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LIBRARY INFORMATION SYSTEM TIME-SHARING ON A LARGE, GENERAL-PURPOSE COMPUTER

In the spring of 1967, several of us at System Development Corporation (SDC) undertook the development of LISTS (Library Information System Time-Sharing)–a system that would allow library processing tasks to be performed on-line, utilizing general-purpose computer equipment. We believed that three developments in the field of computer technology had converged to the extent that it had become technically feasible to design such a system. These three developments included the development at SDC of sophisticated time-sharing and data-management systems, the advances being made by the Library of Congress and others in formatting large data bases for storage on magnetic tape, and the advent of third-generation computer equipment, which we believed could accommodate the large files that would be required. We believed that, together, these developments would make it possible for all types and sizes of libraries to use a large computer for their processing and housekeeping functions without changing their traditional patterns of operation or giving up the autonomy they now enjoy. More importantly, we believed that they could use such a computer without having to undertake their own system design and development efforts, procure programmers, or either acquire a computer for their own use or rent computer time from a service bureau.

We were fairly secure in believing that the system we proposed to develop was technically possible. What we did not know was whether it would be economically possible; we did not know how much it would cost either for us to develop the system or for a library to use it when it was developed. For that reason, we conceived the LISTS project to be more than a system development effort. We wanted it also to yield realistic cost information.

Therefore, we added to the system development effort the idea of asking a representative group of libraries to use the system, on an experimental basis, as it was progressively implemented. We could then determine the system's actual cost to a user as we were developing it—and we could alter the design as we proceeded if it became apparent that the course we were on was too expensive. We also determined that the libraries participating in the experiment should contribute as much as they could to the design—that their day-to-day requirements should influence the choices among design alternatives.

TECHNOLOGICAL FOUNDATIONS OF LISTS

Of the three technological developments that I have mentioned, the development of sophisticated time-sharing and data-management systems was one with which we at SDC were most familiar. SDC has a long history of using computers in a time-shared mode. In 1963, SDC had one of the first two operating systems in the country for general-purpose time-sharing. SDC's system was developed utilizing the special AN/FSQ-32 computer built by IBM for the United States Air Force.

Time-sharing implies on-line processing, at least to the extent that there is input from a terminal and interaction with the user. Some aspects of the computing environment are:

1) Some portion of the data base must reside in direct-access storage and be available for both on-line and batch processing. Some data may be kept on tape, but should then be used only for batch processing;

2) Updating of the data base may be triggered by a message from the terminal of the remote user;

3) Inquiries may be processed on-line or may trigger later batch processing (especially inquiries that generate large reports or require complete file searches);

4) Transactions received from terminals are queued with other transactions and may be processed to completion with priorities higher than those of batch-processing transactions;

5) Both types of processing—on-line and batch—will use standard routines to interface with the data base; and

6) Many terminals must be accommodated in such a way that it appears to the users at those terminals that they are being accommodated simultaneously.

The system must be in operation during the time users are normally working. In libraries, this will be during the typical, normal daytime working hours. It is foolish to expect librarians to use the latest in technology and be forced to change their working habits, to come in and work a swing shift or a graveyard shift in order to have better access to the computer. Except for emergencies, an on-line system will be active during the normal working day. A successful time-sharing system will have a built-in restart capability so that if a failure is due to software, very little time will elapse before restart is effected. Hardware failures require adequate duplication, or backup hardware, and it may be that only the military can afford truly adequate backup capability.

The time-shared system built around the Q-32 has been developed to the point where it supports approximately thirty terminals at any one time, each of which can be doing a completely separate task. Some of the operational programs on the Q-32 are very similar to the kinds of programs necessary to manipulate library data bases, and to produce such items as orders to vendors, catalog card sets or bookform print-out, various statistics on the order process, etc.

While our LISTS program is directly concerned with technical processes and housekeeping functions, we have had operational for over a year a user-oriented reference retrieval system. SDC's ORBIT (On-line Retrieval of Bibliographic Text) system has been operating every day with excellent success, on a data base of about 180K (or entries) in the catalog. This catalog can be accessed from a remote keyboard terminal by author, by subject codes similar to traditional library subject headings, by more "free-form" descriptors, and by certain other qualifiers of interest only to the particular user group for whom the system was designed.

