An On-line Intellectual Community

or

"MEMEX" Revisited

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ABSTRACT

This paper represents one individual's view of the potential impact of Computer and Information Science technology on the future of scientific and technical information transfer. However, the propositions put forth are based upon a synthesis of existing efforts tempered by what seem to be the most significant needs in the current process.

The paper attempts to piece together how current efforts in abstract services, journal and book publication, word processing, computerized conferences, and information retrieval systems may ultimately evolve as a single system serving the needs of the scientific and technical community.

INTRODUCTION

In 1945, Vannevar Bush, President Roosevelt's wartime director of the Office of Scientific Research and Development, published an extremely foresighted article* in which he predicted among other things such products as the XEROX machine, the POLAROID camera and FORTRAN. One of the items predicted was "MEMEX" - a writing, reading, filing and communication system contained in a desk and including a screen and keyboard. This device would allow an individual to accumulate and develop his own personal library of materials. It would also allow him to compose and edit his writings. Besides allowing an individual to accomplish what then took card files, notebooks, typewriters, scissors, paper, copying machines, index tabs, graphic boards and roll top desks, MEMEX would also allow a high degree of non linearity in the structuring and association of text not possible with current linear forms such as articles and books. In essence, the electronic form of the printed word would allow our creation and use of text in manners more akin to our cognitive processes which appear to be parallel and associative in nature.

Needless to say there is no MEMEX machine available today. However, the pieces of MEMEX exist and it is now clear that it is only a matter of time, cost reduction, packaging and human interface design before MEMEX becomes a reality. The current generation of word processing equipment represents one crude but significant step towards the MEMEX machine described by Bush. Even more significant are the software developments that have emerged under the concepts of "Hypertext" and NLS** as well as a significant number of

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*AS WE MAY THINK by Vannevar Bush, The Atlantic Monthly, July 1945, p. 101-108.

**See for example:
Theodore H. Nelson, "A File Structure for the Complex, the Changing and the Indeterminate, edited," 20th National Computer Conference of the ACM, 1965.

D. C. Englebart, et. al. "The Augumented Knowledge Workshop," in Computer Networking, edited by Blanc & Cotton, IEEE Press, 1976.

specific large scale text editing systems such as WYLBUR, TEXT, etc.*

Utilizing existing components to fabricate a MEMEX today would probably result in a cost of $50,000 to $100,000 dollars. However, a decade from now it will be here at a cost making it available to professionals in most organizations. What is important to observe is that a decade from now document composition and preparation and the retrieval and maintenance of personal files of text material will largely be carried out on stand alone text oriented systems for the direct use of professionals and secretaries. This would likely be bourne out from an economic standpoint by any extrapolation of microprocessor and floppy disc type technology costs versus communication costs. Furthermore, the composition and editing of an article by the author does not inherently require communications and centralized files for a large portion of the task. As we shall see, however, this is not true of other steps in the publication and review process. Also, this is not true of the pre-publication efforts involving the exchange of recent research findings among those working at the forefront of some research specialty.

Another key in the current state of technology is the on-line abstract services which allow rapid retrieval of (hopefully relevant) documents related to a professional's concern, and certain current off-line approaches such as Citation Indexing. While these have proved their worth, the diversity, incompatability, and overlapping nature of these systems leave the user in

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*David Rice and Andries Van Dam, "On-Line Text Editing: A Survey," Computing Surveys, Volume, 3, No. 2, September 1971.

somewhat of a quandary. Over the long term one can expect a shakedown of this industry as market place mechanisms become more dominant and direct federal subsidies begin to become less of an economic factor. Furthermore, users will gravitate to those services that can fulfill the greater portion of their needs, and thereby an integration of service will occur.

Publishing technology in terms of final document preparation and reproduction is another element in this puzzle. Personalized, stand alone, editing systems will not provide the photo-composition capabilities of existing publication systems, or their ~~and the~~ professional editing and distribution services.

