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SYSTEM DESIGN, EVALUATION AND COSTING--IN PLAIN ENGLISH[1,2]

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Introduction

The place to start any meaningful discussion of systems, as applied to the collection, organization, and dissemination of information, or sources of information, is by defining them. The concept of the information system is one which has been very much maligned and misunderstood. This is due, in large measure, to the fact that we have delegated much of our thinking, not to persons actively involved in the operation and management of library and information programs, but to computer and systems specialists, who, all too frequently, try to mold or contort information program requirements to make them conform to the capabilities of their hardware or to previously designed systems, and who, all too frequently, obfuscate the meaning and significance of the concept, as it applies to libraries and information services.

We, in our firm, had a very interesting opportunity in the past year to design and operate a small-scale Selective Dissemination of Information (SDI) system, starting from scratch. I will not go into the details of the design and operation, but I do want to mention two things about the system: First, the design, planning, and debugging that went into it consumed about two months of a senior information specialist's time, and one month of a computer programmer's time. Second, we sent out the first notifications to our audience within three months after the onset of

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the project. From the regular feedback we are receiving from the audience, the system is working very smoothly; its error rate--or spurious document rate--is about 26 percent, which is a very typical average, and its omission rate--failure to pick out pertinent documents--is five percent, which is somewhat better than average.

The reason for the success and economy of the system, and the point of this digression, is that it was designed by persons with an intimate knowledge of libraries and indexing and retrieval systems. Long before the system ever got close to a computer or computer programmer, what it was supposed to do and how it was supposed to do it had been carefully thought out and documented by people with a first-hand knowledge of the processes involved.

One major weakness in what we did was that we were forced to prejudge the need for an SDI system at the onset. We were told that the system had to include SDI. We are trying to make up for this by doing a careful evaluation of the impact of the system on its audience, and by comparing its utility against an abstracting and indexing publication which we are also producing for the same client. We are very fortunate that the design and implementation of the SDI system cost relatively little. But one is not always that fortunate. As a rule, it is a good idea to avoid the common trap of building first and analyzing afterward. This can be very dangerous and costly.

Systems Defined

To get back to the subject of definitions, a system is an ordered, consistent, predictable way of accomplishing a desired end. The desired end may be the preparation of food, the treatment of disease, or the retrieval or dissemination of information.

Order and consistency in systems give rise to predictability, which, in turn, gives rise to dependability and efficient use. Take, for instance, the subject index to Chemical Abstracts. A user may not necessarily agree with the way a given compound or phenomenon is indexed in Chemical Abstracts, but he generally knows how CA does it and where to find it in the index, because CA generally tries to do it the same way. That makes it a system.

Or take the case of the classification systems used to arrange books in libraries. One may not agree with the way books are categorized in libraries--the Library of Congress, for years, classified computers under Calculating Machines, completely ignoring non-numerical applications. However, you could always depend on books on computers being shelved with books on calculating machines in libraries using the LC classification and this makes it a system. It is dependable--or perhaps consistently undependable would be a better way of putting it.

When I was an undergraduate taking a course in Quantitative Analysis, one of the first things we were taught is the difference between accuracy and precision. We were told that accuracy is being right in the absolute sense, and precision is being consistent in our results. We soon learned that absolute accuracy is very difficult to attain, because of imperfections in the instruments we worked with and a variety of other factors, and that we had to make up for this by being precise or consistent in our measurements. This condition is, if anything, amplified in the case of the analysis and organization of documents, where accuracy in the interpretation of significance, usefulness, and meaning lies mainly in the eye of the beholder. And so, as in the case of quantitative chemical measurements, we aim first for precision or consistency and then for accuracy. This makes for a system.

To recapitulate, a system is a device that is consistent and compatible with itself in doing what it was established to do. This is true whether the system is the index to a book, a library card catalog, an entire library or information center,

or, for that matter, a national or international network of libraries or information centers. A system must be as responsive as possible to the needs of its users. However, it can never be completely responsive to the interests, viewpoints, and contexts of all of its users; if it were, it would not be a system but an anarchy. Ultimately, the best of systems is a compromise, and the ultimate aim of a system design is to define and implement the most optimal compromise.

Definition of System Requirements

So much for definitions. Now how do we go about defining, designing, and implementing this optimal compromise? I thought that a good way of discussing this would be to recount a case from our own recent experience, in which we were called upon to develop a rather complex system for an information center dealing with a broad range of the social sciences.

