ABSTRACT

1

This report covers two years of research in a continuing program in the Augmentation Research Center (ARC) of the Information Sciences Laboratory of Stanford Research Institute, supported by ARPA and RADC under Contract F30602-68-C-0286. 1a

Some of the work reported was also supported by ARPA and NASA under Contract NAS1-7897. 1a1

The research reported is aimed at the development of on-line computer aids for increasing the performance of individuals and teams engaged in intellectual work, and the development of techniques for the use of such aids. The report covers hardware and software development, applications in several areas relating to management of a community of workers who use on-line aids and to information management for such a community, participation in the ARPA computer network, and a summary of plans for the continuation of the research.

1b

PREFACE

2

The research described in this report represents conceptual, design, and development work by a large number of people; the program has been active as a coordinated team effort since 1963. The research reported here was a cooperative team effort involving the entire ARC staff. The following is an alphabetical listing of the current ARC staff: 2a

Geoffrey H. Ball, Walter L. Bass, Vernon R. Baughman, Mary G. Caldwell, Roberta A. Carillon, David Casseres, Mary S. Church, William S. Duvall, Douglas C. Engelbart, William K. English, Ann R. Geoffrion, Martin L. Hardy, Jared M. Harris, J. David Hopper, Charles H. Irby, L. Stephen Leonard, John T. Melvin, N. Dean Meyer, James C. Norton, Bruce L. Parsley, William H. Paxton, Jake Ratliff, Barbara E. Row, Martha E. Trundy, Edward K. Van de Riet, John M. Yarborough. 2a1

The following former ARC staff members also contributed to the research: 2b

Donald I. Andrews, Roger D. Bates, David A. Evans, Stephen R. Levine, Stephen H. Paavola, Helen H. Prince, Jons F. Rulifson, Elmer B. Shapiro, F. K. Tomlin.

2b1

CONTENTS 3

3q

ILLUSTRATIONS

4

4p

4ar

I INTRODUCTION

5

A. General 5a

The Augmentation Research Center (ARC) is a community of about 28 researchers, supported by several different contracts, in which all the research activity is aimed at (1) exploring the possibilities for augmenting the performance of intellectual work with the help of real-time computer aids and (2) the experimental development of computer aids and augmentation systems. 5a1

Several different coordinated research activities have been developed, sponsored by different contracts, to pursue the various aspects of this augmentation research. The aspects reported here are: 5a2

(1) The Management System Research Activity, which has been supported by RADC under this contract. 5a2a

(2) The development, operation, and maintenance of a real-time computer-display system, including both hardware and software aspects and participation in the ARPA computer network experiment. This has been supported by ARPA and RADC under this contract, and by ARPA and NASA under Contract NAS1-7897. The facility is dedicated solely to the ARC's activities. 5a2b

All the researchers within the ARC do as much of their work as possible at display consoles (depending on console availability and whether a specific task can appropriately be done at a console). Thus they serve not only as researchers but as the subjects for the analysis and evaluation of the augmentation systems that they are developing. 5a3

Consequently, an important aspect of the augmentation work done within the the ARC (for instance, of the RADC-supported Management Systems Research) is that the techniques being explored are implemented, studied, and evaluated with the advantage of intensive everyday usage within a coordinated working environment that is compatible with the particular techniques being studied. 5a4

This strategy, called "bootstrapping," is a key concept in much of our design philosophy. 5a5

B. On-Line Aid Systems in the Augmentation Research Center 5b

This section very briefly describes the two major augmentation systems available to workers in the Augmentation Research Center. These systems are the On-Line System (NLS) and the Typewriter-Oriented Documentation-Aid System (TODAS). 5b1

Appendix A is a more complete description of the user features of these systems; the reader who is not already acquainted with ARC's research will find that this appendix provides a useful background for the main body of the report. 5b1a

In addition, Appendix D gives a detailed description of NLS/TODAS implementation. 5b1b

1. The On-Line System (NLS) 5b2

NLS, as currently implemented, is essentially a highly interactive, display-oriented text-manipulation system. 5b2a

NLS is intended to be used on a regular, more or less full-time basis in a time-sharing environment, by users who are not necessarily computer professionals. The practices and techniques developed by users for exploiting NLS are as much a subject of research interest as the development of NLS itself. 5b2b

a. Structured Text 5b2c

All text handled by NLS is in "structured-statement" form. This special format is simply a hierarchical arrangement of "statements," resembling a conventional "outline" form. 5b2c1

A statement is simply a string of text, of any length; this serves as the basic unit in the construction of the hierarchy. Each paragraph and heading in this document is an NLS statement. 5b2c1a

b. Use of the System 5b2d

The creation of new text material as content for a file is achieved by typing the new material on a keyboard, under any of several possible NLS commands. 5b2d1

The study capabilities of NLS constitute its most powerful and unusual features. The following is a brief, condensed description of the operations that are possible. 5b2d2

The process of moving from one point in an NLS file to another, which corresponds to turning pages in hard copy, is called "jumping." A very large family of "jump" commands allows the user to specify locations in the file in a number of ways -- e.g., by specifically identifying a statement or by specifying a structural relationship to some other statement. 5b2d3

The NLS content analyzer permits automatic searching of a file for statements satisfying some content pattern specified by the user. The pattern is written in a special language as part of the file text. 5b2d4

A large repertoire of editing commands is provided for modification of the text in a file. 5b2d5

2. The Typewriter-Oriented Documentation-Aid System (TODAS) 5b3

TODAS is a text-handling system designed as a "typewriter" counterpart to NLS. TODAS can be operated from a Teletype or any other kind of hard-copy terminal, including terminals linked to the ARC timesharing computer facility (an XDS 940 with special hardware) through acoustic couplers and ordinary telephone lines (as opposed to NLS, which requires microwave transmission to achieve the necessary bandwidth for displays). 5b3a

3. Output Facilities 5b4

The facilities for producing hard-copy output from NLS/TODAS files include a line printer, a paper-tape-driven typewriter, and the Graphics-Oriented Document Output System (GODOS). 5b4a

The line printer, because of its speed of operation, is the routine means of producing hard copy for use within ARC. It is used heavily by all NLS/TODAS researchers. 5b4a1

The paper-tape typewriter is used for producing report-quality typing, such as this report. As it is relatively slow and inconvenient, it is not normally used except for final output of material to be published. 5b4a2

GODOS produces magnetic tape which is then turned over to an out-of-house facility where it is run on Stromberg-Carlson microfilm equipment to produce frames of microfilm (or microfiche) corresponding to pages of full-size hard copy. The advantage of this system is that it can handle drawings produced in NLS files by means of the NLS graphics capability. GODOS is still in the experimental stage and has not been used extensively. 5b4a3