In addition to a great amount of experience with time-shared systems, SDC has also been working for a number of years on general-purpose programs that allow files to be manipulated on-line by non-programmers to produce many forms of output from data in the files. Rather than requiring a specific program, such systems allow a non-programmer, utilizing a langugage very close to English, to describe the existing data base and to describe the data desired in the report in order to generate it. The development of the Time-Shared Data Management System (TS/DMS) which is the foundation on which we are building LISTS, has been under way at SDC for some time for the 360 series of IBM computers, specifically the 360/50 and 360/67.

TS/DMS makes the data management capabilities of a large computer directly available to a user without the necessity that he communicate his requirements through intermediaries, e.g., a programmer. Instead, the user "talks" directly with the computer. He may be asked by the system to supply control information, to file names, to name the operations to be performed, and the format desired. He may, in turn, ask the system to define a term, to comment upon a process he did not understand, to tell him what steps of the procedure are available, to explain error messages, or to give him other tutorial help. LISTS further simplifies the TS/DMS approach and, for the most part, very little except pre-arranged information must be input by the library user.

The second technological development that we believed would make LISTS feasible was the work being done by the Library of Congress, NASA, Defense Documentation Center, the Chemical Abstracts Service, and others in formatting large data bases for storage and distribution on magnetic tape. The Library of Congress MARC System is a primary example. The LISTS project will make regular use of MARC tapes. MARC data will form the main data base until one or more of the participating libraries converts an existing catalog and adds it to our file.

The third technolgical development was the advent of third-generation computers, which are capable of accommodating large data-base files in rapid-access mass storage. The capability and speed versus cost of the hardware is of prime importance. Second-generation equipment simply is not adequate. Even third-generation machines may be incapable of handling truly large data bases cheaply enough to make a system economically feasible. But we believe they are.

The task we in the LISTS project set ourselves, then, was to combine a large, general-purpose computer system, a time-sharing system, a powerful data-management system, and large, tape-stored data bases into a system that would, initially, allow small to medium-sized libraries to use an inexpensive terminal linked to a computer to perform their customary housekeeping and processing functions on-line.

PLANNING AND IMPLIMENTATION OF LISTS

Active work on LISTS began in June 1967 to develop the system to the point at which we could approach a number of libraries that would serve as testing agencies for the experiment.* We decided early that in order to make the experiment realistic enough to secure valid cost data, it was necessary that we have the active participation of operating libraries. Working with SDC's technical library during the summer of 1967, we outlined possible ways the system could operate, and possible products of its operation that could operate, and possible products of its operation that could be offered to participating libraries (see Figure 1). Much of the planning, of course, had to do with the specific requirements of the SDC library, which is a typical industrial (special) library. However, the system was meant to be flexible enough to allow libraries of any type to use it, and while, in our initial planning, the special requirements of an industrial library were indeed paramount in our thinking, it was not intended that the system be limited to their needs. Thus, we established the goal of participation by a number of libraries that would represent a broad spectrum of typical library practice and problems. In addition to the SDC library, two public libraries and four academic libraries are now part of the experiment: Beverly Hills Public Library, San Marino Public Library, Fullerton Junior College, Pierce College (a junior college within the Los Angeles city school district), University of California at Riverside, and University of Southern California.

San Marino is a city of approximately 14,000 people. The library there had a total income of $128,485 for the fiscal year ending June 1967. The Beverly Hills population is 35,000. Its total library income for the same period was approximately $208,658. The libraries were asked to provide the terminal (i.e. typically to be a teletype model ASR33), a telephone line, and to pay the line charges to Santa Monica. In addition, the libraries must contribute sufficient staff time to provide necessary system design specifications, and they will be expected to make full use of the system regularly, once it is operational. Here are some brief statistics to give perspective:

*The project is under general direction of Carlos Cuadra, and the management of Jules Mersel, with the author as principal investigator. The number of people working on the project has varied from three to five at any one time.