The first thing we did was to enter into detailed discussions with the managers of the institution to determine why they thought they needed a system, what they wanted or expected it to do, and what specific problems they expected it to solve. All too often, the motivation behind the desire for a system or program is not a clear-cut definition of need but a desire to be in the forefront of current fashion. But all too often what is fashionable for one institution is quite out of context for another, and all too often fashions change, leaving us with white elephants rather than viable working mechanisms that do required jobs in the best and most efficient ways.

When we had defined what, in general, the system was needed for, and what, in general, it was supposed to do and for whom, and when we had pinned down all possible financial and administrative constraints that would affect or limit what we came up with, we turned to the next step in the design procedure, which was a

detailed interview study of the user group. The purpose of this study was not merely to stick pins in the users to find out what made them tick; nor was it an effort to get the users to design the system for us, although one does get many useful hints from analyzing successes and failures in the use of information tools and techniques. The user study was addressed to very specific, carefully developed points which would ultimately guide us in defining real needs and determining the best available means of meeting them.

Ingredients of User Study

The first point with which we concerned ourselves in the user study was the exact activities and work-related subject interests of the users. The purpose of this line of questioning was to guide the collection of pertinent literature, and to define sources of expertise within the user group.

The second point that we dealt with in our interviews was the exact words and phrases used to describe the subjects and activities encompassed by the audience. The purpose of this line of questioning was to help us develop the beginning basis for an indexing and retrieval vocabulary which was reflective of the actual working language of the user group.

The next series of questions had to do with the existing means by which the users keep abreast of current projects, how they get current research results, how they find out what has been done in the past, how they get answers to questions, and how they generally get the information they need to do their work. The purpose of this section of the interview, which was handled by means of general questions and the collection of specific cases, was to determine what the system had to do and what it did not have to do because it was already being done satisfactorily.

We gained further insights as to what the system had to do via a series of questions in which we tried to identify real and actual problems encountered by the users in trying to obtain the different types of information they needed. Our aim in this series of questions was to pinpoint those areas that were in the most urgent need of improvement, and, in so doing, to establish a schedule of priorities for what the system had to do.

A fifth set of questions was addressed to time variables that might affect the system requirements. Examples of such variables are: frequency of use of libraries and information centers, frequency of requests for different types of services, needed speed of delivery of responses and alerting services, time actually available and given to gathering and use of information and information sources, and active life of literature used.

Another series of questions was designed to identify libraries, information centers, institutions, and individuals from which the users had obtained information in the recent past, and those to which they had given information. Our purpose here was twofold: First, we were trying to identify information sources and resources that could supplement those within the information center we were designing, and perhaps eliminate certain of the collecting and service functions that the center might otherwise have to perform. Second, we were trying to identify the probable characteristics and size of the institutional and individual clientele that would be served by the center.

Finally, as a further means of identifying existing sources and resources, we asked a series of questions regarding the use of group and individual files and collections, again with a view toward supplementing the facilities of the information center and eliminating jobs for it where feasible.

Analysis of Background Information

Following completion of our user-interviews--and, incidentally, since we are talking about an optimal compromise and not perfection, such interviews need not be with all the users but with a representative cross section of them--we did a careful analysis and synthesis to see what we had gotten, and to turn these findings into a set of requirements. I want to emphasize once again, because this tends to be a bone of contention in this field, that we developed the system requirements, not the users. However, we based the set of requirements that we developed primarily on information obtained from the users.

What we found in the way of requirements was this:

1. The system had to have the capability of putting people in touch with one another directly, not via the literature, for purposes of consultation and quick access to specialized information.
2. The system had to provide information about ongoing research projects--in advance of publication of their results.
3. The system had to provide information on current research results.
4. The system had to provide information on sources of information.
5. The system had to provide rapid access to literature that it did not own or contain.
6. The system had to have a capability to perform retrospective searches.

In regard to searches, we found the need for search capabilities in this situation to be quite secondary to capabilities for current awareness. The reasons for this were, first, because of the dynamism of the subject or subjects we were dealing with, and second, because of the nature and habits of the people who would be using the system. The potential users were, as a rule, experts in the fields

they were dealing with; they knew the literature and the people in their fields intimately; and they were perennial scholars. Only when they had to look into new or alien fields, for one reason or other, did they require retrospective searches, and this was relatively rare. More often, in such instances, they sought out specialists in the fields involved.

What we ended up with was a set of requirements which were quite atypical, when viewed in terms of the current mores of information systems. The emphasis was on interpersonal communication and current awareness, rather than on information retrieval as such. It is true that past is prologue, but in this specimen field that we're discussing--Counterinsurgency--and in many other fields, when we refer to the past we mean the very recent past, and it appears to be becoming ever more recent.

However, the main point is that we developed our requirements not on the basis of what information systems ordinarily do, but on the basis of what was needed to serve the identified needs of a specific group.