4. This Report as an Example of NLS/TODAS Capability 5b5

The following discussion may be taken as a very rough indication of the power of NLS and TODAS as applied to a single specific problem -- namely, the writing, editing, and production of this report. 5b5a

The above descriptions of NLS and TODAS were produced by modification, using NLS, of the more detailed descriptions in Appendix A. 5b5b

The entire task of modification, including formatting, insertion into the body of the report, and all other details, required about half an hour of work by an NLS user who was already familiar with the contents of the descriptions. If the job had been done by someone who was not familiar with the material (but who was familiar with NLS) it might have taken fifteen minutes longer. 5b5b1

The original description was written for an earlier report and then kept available as an NLS/TODAS file in anticipation of future opportunities for using it. 5b5b2

Indeed, a considerable amount of the material in this report was developed by modification of existing files, and we may expect the new material generated for this report to continue in use as a collection of NLS/TODAS files for as long as it can be updated to reflect current reality. 5b5c

TODAS was used primarily for the task of entering new material into on-line files. Considerable portions of the material were put on line by a secretary using TODAS, working from handwritten material and from recorded dictation. 5b5c1

Finally, we may note that the writing of this report, using NLS and TODAS throughout, was achieved under considerable time pressure by a team consisting of about a dozen people, all of whom were doing other important work at the same time.

5b5d

II MANAGEMENT SYSTEM

6

Our Management System Research Activity has involved three major areas of concentration. In practice these areas overlap considerably, so that there is an integrated research effort on many phases of management technique and theory that impinge upon the operation of ARC. For purposes of description, however, we discuss each area of concentration as if it were an independent effort. 6a

The three areas are: 6b

(1) Management-Information Operations -- research on techniques for using management information in the ARC environment, including the development of computer aids for the storage and manipulation of such information 6b1

(2) Organization Studies -- research on the ARC on-line community of workers and experimentation with organization structure and planning methods in the on-line community 6b2

(3) Team Augmentation and Dialogue Support-- research on augmenting a team or community of intellectual workers by means of systems that support the intellectual dialogue of the team. 6b3

A. Management-Information Operations 6c

1. Introduction 6c1

In accordance with our usual strategy, we have pursued our investigation of management-information operations by using NLS and TODAS to develop and provide aids for management of the ARC on-line community. 6c1a

There are many areas of potential application for on-line aids; we have chosen those which appear to be most useful operationally for experiments with the development of on-line aids. 6c1b

This section gives detailed descriptions of several applications that have been developed, illustrated with photographs of the NLS display screens to show sequences of information-manipulation operations. A familiarity with the basics of NLS is assumed; Appendix A is intended to provide the necessary information about NLS. 6c1c

In following the descriptions, it is worth keeping in mind that the speed with which NLS serves its users is an important part of its utility. The photographs indicate transitions that normally take only one or two seconds. This speed lends great power and flexibility to the relatively simple service functions performed by NLS. 6c1d

2. Project Costs 6c2

The most obvious area for application of on-line aids to management within ARC is project cost accounting. Considerable work has been done on the development of several cost-information files and of techniques for their use. 6c2a

a. Cost Records 6c2b

The Institute's accounting system provides ARC with detailed cost records for the various "SRI projects" (i.e., individual contracts) being carried out in ARC. 6c2b1

The primary inputs to SRI's system are (1) weekly time cards reporting hourly charges to various projects by individual staff members, and (2) non-labor costs charged directly to projects, including actual charges to projects and commitments (uncompleted orders). 6c2b1a

For each SRI project, the accounting system computes dollar costs based on actual salary data for each staff member's hours charged, adds payroll burden and overhead amounts at current rates, combines these costs with non-labor totals, adds appropriate fees, and totals all such charges each week on a cumulative basis. 6c2b1b

Current charges are reported to ARC each week on the Project Status Report. 6c2b1c

We need frequent and rapid access to project cost summary data for operational use, with less reference to lower-level details, except as the costs are first checked for reasonableness and accuracy. Therefore we decided to start by putting summary data on-line at ARC. As needed in the future, we can add more levels of detail. 6c2b1d

File HISCO 6c2b2

We first constructed a cost-history file for 1968-1969 costs on SRI projects ESU 7101 (RADC Contract F30602-68-C-0286) and ESU 7079 (NASA Contract NAS 1-7897). This file is called HISCO. 6c2b2a

We decided that the elements of HISCO would include the following for each of the two projects, on the basis of 4-week accounting periods (as used by SRI's accounting system): 6c2b2b

(a) Salary 6c2b2b1

(b) Burden 6c2b2b2

(c) Overhead 6c2b2b3

(d) Total cost 6c2b2b4

(e) Fee 6c2b2b5

(f) Total charges. 6c2b2b6

See Figs. II-1, II-2, and II-3. Each of these figures shows a display of one branch of the file, containing the information for a specific project and year. 6c2b2b7

We also needed a section showing combined salary costs and combined total charges for all of our projects (see Figs. II-4 and II-5). We put these costs in separate branches of the file. The last branch shows total costs for both projects combined. We retroactively studied existing records for all 1968 data and kept up the 1969 costs every 4 weeks, entering the new data by hand. 6c2b2b8

We experimented with the use of graphic representations by entering charts in HISCO. These charts showed the cumulative cost trends for each project in a separate branch of the file. 6c2b2c

We established links between tabular data and chart projections. This made it quite easy to refer to both formats alternately. 6c2b2c1

The use of graphics in HISCO gave some indication of the usefulness of such linking, but the existing package has limitations in the form of a few bugs and capacity that makes its use of marginal value. Work is currently under way to improve this capability. We also need local hard-copy output to make these features of real value. 6c2b2c2

HISCO was a testing ground for the first version of the NLS calculator package. As the file was updated, cost data were entered into new statements, and the calculator was used to check the cost data and to determine the total ARC project costs. 6c2b2d

This employed the ADD, SUBTRACT, MULTIPLY and DIVIDE capabilities and used the four holding registers. 6c2b2d1

The calculator package has an 'INSERT' command that inserts the current contents of the calculator's accumulator into the file text as indicated by a bug selection. Work with HISCO indicated that a 'replace' command would be very desirable. 6c2b2d2

The usual way of accessing HISCO was via pre-established links from other working files whenever the user had a question about recent costs. The VIEWSPECs in the link usually caused HISCO to be brought in with only high-level statements on display, showing only the headings for project name, combined salary, total charges, and total ARC costs (see Fig. II-6). 6c2b2e