I. Acquisitions of Monographs (New or Out-of-Print)

A. Production of orders to vendors or publishers from teletype input of either:

1. LC card number and quantity desired, or
2. normal author-title-publisher description

B. Creation and maintenance of an "in-process" file within the computer Reports available optionally:

1. on demand by teletype with immediate response
2. on demand by teletype with off-line response
3. on a scheduled basis off-line

C. Creation and maintenance of out-of-print "wants" file. Reports as per (I.B) above.

D. Reports for:

1. Budget control
   a. liens
   b. special funds
   c. forecasting of expenditures by various breakdowns, e.g., subjects, funds, vendors, etc.
   d. expenditures-to-date by various breakdowns, as in (c) above
2. Prevention of unwanted duplication of orders
3. File access by several alphabetic sequences, e.g.:
   a. author
   b. title
   c. subject
   d. vendor
   e. key-word-in-context

II. Cataloging Routines

A. Creation and maintenance of cataloging "in-process" file in common with acquisitions file (I.B). Reports available on same basis as for acquisitions (I.B, 1-3), above, i.e., by teletype or off-line, scheduled or on demand.

Figure 1. LISTS Products and Service Areas

B. Production of cataloging aids, e.g.:

1. cataloging work sheets
2. temporary entries in card form or book form
3. authority file creation and maintenance
4. final catalog records in either card form or book form

III. Circulation Management

A. Loan file creation and maintenance with reports and notices produced for:

1. overdues
2. recalls
3. fines
4. use of the library collection

B. Borrower registration file created and maintained for such uses as:

1. use of the library collection
2. selective announcement service on newly received titles

IV. Serials Control

A. Serials acquisitions

1. Preparation of initial orders to vendors, as for monographs (I.A) above
2. Expiration warnings
3. Production of renewal lists

B. Serials records

1. Creation and maintenance of serial records file within computer. Reports available optionally:
   a. on demand by teletype with immediate response
   b. on demand by teletype with off-line response
   c. on a scheduled basis off-line
2. Reports in the form of:
   a. serial holdings in various possible alphabetic sequences, e.g., title, subject, classification number, language, etc.
   b. serial "wants" or gaps in holdings
   c. current receipts
   d. items to be claimed
3. Bindery processing records, e.g.:
   a. list of complete volumes ready to bind
   b. bindery instructions for each volume or in list form
   c. list of volumes at bindery

Figure 1. (continued)

Income figures are not available for the academic libraries. Pierce College has approximately 10,000 daytime students. Fullerton Junior College is about the same size. Both of these institutions are part of a school district that has more than one campus. Fullerton is a part of a three-college system and Pierce is a part of the general Los Angeles junior college district, which has several institutions. The Los Angeles system is a part of the city school system, whereas the junior college district in Fullerton is not otherwise connected with the public school system.

The University of California at Riverside has a moderately large university library of approximately 600,000 volumes, with an annual growth rate of about 45,000 volumes. The University of Southern California has about 1,200,000 volumes and a growth rate of approximately 35,000 volumes per year.

The approach made to these libraries was that we would develop processes which would be applicable in a time-sharing system for virtually any function of their technical operations. We assumed (correctly) that all of them would want to begin with the acquisitions function. Figure 1 depicts the areas in which we have promised to work. Since January 1968, work has been under way in many of these areas to develop the various operations for each of the libraries in the experiment. In addition to acquisitions, we are working in such areas as serials control, the possible application of an on-line circulation system, and the production of a book-form catalog for Fullerton Junior College. The implementation of the acquisitions function has now reached the point at which the input procedures are in prototype form and will result in certain specific outputs and processing within the computer.

```
LOGIN XE302 NP010 LISTS
$LOAD 16
GO

$MSG IN.

   LISTS IS NOW OPERATING.  GO AHEAD PLS.  IF YOU NEED
INSTRUCTIONS ENTER THE WORD  HELP  .

*'ACLA"
'ACLC
OK*67-1145&68-421&67-9302 &67-60561&SA68-4003
*A:/SHAKESPEARE,/WILLIAM;/COMPLETE WORKS;P:CROWELL;1966
ILLEGAL DATA. INPUT ONLY LC CARD NUMBERS, OR GIVE A NEW COMMAND.
*'ACAT
OK*/SHAKESPEARE,/WILLIAM;/COMPLETE WORKS;P:CROWELL;1966
* !QUIT

$MSG IN.
```