The final ingredient is human communications. This is the area that has received little attention to date and probably represents one of the primary bottlenecks in the current distribution systems for professional and technical information. These bottlenecks are:

Recent Research Findings and Peer Group Exchanges

The process of mail, phone, travel and professional meetings all carry with them delays and characteristic inefficencies that have grown rather than decreased in recent years. Both the rising costs of travel and the greater needs of multi-disciplinary and/or interdisciplinary research make these informal and semiformal communication and exchange processes somewhat inadequate. Many research communities are finding the members rarely have professional meetings in common.

Joint Authorship and Joint Efforts

Unless authors and/or team members are in the same location this is a rather difficult and time consuming operation. Certain types of efforts like the implementation of a computer model are almost impossible to undertake unless the key members of the team are co-located. Furthermore, it is somewhat common today to find researchers who have discovered the fellow researchers they most relate to are located elsewhere than their home institution.

Refereeing

The time delay in getting a paper reviewed and often re-reviewed prior to publication is well known to us all. For many areas of professional activity, this can take a year or more.

Evaluation

This is perhaps the area that has received the least attention in current efforts at improving scientific information flow and transfer. How often have we retrieved an article based upon an examination of title, abstract and/or index keys only to discover it was not what was expected. Where was the mechanism for the reader to update the system, indicate an appropriate change in the title, abstract or keys so that others would have a better chance of a more relevant search with respect to the particular item. As primary as the original article are the later reviews of or reactions to it published elsewhere or merely passed among the scientific group. Even if published, these are not well correlated with the original reference in most information retrieval systems.

All the above processes involve a high degree of human communication and exchange as opposed to the broadcast nature of a finalized article. We all tend to take the human communication process for granted in assuming we are limited to the forms of communication we are familiar with mail, phone, meetings. We spend so much time at these processes and thereby seem to feel we are stuck with them as the only alternative.

Recently, there has emerged an alternative and/or compliment to the existing forms of mail, telephone, travel and group meetings that holds the promise of improving the situation in the above problem areas. It is the general concept of utilizing computers and digital communication networks to facilitate a direct written communication process among a group of individuals by providing them a communication structure that is well suited to their endeavors.

For the past six months at the New Jersey Institute of Technology we have been experimenting with EIES (Electronic Information Exchange System) whose development and operation are supported by the Access Improvement Program of the Division of Science Information of NSF. This system was specifically designed to improve the ability of scientific and technical groups to overcome the problems listed above by providing a total communication environment.

EIES DESCRIBED

The system itself may be viewed as a large common blackboard available to scientific users of the system regardless of their location or their preferred time of use. The blackboard has been subdivided into four major segments which offer the different components necessary for a communication and information exchange environment among a group of professionals. These are:

> A personal NOTEBOOK where an individual can leisurely compose material for later use elsewhere in the system and where he or she can invite others to co-author short papers or reports.
>
> A private MESSAGE system where an individual can send a private communication to any other individual or set of individuals such as a group.
>
> A CONFERENCE system where a group of MEMBERS can hold a common discussion around a specific topic and maintain a proceeedings for later reference and reflection.
>
> A BULLETIN where an author or co-authors can submit a short paper or recent findings for review through direct conferences among anonymous referees and the authors. If accepted, such papers are considered public and placed in the BULLETIN. The BULLETIN is similar in concept to research newsletters which are published by some professional societies for the benefit of special interest groups.

The system is designed to provide regular and current communication facilities for a group. It is not designed as an archival system for historical records or for the production of large documents.

There is also a directory of users or members of EIES, into which each user is asked to enter his address, telephone, number and a brief description of interests for the benefits of other users. The directory also allows the description and membership listing of groups, where a "group" is a set of members engaged in some common purpose or objective.

A user can belong to more than one group. Normally a group has associated with it a private group conference or discussion. The group may also have its own bulletin or "newsletter" in which to publish material it wishes to make public.

The message file has a finite size which will be adjusted so that delivered messages will disappear approximately one week after delivery or if undelivered, in two weeks. Originators of undelivered messages will automatically be notified of such actions. A sender or receiver of a message may choose to copy the message into his or her notebook if desired. The sender may also initiate a termination of an undelivered message at any time.