The user could then select the project he was interested in (by the command JUMP TO ITEM) open up an additional level for viewing, and see column headings and numerical data (Figs. II-1, II-2, and II-3). 6c2b2e1

Then he could jump down through the accounting periods to the one he was looking for. 6c2b2e1a

If he was making a calculation (perhaps already started in the file he was working in before he linked to HISCO), he could then call the calculator and add, subtract, multiply or divide by any of the numbers in HISCO. His previous calculations while in the previous file would remain intact. 6c2b2e1b

If finished with HISCO, he could then return to the previous file (by the command JUMP TO FILE RETURN) and continue with the calculation, having found in HISCO the input number or numbers he was looking for. 6c2b2e1c

Such a sequence occurs very fast. Experience with HISCO seems to prove the value of having a simple calculator built into NLS, where it is instantly available when needed and can interact directly with data in an NLS file. 6c2b2e2

Desk calculators are available for most people who need to do basic arithmetic work, but when one is looking through extensive files for inputs to calculations, the conventional calculator is not nearly as useful as this on-line version. 6c2b2e2a

Summary: As an arena for experimentation, HISCO proved very valuable. Operationally, it was useful from time to time but revealed a need for more frequent updating of the summary data. Our experience with HISCO led to the development of a redesigned cost-history file called COSTS. 6c2b2f

File COSTS 6c2b3

This file is updated weekly, with 4-week and cumulative summaries. 6c2b3a

The COSTS file is referred to frequently, because the weekly inputs now show trends with considerable sensitivity. 6c2b3a1

We decided that the elements most useful to us for this year are the following: 6c2b3b

(a) Salary costs 6c2b3b1

(b) Total personnel costs 6c2b3b2

(c) Non-labor costs 6c2b3b3

(d) Total costs 6c2b3b4

(e) Total charges with fee 6c2b3b5

(f) Balance remaining 6c2b3b6

See Figs. II-7, II-8, and II-9. Figures II-7 and II-8 show the same branch of the file with different VIEWSPECs; Fig. II-8 displays one more level than Fig. II-7, and this level shows the weekly data. Figure II-9 shows the weekly data for another project. 6c2b3b7

We also decided to include funding information showing current totals, unfunded totals, and total contract amounts in the categories cost, fee, and total. 6c2b3b8

We use separate branches for each project and for total ARC project costs (Fig. II-10). The skeleton format for the file was set up in advance for the entire year of 1970. 6c2b3c

Our approach was to create a separate statement for each week, one level below the "total" statements for each 4-week period. For the second week of 1970 (which is in the first accounting period) the statement starts with a 2-1 and then, proceeding across the line, shows the amounts listed above in six columns (Figs. II-8 and II-9). 6c2b3c1

Before entering any actual data, the first top-level branch (containing some 70 statements) was copied within the file at the same level four or five times. Then each blank branch simply had the project name headings inserted for the project using that branch. We keep one extra blank format branch available in case any new projects should arrive. 6c2b3c2

Like HISCO, COSTS is usually reached through a link from some other working file, perhaps while a study of near-future costs is in progress, or from an ongoing proposal cost estimate. Again the file is usually entered with only the top-level statements or project headings showing (see Fig. II-11). 6c2b3d

If a particular project is of interest, that branch is selected and another level opened for view. The second level shows period-by-period subtotals in each cost category (Fig. II-7). If weekly data are desired, another level is opened by changing the VIEWSPECs (Fig. II-8) and a particular week is selected by the command JUMP TO ITEM. 6c2b3d1

The statement for each week has the week ending date as its name. The reason for this is not only so that the statement for a particular week can be accessed by the JUMP TO NAME command using the ending date, but also so that the date may optionally be suppressed from the display. NLS has the capability of suppressing all statement names from the display. 6c2b3d1a

The normal way of looking at the file is with names suppressed; thus the dates do not clutter the display; however, a user who needs to know the ending date for a particular week can see it by executing a single command. 6c2b3d1a1

To access the information for another project within COSTS, one executes JUMP TO RETURN twice to see the top-level statements again (Fig. II-11). 6c2b3d2

One can move very quickly and accurately through a file that is set up in this fashion, even without any familiarity with the information it contains. 6c2b3e

The primary function of COSTS is to show a consistent week-by-week progression of costs for each project by category. The file can also be used for study purposes, through the use of content-analyzer patterns, some of which are stored in the header statement (see Fig. II-12, which is the same as Fig. II-11 but with different VIEWSPECs). Any other patterns can be created as needed. 6c2b3f

This allows a user to extract special categories of information from the file very quickly. For example, a user may easily create a display showing all project costs for the eighth week of 1970, for each ARC project. It is also possible to output such a "filtered" display via a line printer, thus obtaining hard copy of a special-purpose extract from the total file. 6c2b3f1

The content analyzer is helpful when using the calculator on all the data for one week, project by project, to find total ARC charges by category. 6c2b3g

When only one week's data are displayed, one can add items down each column and insert the answer in the "ARC total" space. One can then clear the accumulator, and add down the next column. This is done very rapidly through bug selection of input numbers and keyset entry of commands -- ADD, ADD, ADD, ADD, INSERT, CLEAR, ADD, ADD, ADD, ADD, INSERT, CLEAR, and so forth. 6c2b3g1

Figures II-13 and II-14 are before/after photos of this process. 6c2b3g2

The COSTS file is now operationally useful to us, and we expect it to be useful for future experimentation with automatic processing techniques. 6c2b3h

b. Estimates 6c2c

Proposals 6c2c1

Another use of the system is in creating proposal cost estimates. We first estimate the amount of effort required for the proposed work. To estimate the cost of this effort, we make reference to various on-line files. The estimating process typically proceeds along the following lines. 6c2c1a

Personnel Costs 6c2c1b

The estimator loads a special file, maintained by himself, which is a directory to all of his other files and perhaps to a few files belonging to other people. Figures II-15 and II-16 are two displays of a user's file directory. In Fig. II-15, only first-level statements are shown; these are used for establishing categories. In Fig. II-16, another level is shown, containing the actual directory listings in each category. 6c2c1b1

This "file directory" contains links to each of the files that it lists. In the present case the files probably would be cost histories, personnel listings, previous special studies of costs, and other administrative information. 6c2c1b1a

He loads a previous cost estimate, makes a working copy of it, changes the heading to reflect the name of the new proposal estimate, and eliminates the amounts from the old estimate. 6c2c1b2

This produces a blank cost estimate format. If any items from the old estimate are inappropriate, they are easily deleted; new items are easily added as separate statements. When the format is ready, it is output as a new file. 6c2c1b2a

He can then load a file that lists names of people in the group and some projection of expected additions. Figures II-17, II-18, and II-19 show portions of such a file. 6c2c1b3

Using this personnel-listing file, he obtains information about labor categories.