Figure 2. Prototype Interaction Exchange between User and Computer

Figure 2 shows a prototype interactive exchange between a user and the computer in establishing an acquisitions operation that will result in the production of book orders. The codes for the different types of processes and elements of the data are chosen to be as simple as possible, and to be like the abbreviations normally used by people working in library technical processing departments. Routines are established in such a way that the most typical operation is the one that requires the least amount of specification by the user. (for example, a public library may well order 90 percent of its materials from one vendor. With this established, the system allows input without specification of vendor and assumes, unless informed otherwise, that the orders are to be prepared in the proper format for submission to the specified vendor.) We have used an expansion character, the semicolon, to allow specification of data elements as necessary within the record. For example, one of the modes of operation for acquisitions would be to input a string of Library of Congress card numbers, separated by an ampersand. If a Library of Congress card number represents an open entry or a multi-volume set of which the library wants only volume four, the LC card number is simply followed by a semicolon and the precise item, e.g., the eighth edition would be indicated by E:8. A volume would be indicated by a semicolon following the LC card number and then V:4, for example, for the fourth volume. This would result in the order specifying "eighth edition *only*" in the first case, and "fourth volume *only*" in the second case (e.g. 67-14891; E:8 or 67-19912; V:4). The same kind of expanded input would be necessary where there exist varying editions of a work. In specifying a particular edition of Shakespeare, for example, the semicolon would follow the initial elements of author and title, and a particular publisher, and perhaps a specification for edition, would have to be shown. In Figure 3 the standard citation is shown first, followed by the specification for the input into the LISTS system. Figure 4 shows some of the abbreviations we will use.

```
Shakespeare, William.  Complete works, edited by G. L. Kittredge.
Waltham, Mass., Blaisdell, n. d.

Shakespeare, William.  Complete works, edited by G. L. Kittredge.
N. Y., Crowell, 1966.


A:/SHAKESPEARE,/WILLIAM; /COMPLETE WORKS; P: CROWELL; 1966
```

Figure 3. Standard Citation and LISTS Input Specifications

PROBLEMS

Design

The design of the LISTS system will be influenced to some extent by that of TS/DMS. Since some parts of the general-purpose programs are still in prototype, or experimental, form they are subject to change; these changes obviously can affect what we do in LISTS. Some changes may involve computer code, in which case our coding must be redone. Other changes may make functions difficult to perform because special characters have been dedicated for system use. There are thus several levels of interference complexity that we may encounter and indeed, have encountered.

```
'LIB  UCR  'AC      66-0345 & 67-542 & 66-32579&
                    67-54321&
                    68-599; E7, V6, C5&
                    68-532; HOLD: F: fund name; R: requestor;
                    A: author name; V: vendor name and address;
                    E:6; &
```

LONG FORM	SHORT FORM
'ACQUISITION	'AC
'ARRIVAL	'AR
'UPDATE	'UP
'SERIAL	'SE
'REPORT	'REPORT
'LIB	'LIB
'QUIT	'QUIT
'MORE xxx	'MORE xxx
??	??
AUTHOR:	A:
TITLE:	T:
ARRIVAL DATE:	D:
PUBLISHER:	P:
LOCATION:	L:
FUND:	F:
VENDOR:	V:

Figure 4. Abbreviations

Initially, we had felt that most of our file processing and output needs would be met by the general-purposes programs, but TS/DMS has been set up basically to handle only sixty-four characters. This is unsatisfactory for a number of reasons. For one, the Library of Congress MARC tapes are coded to handle a full upper/lower-case capability, plus many special characters. The MARC II format presumably would be able to handle 256 separate characters. Certainly the 360-series machines could handle that many in the available 8-bit codes. So, we have the problem of maintaining the identification of the data taken from the MARC tape so that it can be output in upper/lower case form.

For local input terminals the problem is not so severe. Although the ASR33 teletype lacks lower-case alphabetic characters, a number of codes can be used to indicate a shift character. This would give us, then, an "escape" character, which would provide sufficient codes to retain the upper/lower case Roman letters.