A conference set up for an established group will maintain a proceedings that is normally up to three hundred comments long. This may be adjusted in special cases to be larger. Normally the oldest comments will disappear to make room for new ones, once 300 or the adjusted maximum has been reached. The individual moderating or facilitating the conference has the ability to selectively delete comments. The author of a particular comment may also date or delete that comment. This means that conference groups can selectively determine what is outdated.

A temporary conference, which can be set up by any user, is normally allocated space for fifty comments, which may also be adjusted by a request to the system monitor. Such conferences will be automatically deleted if a minimum level of activity, as defined by the system monitor, is not maintained. A particular user may normally have only one temporary conference in existence at any one time. The user setting up the temporary conference designates who are the other conferees. If the conferees wish to pool their allocations for temporary conferences the system monitor would increase the allowance on conference size.

There are also a number of public conferences which do not maintain a membership list and are therefore open for anyone to access and make comments. Typically, this facility would be used for describing problems with the system or offering suggestions for improving the system.

Each user is normally allocated a fifty page notebook. This may also be adjusted by the System monitor when a special need arises. A set of two or more users may merge this allocation into one. In addition, the owner of a notebook may make portions of his or her notebook available to others for reading and writing or reading only. The notebook is basically a personal file for retaining copies of items and for developing items at leisure, such as comments for a conference or papers for the bulletin.

The bulletin is designed for short papers on current research activities (in the range of five to twenty pages, although this is not a hard and fast rule). There is an automatic procedure to submit a paper for review. Until accepted it remains in the user's notebook, where it may be modified until the review procedure is complete. The reviewers chosen by the bulletin editor are given access to read the paper and can engage in an anonymous discussion with the author or authors through a temporary conference set up for that purpose.

The bulletin also allows members of the research group to submit news items or items that can be voted on and the vote displayed to the readership. This might be the statement of a research hypothesis, with a group response as to the degree of agreement, or the proposal for an experiment with potential significance evaluated by the group. The author may select from some nine available voting scales. In addition direct comments on submitted items or papers may be contributed and will be automatically associated with the

original item for those wanting to retrieve the commentary on such items.

In addition to being a user or member of EIES and a member of different groups, certain individuals have the following roles:

The "editor" of the bulletin for a group;

The "coordinator" of a group, who may add or delete members of the group;

The conference "moderator," who can act as the chairman of a meeting through his or her editing powers, or merely act as a secretary in keeping the "minutes" or proceedings organized.

The "system monitor," who established the existence of members, notebooks and groups, and who can adjust the sizes allowed for conferences and notebooks;

The "user consultants," who are available for aid in learning to utilize the system or some of its advanced features.

The system provides four modes of interaction which may be used singly or in combination:

The straightforward menu selection-i.e., selecting an option from a list of choices;

A command mode which provides all the options in the menus and then some advanced features as well;

An anticipatory mode, where a user can answer questions ahead of time and avoid being asked a series of questions to accomplish something;

A procedure mode, where the advanced user can define his or her own commands by storing under labels preset answers to operations he or she often performs.

The system also provides a number of elementary text editing features for quick error corrections as well as some advanced ones for automatically formating tables, centering items, etc.

Currently there are no graphics available, but there is development work underway for terminal display graphics such as plots, histograms, and simple figures made out of standard typewriter symbols.

The system is designed in a segmented manner so that the user need only learn the minimum necessary to do specific things such as composing, sending and receiving messages. An on line explanation file allows the user to learn about advanced features as the need arises. The basic operations of composing, sending and receiving items can gradually be learned by someone with no computer background in less than an hour of practice. The system, hopefully, forgives all errors and allows a trial and error approach to learning.