A branch containing content-analyzer patterns is kept in the file. These can be easily reached by jumping to a link which causes all the patterns to be displayed (Fig. II-20). 6c2c1b3a

Each pattern will select some particular category of statements from the file. For example, the estimator will need to know which people have the status of Senior Professional. 6c2c1b3a1

He selects the appropriate pattern with the command EXECUTE CONTENT ANALYZER, and then jumps on a link which turns on the content analyzer, starting the search at the beginning of the branch containing personnel listings and restricting the search to that branch. 6c2c1b3a1a

This produces a display showing only the listing of senior professionals in the group. This set of statements can then be transferred to the new proposal cost estimate file. 6c2c1b3a1b

Other patterns can be used to extract sets of statements according to other criteria -- for example, all the hardware or software people in the group (Figs. II-21 and II-22). 6c2c1b3a1c

Thus the estimator can select, by labor category, representative people who may be involved with the proposal; as he selects them, he can transfer their names and the information that goes with them to the file where he is building up his estimate. 6c2c1b4

At present we do not keep individual salary information on line, although we could do this if we added some security measures. Calculations for the average salary category, based on the specific people contemplated, are made off-line at present.6c2c1b4a

These average salary amounts are inserted into the on-line cost estimate. The calculator is used to multiply numbers of man-months times average salaries per month to determine total salary costs per labor category and overall direct labor totals. All of this is achieved within the actual file that will become the finished estimate. 6c2c1b4b

The payroll burden and overhead rates are checked for currency and inserted into the estimate, using the calculator to apply them to the direct labor. At this point the labor portion of the estimate is completed. 6c2c1b5

Non-Labor Costs 6c2c1c

A typical estimate will involve some travel costs, some consultant costs, and some report costs. Data supporting the cost of consultants may be checked by reviewing current consultants' costs by project and by consultant. These are kept in a separate file and reached through a link for review. The data may be copied into the estimate if some of the information is of use. 6c2c1c1

Report production costs are estimated using current Institute schedules, which are based primarily on the number of pages expected in the end product. These computations can be made using the calculator, and the existing cost factors from the last proposal, checked for current applicability. 6c2c1c2

In addition, there may be plans to add equipment in the proposal. In this case, the estimator will use an equipment study written in another file by the people involved in hardware design. 6c2c1c3

The equipment costs contained in the special study are summarized in total and reached by a link. The special study can be viewed and updated as appropriate and can be copied to go with the proposal as an appendix or used later for back up. 6c2c1c3a

In this fashion, various information is gathered from various files and transferred into the developing cost estimate. Figures II-23, II-24, and II-25 show various portions of a completed on-line cost estimate as actually used for a recent ARC proposal. 6c2c1c4

Working Forecasts 6c2c2

Operational Use of Estimates 6c2c2a

As the project progresses, proposals and estimates can also be used as guides for management of the project. It is useful to forecast the expected project costs on either a four-week period or monthly basis. 6c2c2a1

This can be done by creating a new file using the type of format that the COSTS file uses. We insert total figures from the cost estimate, using the calculator to determine average rates and specific estimated amounts, and insert answers into the file as it builds. This month-by-month estimate can be reached through a link from working cost files, from the original estimate, or any other file where the question of monthly estimated project costs may arise. 6c2c2a2

c. Purchase-Order Processing 6c2d

In making an estimate of costs for new equipment being constructed at ARC, reference to previous cost information is very useful. We have constructed a purchase-order/requisition processing file which contains a separate statement for each item purchased for the past two years at ARC. Figure II-26 shows a portion of this file. 6c2d1

Each statement contains the following information about each purchase: 6c2d2

(1) Total price 6c2d2a

This is entered as the statement name. 6c2d2a1

At present this is not used as an NLS name, but as a way of eliminating information from the screen at will, keeping a consistent location in columnar form for such totals. 6c2d2a2

(2) Description of item 6c2d2b

(3) Vendor 6c2d2c

(4) Number of units purchased and price per unit 6c2d2d

(5) Purchase Requisition number 6c2d2e

(6) Date requisition sent 6c2d2f

(7) Purchase Order number when order is placed 6c2d2g

(8) Date order is placed 6c2d2h

(9) Project or account charged 6c2d2i

(10) Date order is received 6c2d2j

(11) When the order is completed, it is marked with the special code *comp*. This can be detected by a content-analyzer pattern. 6c2d2k

All outstanding orders are contained at a second level under a single branch (see Fig. II-27); therefore the distinction between outstanding and completed orders is easy to see just by reference to level. To reduce clerical error, we consider an order completed when the *comp* pattern is inserted and the statement is moved to its alphabetical position on the top level. 6c2d3

This file can be searched using the content analyzer in some interesting ways. We can ask for all items purchased from a particular vendor on any particular project and see only those. If we wonder about the unit price of a thermal wire stripper, model 2W-1, we can quickly get that information. If we wonder what we purchased on PR A08927, that comes simply by executing a content analyzer pattern specifying the number. We can see all outstanding orders charged to a particular project quickly. Figure II-28 shows a content-analyzer pattern that has been temporarily written into the file, for finding any entries pertaining to orders for relays under Project 7101. Figure II-29 shows a view generated by using this pattern. 6c2d4

This file is useful, then, from a project-administration standpoint, from the standpoint of following a purchase requisition from the order stage through completion, and also for providing backup information for cost estimates. 6c2d4a

This file can also be used as a tickler file by inserting a pattern in the "outstanding requisitions" branch which shows the date we feel we should follow up on the order. Each day one can ask for all those items that have the current date as a follow-up date. 6c2d4b

This file is kept up-to-date by the secretary of the hardware group, who is most involved with requisitioning. She does this updating entirely with TODAS. 6c2d5

d. Summary on the Systematic Use of Project Cost Files 6c2e

One by one each of these files might be interesting. As a combination, quickly available to many users, their utility seems remarkable. 6c2e1

A cost study, as discussed above, can rely on all previous project costs as recorded in the system and can draw on those files for inputs. One can draw on the personnel roster file by labor category, work interest or as extended into a skills inventory. 6c2e1a

We can browse through the purchase-order file, reflecting the current or previous costs per item. We can link to activity-planning files to see which people are involved with various ongoing tasks and to see on what tasks we are contemplating certain equipment purchases. We can link to proposal cost estimates for month-by-month cost projections. 6c2e1b

These files can be accessed in any order, from any direction, at any time, with only a few keystrokes by the user. They are also accessible remotely through the use of TODAS, thereby giving mobility to the user with less load on the system. 6c2e2