The line printer we are using lacks accent marks and other special characters dear to the hearts of librarians. Fortunately, this is not so serious as it might first be assumed, since the two public libraries, the two junior colleges, and the SDC Technical Library purchase only English-language materials, with rare exceptions. The other two academic libraries, however, purchase significant quantities of material in foreign languages. How will they react to the lack of accent marks? Frankly, we do not know at this point. We believe that it may be possible to present a surrogate for some of the characters by overprinting. Other marks may be rare enough that the character could be marked in by hand—a ridiculous thought, considering the extent of automation we are seeking. The new Stromberg-Carlson printer, which uses non-impact methods, may come to our rescue. We could also procure the library print chain. We may be forced to expand our graphic arts capabilities in order to meet the requirements of discriminating librarians.

With only sixty-four characters, what will be the effect of the available sort routines on our output? We have had to develop special output packages apart from the general-purpose program available to us. This, of course, increases the cost of the system, narrowing what may already be an all-too-small margin between profit and loss for an operating system based on what we are now developing.

There are also some problems concerned with the participating libraries. We want very much to have them participate in the design process, so that we will provide programs which truly meet their needs, rather than say to them "Here is what we have. What can you use?" How, then, can we ensure that the library personnel are imaginative enough to push us to the limits of data processing technology without going over the line into the "blue-sky" area, where we cannot achieve the desired operation economically? We have tried to solve this problem by mentioning possible areas of operation and possible products, and leaving it up to the librarians and their staffs to seize upon, and request the implementation of, particular processes. For example, one of the public libraries decided that it would be of interest to them to attempt to develop a selective dissemination of information (SDI) package so as to send announcements of new books to selected patrons, based on interest profiles provided by the patrons. That library is in a very library-minded community and is used heavily by the residents for their cultural and informational needs. Thus, such a service would indeed be useful to bring to the attention of the patrons material presumably in fields of interest to them. To be sure, new-books lists are being produced by libraries now and posted; new books are displayed. But would it not be preferable to direct individual notices to patrons, so that they are not forced to scan items that may not be of interest to them in order to find those that are?

The answer, of course, is that a library ought not to utilize one method only. The "new acquisitions list" is simply another product of LISTS that will continue to be produced and posted, and new books will continue to be displayed. But now we will have two or more ways of notifying patrons, which ought to ensure that they will receive notification of new materials that will interest them. After all, maximum usage is the goal of the public library, and if such products will help achieve that, then they are indeed of value to the library.

Operations

There are also possible operating problems, For example, suppose that a given library has used a series of LC card order numbers. to initiate an order process. The orders have been created, and the items have been added to the in-process file for that library. Suppose now that the library desires to update the record and uses an LC card order number as the input to update the record, in this case adding some additional material and deleting earlier material. What happens if an error is made in the LC card number? This would result in a different entry being selected from the file to be updated. In this case, then, we must establish procedures to ensure that when changes are made, a sufficient amount of information is input to match existing records, so that these errors will not occur.

For some files we have chosen to use an identification code based on what has been done with CODEN as developed originally by the American Society for Testing and Materials. We will use three-letter codes for identification on listings of items wherever the files are small enough. In our experimental group of libraries all in-process files will be that size (with the possible exception of USC and Riverside). The same technique can also be used in handling a serials record file; a three-letter code will identify each entry. These codes will not be permanent identification codes; rather, they will identify a file *at a given time.* This is discussed further below.

ADDITIONAL PRODUCTS

The entire list of products and services as shown in Figure 1 obviously cannot be implemented in a short period of time with a limited staff. However, some areas are receiving attention, and possible products are being developed as follows.

One of the products that we can produce readily for acquisitions is an in-process file in at least three sequences: 1) by entry, alphabetically arranged;

2) in permuted form by key words in titles; and 3) by order numbers or fund numbers, or some other numerical listing meaningful to a particular library. The three-letter codes (mentioned above) would initially be assigned on the basis of, perhaps, the main entry listing. The same code would be assigned to any appearance of the same item in the other two lists. Simply inputting the three-letter code as part of an acquisitions update will cause the computer automatically to pull out the entry represented by that code. Some form of feedback will be given, either by off-line printout or by direct feedback on the terminal, so that users will be able to verify that they wish to update the record for each of the given codes.

For accounting purposes we can produce listings, on a regular basis, in such forms as: 1) volume (number) of purchases, year-to-date, by fund number and 2) volume (number) of purchases, year-to-date, by subject area.