Currently, we are developing another facility for EIES which represents an important step in terms of future implications. One of the listed members of the system is Hal Zilog. Hal is actually a microprocessor capable of dialing EIES (or any other on-line system) and receiving messages. Hal is being taught to do simple terminal graphics and some other statistical and modeling routines of potential use to EIES users. We also plan to teach Hal the protocols of some data, modeling, or other communication systems that may be of use to particular groups utilizing EIES. This means that a user of EIES can message Hal and request him to manipulate some data, obtain some information from a large data base somewhere, run a model, or drop some communications off in another system. Hal would supply these results as messages back to the original user and whoever else he may indicate. In essence this allows a member of a group who is knowledgeable about a particular system to easily supply results of that system to other EIES users. Also by educating Hal in protocols we reduce the need for users to become familiar with many different computer systems. Because of the unique communications oriented design of EIES it is possible for it to become the central node in a wide variety of information services available on different computer systems.

For the more advanced user the text editing allows indirect or in line editing where edit commands are embedded in the text. In addition, the standard features of the PILOT Computer Assisted Educational Language are planned as a subset of the text editing features so the user can learn to write "adaptive text," such as the following example of stored text, in which the period represents the start of a command:

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15:  Do you wish more details?
16:  .A                          (reader asked for Answer)
17:  .M NO, N, NOT,              (see if Answer Matches NO, N, NOT)
18:  .JY 35                      (if match on users input occurs
                                  Jump YES to line 35)
19:  The first detail is...
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Example of what is printed:

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Do you wish more details?
Yes                              (put in by user, no match results)
The first detail is .....
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As a result the writer can develop text items that can ask the readers questions and allow the reader to select only the portions of text desired. This is really a special case of a more general capability for filling out forms or questionnaires for the ultimate introduction of Delphi like processes.

Little features like this can ultimately impact on the whole style of writing papers. Because of the segmented nature of EIES the typical user has to learn very little to make use of the system. However, the capabilities and features are being incorporated to allow those who want to experiment with new concepts to realize that goal.

EIES IMPLICATIONS

The cost of EIES is estimated, at a population of 300 users, to be eight dollars per connect hour*. Three dollars of this represents TELENET charges. For 800 or more users the cost would drop to under five dollars. First, this is obviously cheaper than a long distance phone call. More startling is that if 15 people want to communicate as a group by utilizing the mails and copying typical letters to one another, it is cheaper than mail for what can be accomplished at the terminal in an equivalent time span of effort. The technology we have been describing is competitive in costs with mails and without the delays involved, and certainly offers capabilities impossible through the mails.

There is little doubt this form of communication will spread widely in the ensuing decade, not only for researchers but for a wide range of application areas and reflect many alternative designs for differing applications: project management, employment of mobility or communications limited handicapped, education, home recreation, etc.

It is similar to the early days of the telephone where the limitation was who had phones. Today the limit is who has terminals. However, the cost of a terminal should drop to 300 to 600 dollars by 1980 and will then begin to open up the possibility of widespread home terminals and possibilities for working at home a significant percentage of the time.

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*See: The Cost and Revenues of Computerized Conferencing by Murray Turoff, Proceedings of the 1976 ICCC meeting (International Conference on Computer Communications). Also: "Party-line and Discussion: Two Computerized Conferencing Systems," by Murray Turoff, Proceedings of ICCC 72.

Specifically in terms of the problems of Scientific Information, EIES will allow a group of researchers to work together on a day to day basis regardless of geographical location and individual time constraints, since it does not require the time coincidence of phone conversations. The timely exchange of research findings or views, and the resolution of differences can proceed as quickly as desired by the group. Joint authorship becomes a painless procedure with respect to the mechanics of the process. Actual projects can be undertaken by a dispersed team. Refereeing can now involve direct discussions between authors and referees by utilixing PEN NAMES for the referees. Reviews and critiques of published items can be rapidly disemenated. At least, these items seem feasible within the design of EIES. What cannot be stated so firmly is that research groups will take advantage of these facilities. We do not accurately know at this time, what are the characteristics of a research group that make it want to or not want to take advantage of EIES type capabilities. It is, however, the intent and purposes of the NSF announcement and the experimental program established by the Access Improvement Program to try and gain insight into these factors. The planned announcement by the Access Improvement Program of the Division of Science Information of NSF would allow scientific groups to make proposals to utilize EIES and evaluate its impact. Also at the New Jersey Institute of Technology we are carrying out a continuing evaluation of how users respond to the system and how they make use of the various features involved. This program is being carried out by an evaluation team composed of Professor Roxanne Hiltz of Upsala College, Professor Tom Featheringham of NJIT and Professor Ian Mitroff of the University of Pittsburgh and involves questionnaires, interviews, and activity monitoring.