Selection of Methods or Mechanisms

Having defined what the system was to do, and having checked it out carefully and in detail with the client organization, we turned to the subject of how to do it.

We approached the subject of how to make the system go by matching alternative means against each of the jobs that had to be done. We evaluated each of these alternative means in terms of its relative efficacy in getting the job done, the probability of its acceptance by the users, and its cost. The importance of the ability of a given tool or technique to perform its tasks efficiently is obvious;

the relationship of the tool or technique to its users--the people who are going to be affected by it--and the relationship of the tool or technique to its true costs are not always so obvious.

All too often, in designing systems and sub-systems, we ignore the habits, preferences, and idiosyncracies of the people who are to use them, or on whose behalf we intend to operate them. We set up situations in which we have to change the work habits of the users if they are to use the system. As a result, we frequently see systems or services that are not used enough to justify their costs. It is far more realistic to try to tailor the system to the user than the other way around.

In regard to costs, the ultimate and obvious aim is to get the most for the smallest amount of money. However, this can be a very elusive concept. At the last ADI meeting in Santa Monica, I participated in a discussion on input mechanisms for computer-driven composition devices. At a certain point in the discussion, the subject of costs came up. One person said that he had a device that cost a certain amount of money, could be keyed at a certain rate of speed, and could be operated by very low-level personnel. Another person got up and said that he had a device that could do everything that the first one could do, but it was $5,000 cheaper. This was all very illuminating, but it missed the most fundamental point about costs. If a machine costs, say, $5,000, and it is used to compose ten pages a year, and it has a working lifetime of five years, this means that the cost-per-page, in terms of machine costs alone, is $100. This is obviously high. On the other hand, if we had a machine that cost $500,000, with the same working lifetime, but we used it to compose 50,000 pages a year, the cost per page is $2, which is considerably less than $100. In short, when we determine costs, we must think in terms

of price per unit of output, and not merely how much money we put into the system. This applies to SDI services, searching services, and all other functions and services that might be performed by the system.

One other thing that we should think about when we select a method or mechanism for getting a job done is what, in addition to the specific job, it will contribute to a system. For instance, we might find that we do not have searches of sufficient logical complexity or in sufficient quantity to warrant the use of a computer for this purpose. However, we might still decide to use a computer because this permits us to prepare accession lists and printed indexes rapidly, it permits us to produce catalog cards cheaply and quickly, and it furnishes us a basis for producing an SDI service, which may be a system requirement. And so we always look for by-products to help us justify or amortize whatever device or mechanism we select to do a job. This is another way of keeping the costs of our units of output as low as possible.

Design of System

Having assembled and defined our processes and procedures, we turn to the job of putting them together to make them into a viable system that is, as I mentioned previously, compatible with itself, consistent, and dependable.

We start this by laying out, in detailed flow chart form, each of the processes that are to be performed by the system. We examine each flow chart for each process to make sure that it is realistic and complete--to make sure that the work flows in logical and even sequence, that steps that are precursors for later steps are treated as such, and that there is a minimum of queuing or delay as we go from step to step. All too often, incomplete or foggy thinking results in imbalances or delays in the work flow, and, as a result, people, machines, or both are forced to remain idle or become overloaded because of delays in precursor steps.

This can be extremely costly, and must be anticipated and eliminated at the onset.

When we have completed and debugged our sub-systems, we are ready to put them together to form an integrated, working system. This stage is really the first moment of truth. This is when we test our logic and determine whether our sub-systems are compatible, and whether they can operate in concert to perform the jobs that have to be done, or whether they are, in fact, standing in one another's way. It sometimes happens that the steps involved in one job are in conflict with the steps involved in the performance of another. Situations like this have to be identified and adjudicated at this stage. Reasonable compromises have to be worked out to resolve conflicts between processes, or else chaos will reign and efficiency will suffer.

When we have completely debugged the system plan and its constituent parts, we are ready to turn it over to our programmers, if computers are involved, and to implement it on a pilot basis. I emphasize the word "pilot" here because no matter how carefully and cleverly we develop and chart our design we will inevitably find, at the implementation stage, that we have done something wrong or forgotten something. We minimize our losses by avoiding full-scale implementation until we have thoroughly tested our design and every part of it.

Design Evaluation

This leads us to the next step in the procedure: evaluating what we have done. This is the second moment of truth. Unfortunately, the concept of evaluation in this field is, if possible, even more maligned, misunderstood, and misrepresented than the concept of the system itself. Just as there are vogues and fashions in systems--SDI, library mechanization, etc.--there are vogues and fashions in methods of evaluation. Years ago, the fashionable thing in evaluation was

the so-called library survey. Then we got into so-called management studies. Then we got into an era of user-studies. Now the vogue of the moment is relevance and recall. Actually, all of these techniques are useful to a limited degree; but each tells only part of the story.