Serials check-in could be accomplished by a listing that would show all "expected" items on one half of the page and all "unexpected" items on the other half of the page. Thus, in one alphabetic sequence one would have a complete record of all possible arrivals. The "expected" ones would require no action on the part of the check-in clerk; only those that did not appear on time would have to be entered into the computer system. Recording the fact of arrival could be done by a checkmark; the items remaining unchecked at the end of the period would be those that had to be entered into the computer. To notify the system of the non-arrival of any issue listed in the "expected" column, only the three-letter code needs to be input. (Since these codes are changed with each output of the list, they serve as identification only for that specific print-out.)

Items that are not expected—that is, either irregular items or materials that have been "claimed" and cannot be precisely pinpointed as to arrival date—are listed in the other column. When the materials are received, a checkmark is made against each item. At the end of the cycle, only those items received (i.e., check off) would be input by the three-letter code.

Note that the file is split into two parts, each of which uses a three-letter code. Obviously, with a large file, the codes will be duplicated (across columns) in at least some portion of the alphabet. All "non-receipts" would be input first or in a separate input sequence, and all receipts of unexpected materials would be input in a separate sequence. Thus, the fact some codes are duplicated is of no importance, since the command code (e.g., expected, unexpected) differentiates them. Using the three-letter codes, it ought to be possible for all but the largest libraries in the country to handle their serial files with fairly simple coding procedures for input.

Although problems of error will still exist, sequences of letters are much less prone to erroneous inout than are sequences of numbers. Most typists do not do well with numbers in any case, but are quite skillful in keyboarding letters. Most people remember letter sequences, even when they form non-sense words, much better than they remember numbers. Only time will tell what actual problems there will be with this type of procedure. We do plan to implement it.

Many statistics of interest in the acquisitions area have not been available to librarians in the past simply because it was uneconomical to collect sufficient data to derive the information. For example, a library might well be interested in knowing how many books in a particular subject area had been purchased from a particular vendor over a certain period of time. Using the general-purpose data management system, all that would be necessary to create the appropriate output from the data base would be to type in a command such as:

COUNT PURCHASES WHERE VENDOR EQ* X COMPANY AND
SUBJECT EQ CLASS QC AND DATE OF PURCHASE EQ 1966-67

Another example might be an analysis of the performance of a certain vendor. For example:

COUNT BY VENDOR NAME WHERE DATE OF RECEIPTS
GQ† DATE OF PURCHASE + 30

The system also provides various aids to the user who is unfamiliar with, or who has forgotten about, the structure of the data base, the steps required to retrieve information, the meaning of terms or operation, and so forth. For example, to receive a list of commands available to him, the user merely types in "?". To obtain additional information about an error (after receiving an error message from the system), the user would type in the word "MORE" to receive the desired information. To receive information on words recognized by the system–such as command words– the user types in the word "MORE" and the specific system word. For example, if the user typed in "MORE SIGMA," he would receive the following reply:

SIGMA COMPUTES AND PRINTS STANDARD DEVIATION OF
DATA VALUE FOR AN ELEMENT, SUBELEMENT,
OR ARITHMETIC EXPRESSION

If the user is unfamiliar with the structure of the data base, he can type in the word "COMPONENT" and receive a list of the components including their legality, format, coding types, and so on by typing in the word "DESCRIBE."

HARDWARE

The terminal hardware that we are using, the ASR33 Model teletype, made by the Teletype Corporation, can be used with either the 360/50 or the 360/67. It would be desirable to be able to use display terminals for many purposes within LISTS. Unfortunately, the technology has not yet reached the point where such display terminals are in the same price class as the ASR33, which can be leased for as little as $60 per month, and purchased outright as a complete machine for approximately $650. Without the attached paper-tape mechanism, the machine is known as KSR33, and can be purchased for under $500. Leased, the KSR33 costs approximately $45 per month.

*EQ = equals
†GQ = greater than or equal

Not only are display terminals more expensive, but the communications requirements are somewhat more stringent, particularly where a rapid display capability is required. Slow-speed display devices, which operate character by character at the same rate as a teletype, are available on the market, and do offer some advantages over the teletype, but their cost is significantly greater. One obvious advantage is silence, but a concomitant disadvantge is that, without additional equipment, there is no hard-copy record (at the user's end) of the transactions that have been carried on with the computer.