A VIEW OF THE FUTURE

With this base of current development and activity it is useful to try and project a decade (or two) into the future and see what scientific and technical information transfer looks like. I personally feel that in somewhere between 10 and 20 years the following description will be a reality for a third or more of those engaged in scientific and technical endeavors.

The researcher has access to a version of Bush's MEMEX. His personal files are on some sort of storage mechanism (e.g. floppy disk) he can plug into the unit as needed. The unit is designed for composing and synthesizing papers from files by the author directly but, of course, is usable by a secretary. A "MEMEX" may also serve as terminal for extracting or sending items to computer systems or to other units of the same type. Costs are less than mails for communications. Researchers can always borrow a portable terminal to take home. Researchers have access to a couple of conference systems, probably one in their organization and one for communication with individuals elsewhere representing their primary professional peer groups. These latter conference systems may be commercially offered, or they might be run by professional societies or publishing operations. If a researcher has sent in a paper it is very likely that the complete review procedure would be carried out in a computerized conferencing environment such as provided by EIES. A paper also would have had the benefit of earlier commentary by whatever peer group the authors are commonly associated with through a conference system. The centralized conference system would also have notebooks in addition to those in the stand alone MEMEX to insure the date time records of ideas and concepts, to prevent plagiarism without credit. The authentication provided by a centralized notebook facility is potentially a significant factor to

facilitate free scientific communication in areas where it has become a problem. But as in EIES the Notebooks and Bulletins are largely for short recent findings rather than longer comprehensive articles, mini books, or books.

The abstract and retrieval services would now incorporate a form of communications in terms of reviews contributed on articles and available to the user directly. Because of this journals will have largely disappeared and publishers will send out individual articles on request. They will, however, print a form of a journal when there is a sufficient quantity of articles on a more specific topic than is common today. The recent emergence of special journal issues devoted to a specific topic by various organizations (e.g. TIMS) is indicative of this future development. Published articles will tend to be larger and more complete since they will be primarily for students and those interested in the results of an area of research and development but not primarily engaged in that area. Those engaged in a given area will be utilizing EIES type systems for their primary mode of exchanging research findings and transferring information.

The professional societies and/or publishers will operate the sophisticated text system allowing for graphics and a wide variety of text fonts. There will probably be centers where an author can go to utilize a sophisticated graphics system to dress up a final version of his or her article.

The micro processor technology will make these different systems largely transparent to the user since the conference like system will be the mode he or she uses to gain access to this diversity of services. In essense, the user will see this multitude of services as one system that may be somewhat tailored to a particular field but really represent systems cutting across all fields.

PROBLEMS FOR THE FUTURE

Obviously the future as described will not come easily nor is it clear it will be as attractive to all as to this author. The word processing industry still has not emerged from its infancy and demands have to be placed upon it by consumers for computer and communication alternatives. I find it incomprehensible that organizations are making sizable investments in systems that are not computer compatible through utilizing a standard code.

It is not clear what impact the growing confusion on what is a computer system and what is a communication system will have on regulatory policy towards commercial versions of EIES. Computerized Conferencing is still too much in its infancy for any standards to be imposed on the user design of such systems. One can visualize hundreds of potentially useful designs appropriate for given situations. It would be a mistake to view it like a single phone system with only one type of dialing allowed. The computer makes it easy to allow different designs. On the other hand we have given little thought to the right of the individual to obtain access to computer and information services that may be necessary for him in pursuing a livelihood. Current rate structures often reflect a relatively large buy-in fee or minimum that can only be offered by an organization. This may not be an equitable policy since it presupposes all individuals are affiliated with organizations. The encouragement of public libraries to get into the act as a place one can go to utilize such services may be one approach*. The other is to regulate rate structures that afford individuals entry to these systems.