Our main objective in making cost studies is to arrive at solid sets of projections or other answers as quickly and effectively as possible. Direct on-line access to input information is extremely helpful. 6c2e3

3. Activity Planning and Status 6c3

a. Introduction 6c3a

Section II-B-2 describes the experimental establishment of a TODAS Development Activity and discusses its method of operation. One facet of TODAS work is the extensive experimental use of on-line files as aids in conducting meetings and formulating plans. This section gives some details on the construction and use of these files. 6c3a1

b. Planning and Status Files for TODAS Development Activity 6c3b

File UPLAN 6c3b1

The planning file for the TODAS Development activity contains a branch with comments on how to use the file, a branch for content-analyzer patterns, and a branch containing actual task plans. 6c3b1a

The task-planning branch has, as substatements, task categories which include documentation plans, teaching plans, design plans, META plans, and inactive task plans. The levels under these categories contain separate task plans, such as "TODAS REFERENCE GUIDE DEVELOPMENT," "USER EXPERIMENTS RELATED TO TODAS," and "TEXT MANIPULATION SYSTEMS BIBLIOGRAPHY." 6c3b1a1

Each task branch contains comments by the task leader on the following: 6c3b1a1a

(1) Description of the task, with links to other working files used in its development 6c3b1a1a1

(2) Comments on the relationship of the task to other ARC tasks 6c3b1a1a2

(3) Estimates of people involved (with levels of effort and timing) 6c3b1a1a3

(4) Status comments 6c3b1a1a4

UPLAN is linked to from another file called UMEET (described below), which is used for on-line note-taking during meetings of the TODAS group. Portions of UPLAN can be temporarily copied into UMEET for use during meetings. 6c3b1b

UPLAN contains a blank task format in a separate branch. Whenever a new task is added, this branch is copied into the appropriate planning area (such as documentation plans). Then the name of the task is inserted as a heading along with the initials of the task leader. 6c3b1c

Certain items in this file are useful in content-analysis searches. The most useful are the initials of people involved in tasks, the milestones, the estimates, and the status. To make content-analysis searches more consistent, asterisks are placed before such items. 6c3b1d

With an appropriate pattern, one can then ask a question such as "What is the involvement of a particular person in this activity?" task by task. All branches with estimates containing the specified initials and an asterisk will then be shown. The same branches show expected levels of effort. 6c3b1d1

Since this is the only information displayed on the screen, it is relatively easy to see potential conflicts in the allocation of a person's time between tasks for this activity or to make a hard copy of this displayed information on the line printer. 6c3b1d2

The content analyzer can also return statements commenting on the status of tasks, so that a quick survey of all such comments can be made. This is particularly useful for coordination of several tasks and for preparing for meetings of the group. 6c3b1e

When many people try to update the same file, serious problems are created. This is a well-known situation (discussed further in Appendix B). If two people are both working on the file, one person's work may be lost when someone else who has been using the file writes his copy back out on the disc. Therefore we tried to introduce a convention where people place a signal of some sort in the file when it is in use. 6c3b1e1

This procedure was not well used, probably because people were generally in too much of a hurry. Therefore, some work was lost. We found that it was easier, with the present file-handling limitations, to have research assistants do the updating on the file, gathering information from various people as needed. 6c3b1e2

Part of the description for a task involves the specification of significant milestones, if possible. The task leader has to have some idea of important milestones during the progress of the work and must develop some feeling for whether these milestones are occurring within the resources expected to be allocated to the task. 6c3b1f

We tried an on-line task-planning chart, showing 10-week periods where milestones could be marked for each task. Milestones were indicated by showing an NLS name for each milestone statement (see Fig. II-30). Therefore, viewing this task-planning chart on a display, we could "JUMP TO NAME", selecting one of the milestone points on the chart, and a description of the milestone and its relationship to the task would then be displayed. A "JUMP TO RETURN" brought back the planning chart. 6c3b1f1

This shows some promise of being useful in the future, but some refinements in display techniques and milestone selection are necessary before it can become operational. 6c3b1f1a

Another use of the content analyzer is to search for entries made "since or before" a certain date, or for entries made by certain people. This makes it easy to see who has been updating the file recently, and what they have done to it. 6c3b1f2

This is of less importance for a person who is updating his own file, for he probably remembers the kinds of things he has changed. When many people work on the same file, it is helpful to know who has been changing it and in what areas they have been working. 6c3b1f2a

File UMEET 6c3b2

We created a separate file called UMEET for plans and notes from the TODAS activity meetings. 6c3b2a

This file is similar to the UPLAN file in format. On-line note-taking by a research assistant, as practiced in the user system and software groups, has proven quite useful for recording important parts of discussions during meetings. The on-line note taker has not been a distracting influence in meetings; in fact, she has contributed at times. She is available for finding information in the file and for recording special ideas in other files upon request during the meetings. 6c3b2a1

Meetings are conducted with hard-copy agenda distributed before each meeting. The on-line notetaker has an on-line version of the same agenda in front of her. As the discussion proceeds, she makes her notes right in the on-line agenda. 6c3b2a2

Items left for discussion in following meetings, or as special questions to be resolved before the next meeting, can be marked by the note-taker and retrieved from the file for later study. 6c3b2a2a

When the meeting is completed, the notes are condensed to a meaningful summary, distributed to the participants, and displayed on a bulletin board. In other words, the agenda for a particular meeting is developed, during the meeting, into minutes of the meeting. A copy of the unaltered agenda is also kept. 6c3b2a3

Successive meeting agenda and minutes are kept in one file (see Fig. II-31). This permits us to search for discussions of various topics and to receive answers in chronological order.