There are various aspects and various levels of evaluation, and these all have to be considered and implemented if anything useful is to be deduced from the evaluative processes. Evaluation is not merely whether a library or information center has the right kinds and quantity of books, whether its expenditures for staff are in correct proportion to book expenditures or whether there is adequate space for books, staff, and readers; it is not merely an analysis of whether and how the presumed audience uses a system or service; it is not merely a question of how fast or how well it performs the tasks it is presumed to have to do; and it is not merely a measure of the false drops and misses produced by a retrieval system. It is much more than this. In order to evaluate a system, we have to find answers to five basic questions:

1. What services should the system be performing on behalf of its users?
2. Is the system performing all the services it should be performing?
3. Is the system performing any services that it should <u>not</u> be performing?
4. Is it performing the services it should be performing as efficiently and economically as possible?
5. If not, what are the causes, and what can be done to remedy the problem or problems?

Each of these questions requires a different analytical technique for its answer.

The answer to the first question, relating the services that the system should be performing, is best obtained from analysis of the results of user studies, since,

ultimately, the system should come as close as it can to meeting user needs, habits, and preferences.

The answer to the second question, relating to whether the system is performing all the jobs it is supposed to requires a careful match between the system's mission statement and what it is actually doing. If the mission statement is incomplete or out of date, it may be necessary to supplement it with information derived from the user survey and analysis of requirements to work up the answer.

Essentially the same general procedure would apply to the third question, relating to jobs that the system should not be doing. The answer to the fourth question, relating to the efficiency and economy of the system, is derived by a variety of analytical or management techniques depending on what aspect or aspects of the system we are dealing with. Studies of relevance and recall, and their underlying causes, might, for instance, be the method of choice if we are dealing with the searching and retrieval capabilities of the system. But, then again, another method may be indicated, even in a retrieval situation.

As part of our social science system design assignment, we were required to evaluate the retrieval effectiveness of a file which the client-organization had set up to perform searches. The file was of the "collectanea" type, in which each page of a document was indexed by an average of five terms and a Xerox copy was made and filed for each term. This meant an average of 2,000 pages filed for a 400-page book, and, with indexing, copying, and filing, it meant about $800 per book.

In fulfillment of the evaluation requirement, we ran a series of test searches and analyzed the results. We found that the retrieval effectiveness of the file was

excellent: It produced very few spurious references in its search products, and it missed very few pertinent references. However, retrieval power was actually a side issue in this case, first, because it would cost a prohibitive amount of money to get a significant number of documents into the system; second, because retrospective retrieval was a secondary factor in the information-gathering activities of the group involved; and, third, because the file was cumbersome to use, and avoided wherever possible by its potential users.

The answer to the fifth question, relating to the causes and remedies for identified problems or shortcomings is largely a matter of managerial analysis--of systematically reviewing the steps and processes involved, looking for weaknesses or errors, and determining how to correct them.

I would like to say one other thing about evaluation. If it is done effectively—if it is thought of as a matter of quality control—it is a continuing, and never a one-shot process. In a dynamic situation—and, as I mentioned before, situations in this field tend to be more and more dynamic and truth never stands still—requirements change, methodologies and technologies change; the best way of meeting a requirement now may become comparatively inefficient later. People operating systems change, and machines and mechanisms get old or obsolete. And so we can never afford to be sanguine about systems. We have to incorporate continuous and rigorous quality control procedures into their operation. That is the only way we can be sure we are doing the job we set out to do: to meet the existing information needs of our audience.

Conclusions

The purpose of the foregoing remarks has been to remove some of the mystery and witchcraft which have surrounded the concept of information systems for far

too long, and to urge the return of the design and operation of information services to where they logically belong: to the people who have the day-to-day job of making them go and perform. I have learned from experience duplicated over and over again that it does not take a special person with special training to produce an effective system; what it takes is a willingness to analyze, carefully and rigorously, what is needed and how to accomplish it. Block diagrams and flow charts are not systems; they are merely abstract representations of systems. They are products of disciplined thinking by human beings, and there is simply no substitute for this.

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13 ABSTRACT

The concepts of system design, evaluation, and costing are among the most often discussed and widely misunderstood in the information field. This report attempts, via case illustrations, to describe and explain the steps and processes involved, so as to take some of the mystery and witchcraft out of systems and to facilitate the return of design and operation of information services to where they rightfully belong: to the people who have the day-to-day job of making them go and perform.

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