If a great deal of human communication begins to take place over these systems we must begin to consider privacy since one can program other computers to analyze what is being said. It is different than a phone where one

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*"Libraries and the Implications of Computer Technology" by Turoff and Spector. Proceedings of the 1976 National Computer Conference, AFIPS Press., June, 1976.

must utilize another human to tap a given phone call. Unauthorized monitoring becomes economically feasible on a wide scale. The legal and regulatory considerations opened are enormous.

The major economic impact of these systems will likely fall on the publications industry. Whether they will lead the way or be brought in kicking and screaming, remains to be seen. As an example, the emergence of home terminals will probably, in twenty years, bring down the daily newspaper by the availability of selectively retrievable (electronic) advertising. The smarter news organizations will probably install these systems. Since scientific and technical publication, particularly of journals, is less competitive the industry and professional societies will have more power to prevent the introduction of the alternatives we have discussed. The speed with which the future comes in this area is most likely to depend on the degree of cooperation on interface standards to different systems promoted by both commercial, governmental and professional organization.

However, the rapid rate at which the technology is advancing and the accompanying economics as well as the growing ability of scientific users to seek alternatives to current information mechanisms means the changes described are very likely to take place. The only uncertainty is the time scale. Those organizations that don't take the lead are likely to fall by the wayside as their users move to more attractive services. An information world based upon Bush's MEMEX and computerized conferencing systems will be a very different one from what we have to put up with today.

Hopefully an author will receive credits to pay for the use of these systems as a function of articles, reviews and commentaries of the author that others have decided to retrieve or order. This would be one of the most effective mechanisms for encouraging relevant article production.

EIES lends itself to charging by what is sent and received and we will probably experiment with this when there is a sufficient critical mass of different groups to expect cross fertilization to take place.

We expect in this environment a much greater ease for individuals to move into new research areas and for new research groups to form up and other ones disband. We also would expect less dependency of a good researcher on his or her home base. In other words, a small college, for example, could attract top notch people without a tremendous capital investment in library holdings and support staff. Or, conversely the researcher at a small institution would not be at as much disadvantage as today in terms of local resources and colleagues to relate to.

Professional meetings would orient their programs to a greater degree of discussion and workshops and very likely emphasize smaller but more numerous gatherings, with discussion and workshop agendas prearranged through conference systems.

Just as there are abstracts of papers available there would be abstracts of conference groups and a researcher could check to see if there are some he or she wished to join. I'm not sure of what the joining protocols might be. More likely each group will develop its own criteria or protocols on who they accept in and under what conditions.

Such systems are also likely to evolve mechanisms for consulting since someone seeking a consultant in a particular area can submit a request for aid to a group of experts as opposed to one. There would be real opportunity here for a bid and barter system between problems needing solutions and solutions needing problems.

CONCLUSION

Scientific and technical information can no longer be viewed by researchers as a free good. The past decade has lead to both direct and indirect cost increases. Besides the direct costs for reports, journals, etc., the amount of material being generated has lead to an increased need for informal communications and associated costs of meetings, travel, phone, etc. The researcher who cannot afford to maintain active contact with his peer group will be left by the wayside. In most fields hardly anyone can claim he has read all the relevant material. One of the prime mechanisms of selecting material today is on the recommendations of peer group members. The user will continue to become more selective and only the information sources that can gratify this desire for selectivity will succeed. There is little doubt that the next decade will see dramatic changes in the nature of scientific and technical information systems. The technology is now available and sufficiently cost effective to revolutionalize peer group communications; this, in turn, will alter the nature of formal publication process.

REFERENCES

The following is a list of review type articles dealing with the general area of computerized conferencing and associated computer-communication systems.

Price, Charlton, Conferencing Via Computer in The Delphi Method edited by Linstone and Turoff, Addison Wesely Advanced Book Program 1975.

Turoff, Murray, Day, Larry The State of The Art: Computerized Conferencing Computerized Conferencing: An Overview both in Views from ICC 1974 edited by N. Macon published By International Council for Computer Communication, P.O. Box 9745, Washington, D.C. 70016.