6c3b2a4

B. Organization Studies 6d

Our organizational studies have centered on two topics. The first of these is the study of the "On-Line Community" -- our own ARC group seen as a unique example of a small, close community of workers who make intensive use of on-line computer aids in their daily work. 6d1

The second area of concentration has been the implementation of two experiments on organization structure and planning methods in such a community. 6d2

1. On-Line Community 6d3

Our study of the On-Line Community is described here in terms of the total working environment of the group and the structuring of staff roles within the group. 6d3a

a. Environment 6d3b

We consider the total working environment, for purposes of this study, to consist of the physical environment and the "user environment." The latter is a general term intended to indicate the existence, availability, and performance of the numerous on-line aids used by the group. 6d3b1

Physical Environment 6d3b2

We have changed the basic work room or laboratory configuration from isolated one-man offices and a remote shop and computer/work room to one-man offices opening directly onto an open, courtyard-like work area. We still use a remote shop and computer room due to building layout restrictions. The consoles were moved out of the offices into this central working area. We have put in separate lighting circuits so we can turn off lights in different parts of the room, reducing reflections on the displays. Within the work area, the consoles can easily be regrouped to permit users to work cooperatively. 6d3b2a

One effect of this was to change the personal interaction pattern dramatically, simply by increasing the amount of interaction. 6d3b2a1

A second effect was to permit much more effective utilization of the display facility; the facility is much more "available" than it otherwise would have been. 6d3b2a2

Within the general work area, the consoles (which are of several different designs offering different advantages) are set up in varying configurations, with differing arrangements for lighting, seating, proximity to other consoles, etc. In general, the individual configurations can be quickly and flexibly altered as various needs arise. As a result, an individual who is about to start a working session at a console has a considerable choice of immediate conditions. Figure II-32 shows four views of consoles in the work area, in actual use for various modes of work. 6d3b2a3

A further modification to the physical environment was the addition of light movable partitions, for visual privacy. These are low enough so that a person, when sitting, does not see other people working but can, by standing or moving his chair two or three feet, contact 4 or 5 other people working at consoles. Most people apparently prefer to partition off only the front of their work stations. Partitions are rarely moved into positions completely surrounding the work stations. When seclusion is wanted, people tend to work in the Herman Miller experimental office, which is isolated from the general work area by high partitions. 6d3b2b

The Herman Miller office has also become the place where the system is demonstrated to visitors. Visitors have the feeling that they are inside the working environment, and no one else is bothered by the visitors' presence. 6d3b2b1

We have adopted the practice of holding some types of meetings in the Herman Miller area around one or two displays, with a research assistant taking on-line notes. 6d3b2c

We have found that display viewing is difficult, and multiple-participant access to the system ineffective, with meetings of more than three or four people. 6d3b2c1

On the basis of our experiences with such meetings, we are now redesigning the conference facility (see Sec. II-C-2-d). 6d3b2c2

We have found that it is highly desirable to make use of the system both night and day. Night access to our work area is inconvenienced to some extent by the existing security measures, particularly when we wish to work with non-SRI personnel, such as consultants. A much more open and accessible working environment would be greatly preferred. 6d3b2d

We see great practical utility in having a maximally flexible physical environment. Each time we have increased the flexibility of the environment, work interaction has increased without any damaging increase in social interaction. 6d3b2d1

User Environment 6d3b3

During these two years we have provided a useful, though still evolving, on-line text editing and file manipulation system, NLS. This system provides new tools for personal and group use. Appendix A describes NLS in considerable detail from a user's point of view. Appendix D is a technical description of NLS. 6d3b3a

We have also developed the Typewriter-Oriented Documentation-Aid System, TODAS (see Appendix A). This provides some of the same features as NLS but can be used remotely by people not physically in the facility. TODAS will produce considerably less load on the timesharing system than NLS. We have experimented with remote use of TODAS using portable typewriter terminals with acoustic couplers. The resulting mobility, with direct access to all of our files, shows interesting possibilities for team collaboration, together or physically remote. 6d3b3b

With the introduction of TODAS, we have provided more opportunity for people to interact with the ARC files from their offices, although some of the processes are slower. There has not yet been widespread use of TODAS, but this will change with improvement in service capacity of the system and addition of new features to TODAS. Availability of several 30-character/second typewriter terminals will also greatly increase the value of TODAS. 6d3b3b1

b. Staff Functions and Activities Within ARC 6d3c

Activities we have identified as basic include the following: 6d3c1

(1) Hardware 6d3c1a

(2) Software 6d3c1b

(3) Management System Research 6d3c1c

(4) User System Research 6d3c1d

(5) ARPA Network Participation 6d3c1e

(6) Operational Management of ARC. 6d3c1f

Staff functions for each activity involve the specification, design, implementation, documentation, evaluation, and maintenance process as new system features are added. 6d3c1g

As we hire hardware and software people, research assistants, and secretaries, our policy has been that a person's capabilities must go beyond any narrow specialization. A highly skilled systems programmer must have additional background before he can be used effectively in this group. 6d3c2

We need people who are capable of both long- and short- range planning, participating in goal and subgoal setting, and contributing to the the design, implementation, and other processes. 6d3c3

For most ARC work it is important that people be primarily oriented toward designing and building tasks and less toward contemplative and reflective ones. However, since our work mixes both research and development modes we must be capable of acting in either capacity at different stages in the implementation of any given task. It is also a requirement that people have the ability to focus on different levels of the endeavor, alternating modes frequently as the needs arise. 6d3c4

2. Experiments on Internal Activity Structure 6d4

We conducted two experiments on the use of augmented methods for planning work. These experiments were conducted with a newly established group, the TODAS development group, and with a well-established, fairly tight-knit group, the software group.

6d4a

a. TODAS Development Activity Planning 6d4b

A part of ARC user system research involves the specification, design, implementation, teaching, use, and evaluation of new features being added to TODAS as related to anticipated ARC and ARPA Network needs. 6d4b1

The TODAS planning experiment was initiated along these lines: 6d4b2

We first developed a strategy for use as the group formed and for encouraging it to make further plans directed toward ARC and TODAS-related goals. The steps considered necessary for the group were: 6d4b2a

(1) Identify both internally and externally generated goals 6d4b2a1

(2) Agree on structure and mode of operation of the TODAS group, with the following features: 6d4b2a2

(a) A group represenntive reporting to the ARC Manager and to external activities 6d4b2a2a

(b) A team approach to tasks and planning, with one leader for each task 6d4b2a2b

(c) Investigation of decision techniques. 6d4b2a2c

(3) Plan tasks for the group and for the indiviuals in the group (including tasks already in progress, where applicable). We were to do this according to the following outline: 6d4b2a3

(a) Build an easily visible collection of task alternatives, to be modified as appropriate after analysis and review. 6d4b2a3a

(b) Identify and use the skills in the group, securing other needed skills if not available in the group. 6d4b2a3b

(c) Estimate participants' level of effort and the timing involved, assessing the net effect of the combined plans. 6d4b2a3c

(4) Meet periodically to review progress, usually every two weeks. 6d4b2a4

Meetings were intended to be open to interested staff of ARC, with use of an agreed upon format. 6d4b2a4a

Special discussion meetings (and other forms of communication) for "help" when special problem situations arose were also anticipated. 6d4b2a4b

(5) Maintain a TODAS "information center" on-line and off-line. The basic files were the following: 6d4b2a5

(a) File FD: File Directory for TODAS-oriented links. This file also contains links to TODAS group participants' personal file directories and links to the following files: 6d4b2a5a

