substitute characters for nonprintable ones, or stripping certain characters out completely. The result is extra processing time for each user and in addition, tailor-made software for each user depending on his particular display device.

In a library network, the need for a standard character set is even greater. If nodes in the networks use different sets of coded representations, many tailor-made computer programs would be needed at each node to translate the data received from other nodes.

The non-Roman alphabet languages pose problems of additional complexity. If a unique code on an input device signals an escape into another alphabet (e.g., code plus C equals Cyrillic alphabet), it is possible to use the standard keyboard to encode many alphabets. However, how does one display the language that has been recorded? Again, with the exception of photocomposition devices which most libraries cannot afford, the available devices are not capable of displaying the diversity of characters required for many different alphabets.

The design of hardware that will satisfy the requirements for the efficient and economic input and display of bibliographic records is still in the developmental stages. The technology must be constantly monitored and systems modified as the state of the art improves.

5) Large data banks must reside at more than one installation if the system is to be capable of satisfying a user even if one of the nodes is not in operation. It is not feasible to consider the transmission of large files on demand from one node to another in the eventuality of down-time on the prime system, i.e., the node the user should be accessing. Therefore, to maintain back-up, procedures would have to include the storage of files at several centers in the network. What is the impact of the duplication of the machine-readable library files to guarantee back-up? Will it be necessary to provide back-up at all echelons of a library network, i.e., the national data store, the regional data stores, etc.?

6) The installation of a data transmission network implies the

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linking of many pieces of hardware. When transmission problems occur, it may be difficult to determine which device is at fault—the computer, the transmission equipment, the data sets, etc. This problem has a tendency to decrease as the network expands since alternate paths can be used to isolate the cause. In most instances diagnostics do exist that will determine computer failure. However, valuable computer processing time is lost during diagnostic processing and transmission time during alternate path testing. The maintenance of the hardware of the network must be taken into consideration when deriving cost factors and projecting optimum utilization.

7) The monitoring of centralized data banks in a library network will require that users have unique identification numbers for accounting purposes as well as to insure that files cannot be altered by unauthorized individuals. Considerable research is going on in this area but the systems designed to date are limited and subject to being compromised. Some of the proposed techniques look promising but as yet most have not been implemented and tested. There also has been no evaluation of the cost of any of the proposed methods in terms of hardware and/or processing time. Although library files are not sensitive in the same sense as files such as those of personal dossiers, the integrity of bibliographic files could be damaged either by accident or unauthorized use. Therefore, a safeguard scheme must be an integral part of the operation of a library network utilizing centralized data banks.

Outlook

Given the reality of these bibliographical and technical problems, what is the outlook for library networks? Librarians who have been involved with automation know that the design of a system is but one phase of the implementation of automated procedures. There comes a time when generalization must cease and we must face the hard facts of “how to do it.” Networks may be conceptually and technically feasible, but there is a long, difficult road to travel between here and there. The enumeration of problems in this article is not intended to lessen creative drive but to caution that separating the operable from the speculative is a necessary prerequisite for moving ahead. Those actively engaged in network planning may find consolation in Machiavelli’s observation: “There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things.”
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