Turoff, Murray, The Future of Computer Conferencing The Futurist 9:4, August 1975.

Smith, Computerized Conferencing A New Medium in MOSAIC, Volume 7, Number 1, Jan/Feb 1976.

Hiltz, Roxanne Computerized Conferencing and Scientific Research C Communities to Appear in Journal of Technological Forecasting and Social Change, early 1977.

A rich source for more detailed and technical articles are the proceedings for 1972, 1974 and 1976 of the International Conference on Computers and Communications (ICCC). A detailed reference list through 1974 may be found in the book "The Delphi Method" referenced above.

APPENDIX:

TECHNICAL OVERVIEW OF EIES

The system is comprised of two INTERDATA 7/32 mini computers, each connected via a separate disk controller to a DIVA DD/32 dual disk system with over 200 million bytes capacity. Only one of the processors is utilized to operate EIES. The other is utilized for research and computer science educational activities. However, it can be utilized to take over the operation of EIES if a problem develops with the other processor. The EIES utility processor has 384 thousand bytes of core and the other has 256 thousand bytes. We plan to add a memory access channel such that the core memory is mutually accessable betweeen the two machines.

Currently, either processor can access the disk storage via two separate controllers. The 7/32 has a 32 bit word structure and over a million bytes of core can be directly addressed. Therefore adding more core to be able to service more users requires no software change as far as core allocation requirements.

Currently the system provides a sixteen port capacity over TELENET and eight local Newark ports. The TELENET capacity would be expanded to thirty-two ports for a 300 user population. The disk system is expandable to 800 million bytes by adding up to three more DD/32 subsystems. The result is a system able, through the modularity of the hardware, to deal with 100 or more simultaneous terminals and 1000 or more daily users of the system.

The software is based upon round robin service doctrine, where service is given up by a user whenever an I/O (input/output operation) is executed. The "intelligent" I/O routine passes control to a scheduler which chooses the next user in turn who is not waiting for an I/O service operation to be completed. This also means that at certain places in the program virtual I/O's are used to insure that no unfair allocation of service can occur.

The result is a multi user system regulated by events rather than time slicing. We believe this is a more efficient doctrine for a system that is communications oriented as opposed to computational oriented.

This main interaction program itself is written at the FORTRAN level as if it only knows about the one terminal (or one user). All data pertinent to a user is defined in a common block. Special routines, triggered by the I/O, literally fool the FORTRAN code by shifting from where the FORTRAN code believes the common data area to be to the area containing the new user's data. In order to implement this approach, advantage was taken on the INTERDATA FORTRAN V feature of producing assembler level output. A special "Mid-Processor" was produced that could modify the subroutine linkages and reorganize the data structure of the compiled FORTRAN program. Other work necessary involved modification to certain executive routines and I/O routines as well as the disk controller's software.

Having the interaction flow at the FORTRAN level with over 40 subroutines specialized for common types of operations ultimately allows a straightforward capability for adding or modifying user features and allowing the system to adjust to the preferences of the users.

In addition, a re-entrant input and separate output editior were written at assembly level. The editors and user input/output routine represent an integral independent routine that can be off loaded to a front end processor if this should prove desirable for the larger user population that might occur in later years.

The controllers are 7/16 INTERDATA processors with a core memory of 32 thousand bytes instead of the usual 8 thousand bytes. This has allowed us to build some anticipation into the disk I/O process and provides the opportunity

to fine tune this part of the system if the need arises as a function of growth of the user population. The ultimate limiting factor on the number of users the system can handle is likely to be the disk I/O. The flexibility of being able to add core and the predictability of disk requests as a result of the dedicated application system allow us a number of options for stretching the disk I/O limit, which will be investigated as the system grows in size of user population.

The approach to the overall software development effort has been to maximize the flexibility and anticipate what modifications may be desirable in the future. This is in sharp contrast to building a minimal capability needing major revisions to account for any growth in service. The total completed software effort as of December 31st 1976 is estimated to be five man years, expended over an 18 month period.