(b) File UMEET: Meeting plans and notes 6d4b2a5b

(c) File UPLAN: Task plans and status notes 6d4b2a5c

(6) Communicate status of TODAS work to the ARC Manager and the ARC staff. 6d4b2a6

Having determined this strategy, appropriate initial participants were contacted and the group was established. 6d4b2b

The group started having meetings and developed a meeting strategy that contained the following elements: 6d4b3

(1) A "facilitator," whose role includes the following: 6d4b3a

(a) Preparation of the meeting plan, with inputs from the rest of the group 6d4b3a1

(b) Guidance during the meeting to ensure that all important items are discussed 6d4b3a2

(c) Providing an orderly way for new or unexpected items to be discussed as appropriate, or deferred. 6d4b3a3

This role was rotated among the membership of the group from meeting to meeting, depending on the expected agenda subjects. 6d4b3a4

(2) A "process watcher," whose role involves attention to processes in operation during the meeting. This includes verbal and nonverbal interactions between people, decision processes, etc. 6d4b3b

This was done to give the participants added insight about less obvious features of the meeting. 6d4b3b1

This role was rotated among the membership of the group from meeting to meeting, depending on the expected agenda subjects. 6d4b3b2

(3) An on-line note taker, whose role includes the following: 6d4b3c

(a) Distribution of the meeting plan and preparation of the meeting notes outline before the meeting 6d4b3c1

(b) Careful recording of important discussions and points made during the meeting 6d4b3c2

(c) Retrieval of needed information from on-line files during the meeting 6d4b3c3

(d) Summarizing the meeting notes and distributing them after the meeting 6d4b3c4

The role of the on-line note-taker was filled by two research assistants on an alternating basis. This provided flexibility and ensured that an experienced note-taker was available for each meeting. Information gained at these meeting was valuable to the note-takers in their other day-to-day work. 6d4b3c5

(4) Regular participants 6d4b3d

(5) Invited specialists 6d4b3e

(6) A meeting plan and agenda 6d4b3f

(7) Relevant documents produced on-line by any member 6d4b3g

Distribution of documents was arranged before each meeting. Documents included descriptions of design changes in TODAS, drafts of teaching documents, etc. 6d4b3g1

(8) Tentative plan for the following meeting 6d4b3h

(9) An evaluation of the utility of the meeting.

6d4b3i

Notes from meetings were kept on an evolutionary basis as separate branches in one file, UMEET, and also in hard copy for distribution to all members and to a bulletin board. 6d4b3j

Planning 6d4b4

We made an easily accessible listing of tasks in progress and under consideration, in a separate file called UPLAN (described above in Sec. II-A-3-b), which can be modified by individual task leaders or by research assistants. 6d4b4a

This file helped increase the extent to which meetings were used to evaluate and redesign tasks, instead of to report information that would not be changed by group interaction. 6d4b4a1

It facilitated the exchange of reportorial information outside the meetings, when individuals could give their full attention to the file. 6d4b4a1a

It was also available during meetings for reference or modification. 6d4b4a1b

Another use of the file was to communicate information to people not directly involved in the activity, i.e., the ARC Manager and others in ARC. 6d4b4a2

Most of the planning dealt with scheduling and patterns for necessary interaction between tasks and task leaders. 6d4b4b

The short-term goals appeared firm enough that we chose not to divert our resources to longer-term goals while this activity was starting. 6d4b4c

Interaction 6d4b5

Since this group included people who were involved with other ARC activities such as software, the Network Information Center, and Management Science Research (MSR), it explored some interaction between activities. 6d4b5a

It also provided an opportunity for the activity members to be involved in a smaller group than the ARC as a whole. This changed the group dynamics considerably. 6d4b5b

The process of identifying internally generated goals stimulated exploration of personal needs of the members of the group to increase solidarity, mutual liking, understanding, respect, and the desire to cooperate. 6d4b5c

Although social interaction initiated at early meetings was beneficial in developing a cohesive working group, progress evaluation at various times indicated that it could then be more effectively continued outside of group meetings to allow more focus on the primary group tasks related to TODAS. 6d4b5c1

b. Software Activity Planning 6d4c

The software activity is directed toward the design and implementation of new system software features. 6d4c1

Strategy 6d4c2

This was the second experiment, following the initial results of the TODAS experiment described above. In the two years of the contract, the software group has progressively become more integrated into the total ARC functioning and has doubled in size. One result is that more tasks that depend upon each other are being performed concurrently. The need for each member of the software group to be aware of the progress and design modifications of the tasks undertaken by every other member of the group has increased significantly as the size of the group has grown. 6d4c2a

Preplanning by the MSR and group management team included those features found to be most useful from the TODAS activity experiment. 6d4c2b

It recognized the existence of leadership responsibilities already in effect, and formalized them. 6d4c2b1

The same meeting format was used as for the TODAS group. We found immedately that there was more interest in task discussion and plan reformulation and less interest in social interaction and group process than in the TODAS group. As a result, changes made in the planning procedure simplified the documentation to include only essential elements needed for communication by the group members. We also went through the process of listing all current and planned tasks in one consistent format in a file called SOFTP. This resulted in a preliminary listing of 30 critical and separate tasks, with truly distributed task leadership. 6d4c2c

Leadership 6d4c3

Leadership was minimal at the group level, and sufficient because of high motivation to complete tasks on schedule. The strongest leadership was at the task level. 6d4c3a

This experiment is still in progress. Longer-range goal and task planning, with better integration with other ARC activity planning, are currently being developed. 6d4c3b

c. Summary Comments on Planning Experiments 6d4d

Active community teamwork, warm human relationships, and good work attitudes are necessary for our organization to function effectively. We must encourage and develop feelings of trust and common goal appreciation so that our people can work closely together over a long period of time, with so much of themselves open to view to others and with such interrelated and challenging tasks to be undertaken. We found that the TODAS group benefited from the initial energy spent on interpersonal relationships, although there was eventually more effort applied to these factors than we found useful for task accomplishment. A careful balance between application of social and work-oriented energy is a necessity. 6d4d1

Although the TODAS experiment was not successful in all respects, it was an experiment where the particular people involved stand a better chance of succeeding in a future experiment with a reoriented group. 6d4d2

Software meetings were judged by participants and outside observers as extremely efficient and effective in meeting predetermined goals. While little attention was paid to interpersonal variables, group morale was strengthened by the meeting procedure. Uncertainties in task definition and individual responsibilities were clarified. The feedback was reported to be useful rather than either flattering or critical. This, again, was a chance for the participants to be involved in a smaller group than ARC. This contributed to the higher morale. 6d4d3