Figure 5 shows the hardware configuration LISTS will be using. One of the printers has available the standard TN print chain, which is a 120 -character print chain with upper-case and lower-case characters. This is not the library print chain, however.

SOFTWARE

Most of the programming done at SDC involves the use of JOVIAL in one way or another. JOVIAL is a procedural language somewhat like ALGOL, and it has been accepted by the United States Air Force as the standard language for command and control. Certain portions of the time-sharing programs are, for one reason or another, written in basic assembly language. It is also possible to call programs in FORTRAN, COBOL, or PLI and to run with them when operating in batch mode. In due time programming may be done on-line in any of these languages as well as in JOVIAL.

GOALS

The goal of the LISTS project is to derive the cost of an on-line operation set up to satisfy the processing and housekeeping needs of our experimental group of libraries. A data base is now available, or will be, from the Library of Congress and others. We believe that the technologies are ripe for this type of service—that the hardware is now capable of handling large enough files, and that the time-sharing system has been developed sufficiently. The task of the project is to test these beliefs in a realistic situation. At the end of a test period we will know what we have done and what it has cost. Will libraries be able to afford such a system? At what point do telephone line charges become too great and cause the system to become uneconomical for a given library? What can be done to reduce the costs by creating more programs tailored especially for library processing? It may well be that the general-purpose data management system is not satisfactory or is too slow to allow efficient operation. How much must be changed? Our system allows us to keep statistics on its operation that we can analyze in terms meaningful enough to allow us to redesign some part of the system to make it more economical. On the other hand, the costs may be so high that we will conclude that we must wait until fourth-generation equipment is here before we can really say "the time is right."

There is a continuing controversy over the relative merits of time-sharing and batch processing. Reports comparing some form of on-line and off-line data processing with respect to man/machine measures of system performance suggest that, in general, the relative cost/effectiveness between time-sharing

Component	Qty	Capacity/Speed	Total Bytes
Main Core Memory (2365-12)	2	262,144 bytes	524,288
. Cycle time .75 μsec. . Accesses 8 bytes (double word) in parallel			
Drum (2301)	2	4,000,000 bytes	8,000,000
. Average access time 8.6 ms. . Data rate 1,250,000 bytes/sec. . Rotates @3500 rpm			
Disc (2314)	2	29,170,000 bytes	466,720,000
. Average access time 75 ms. (25 ms./min. to 135 ms./max.) . Data rate 312,000 bytes/sec. . Max. number of bytes/track 7,294 . Number of tracks - 4000/2316			
Tape Drives (2402-3,9-Track)	10	21,000,000 bytes	210,000,000
. Tape Speed 112.5 ips . Density 800 bytes/in. . Data rate 90,000 bytes/sec.			
Tape Drives (2402-3, 7-Track)	6	20,450,000 bytes	122,700,000
. Tape Speed 112.5 ips . Density 800,556,200 bytes/in. . Data rate @800 Density 90,000 bytes/sec.			
Printer (1403-N1)	2	1100 lpm	
Reader (2540)	1	1000 cards/min.	
Punch (2540)	1	300 cards/min.	
Communication Terminals (2741)*	25	14.8 char./sec.	
Operator Comm. Terminals (1052)	1	14.8 char./sec.	
CC-30	3	625 char./sec.	
. CC7012 @ serial trans. option . CC72 @ multiplexor allowing up to 30 devices . Two CC30 stations			

Figure 5. Characteristics of the IBM 360/67

*Teletype terminals may be substituted for some of these. Their printing rate is only ten characters per second.

and batch processing is very sensitive to, and varies widely with, the precise man/machine conditions under which experimental comparisons are made. Very little is known about individual human performance differences, learning, and decision-making in connection with time-sharing systems. There is a paucity of information on the data processing problems and tasks and on the empirical use of computer languages and system support facilities. Significant experimental work comparing time-sharing with batch processing, or with any other data processing technique, requires development in depth of the entire applied scientific field of user and system performance as a whole. Such development is presently in its infancy.

General References

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