We feel that the techniques developed for meeting and task planning and for on-line note-taking will be useful as they evolve in future activity planning. We need to learn more about realizing the potential of improved interpersonal relationships in ARC, while expending only a reasonable amount of effort in doing so. 6d4d4

3. Observations From Study of On-Line Community 6d5

a. Use of Public Files 6d5a

The use of public files containing the work of many individual people seems to be well accepted by the group. 6d5a1

Far more communication potential exists in this environment than has yet been realized, although some people have started in some interesting ways. 6d5a2

Our need for development of a Dialogue Support System is clear. 6d5a3

Work habits of the on-line community staff also need development so that they can use the power of existing features and information in the system. 6d5a4

Now is the time for further work on methodology and procedures for use of the system, with the continued parallel evolution of the system itself. 6d5a4a

b. System Dependence by the Group 6d5b

As we augment, we find that it seems less desirable to use conventional tools for many tasks. 6d5b1

This is a problem to be resolved for good use of resources and for the purpose of not overlooking appropriate conventional tools where they can still be very effective. 6d5b2

The various ways that information now gets into the system are: 6d5b3

(1) Direct: 6d5b3a

(a) On-line NLS or TODAS use by originator: 6d5b3a1

Entry of new material 6d5b3a1a

Duplication and/or modification of existing information 6d5b3a1b

(b) On-line NLS or TODAS note-taking at discussions

6d5b3a2

(2) Indirect: 6d5b3b

(a) Transcription sources: 6d5b3b1

Handwritten 6d5b3b1a

External documents 6d5b3b1b

Stenographic dictation 6d5b3b1c

Recordings 6d5b3b1d

Individual use of dictating equipment 6d5b3b1d1

Tape recordings of group meetings 6d5b3b1d2

(b) Transcription processes: 6d5b3b2

Direct NLS use 6d5b3b2a

Direct TODAS use 6d5b3b2b

Paper tape 6d5b3b2c

We are working toward a better assessment of which tools are most appropriate for the various tasks to be performed in ARC. 6d5b4

c. Miscellaneous Observations 6d5c

This is a work-oriented group. Most people work long hours, usually at an intense rate; little time is spent not actually working. 6d5c1

There are many more work opportunities for the group and for most individuals than there are resources -- in terms of both time and funds. 6d5c2

Group and personal work management involves many difficult choices of tasks to be performed, postponed, or dropped. 6d5c2a

The group frequently sets goals at higher levels than it is likely to attain. 6d5c3

This is partly because we want the new features that will make the system more powerful; we are users of our own results. 6d5c3a

Sometimes, also, we overassess the potential power of the system, forgetting that it still has limitations, particularly in the area of consistently good service levels. This problem is getting a great deal of attention, however. 6d5c3b

The interrelatedness of the on-line community tasks makes planning very difficult, but obviously more necessary. 6d5c4

C. Team Augmentation and Dialogue Support 6e

Our efforts in management research have been centered on the attempt to developing a more closely integrated, participatory way of organizing people, efforts, and resources toward specific goals than is provided by classical management theory. 6e1

Toward this goal, we are currently focusing our attention on the problem of improving the management of a working system-development team, using our own organization as the subject of experimentation. This involves two facets of augmentation -- namely, individual augmentation and team augmentation. 6e2

Individual augmentation is simply our continuing effort to provide ways of improving the working capability of individual members of a team. 6e2a

Team augmentation involves the development of improved means for coordinating the efforts of individuals and for integrating their individual contributions into coherent team action. 6e2b

1. Recent Efforts 6e3

A portion of our recent MSR effort has been invested in formulating a "team-augmentation" approach. The initial emphasis is strongly oriented toward the means for communicating and collaborating effectively on issues embedded within a complex and evolving problem domain. 6e3a

An important facet of this approach has been a preliminary study for a "Dialogue Support System" (DSS) -- a special system of coordinated features which could support the communication and integration of collaborative dialogue among team members. 6e3b

Appendix B is a more detailed discussion of this formulation, as extracted from the PhD thesis of David A. Evans (see Ref. 1).

6e3b1

2. Future Approaches to Team Augmentation 6e4

Experimentation with roles, record-keeping conventions, collaboration procedures, decision-making practices, documentation, etc. will be a rich domain for exploratory MSR work. 6e4a

The following discussion of fast editing and publication, "super-documents," and augmented conferencing gives a view of some features needed for team augmentation. 6e4b

a. Fast Editing and Publication 6e4c

Our already fast editing techniques will continue to evolve, and we plan to concentrate early upon automatic production, from our on-line files, of hard copy having a very flexible composition of text, diagrams, tables, equations, footnotes, and indices. 6e4c1

The design of hard-copy formatting conventions must be related directly to the way in which the associated file material can be studied and manipulated on-line. 6e4c1a

b. "Super-Documents" 6e4d

We have been doing research leading to the development and production of very large, very complex documents containing numerous sections whose details are highly interdependent. These documents will be subject to frequent updating. This will involve further work on techniques for creating and using special indices, footnotes, reader-supportive comments, cross-references, etc. 6e4d1

We currently have quite powerful techniques for aiding an individual or a small report-writing team to produce documents of the usual research-report size and complexity. Part of our approach to team augmentation will be the expansion of these techniques to allow for much greater scope and complexity in documents and much more fluid interaction among the team members who create them. 6e4d2

A team tackling a complex system-development project must provide itself with the highest possible visibility over its working environment -- i.e., over the following factors: 6e4d3

Planning: plans, contingency alternatives, resource commitments, status, criticisms 6e4d3a

Design: designs, design principles, constraints, estimates, analyses, supportive data, relevant needs and possibilities 6e4d3b

Operation: roles, task definitions, assignments, policies, operational procedures and conventions. 6e4d3c

We intend to develop and keep up to date a large, detailed, highly cross-referenced and well-indexed "super-document" that contains just such a description of our own project-team activity. Our techniques for facilitating its modification and republication will be under constant evolutionary pressure. 6e4d4

c. Collaborative Use of On-Line File Systems 6e4e

On-line access by collaborators to each other's files, as provided by a number of today's time-sharing systems, leaves much to be desired in supporting effective dialogue. 6e4e1

An effective dialogue-support system is essential to team augmentation. Hand in hand with the "super-document" facility described above must go some such ability as the following: 6e4e2

Any team member at a display console can study swiftly any portion of the super-document's structured files. Our current system is fairly good for this purpose, but not yet adequate for dialogue study. 6e4e2a

Whenever he wishes -- as though he were pencil-marking his private draft with marginal comments, underlines, encircled passages, arrows, etc. -- he can introduce "comments" that are freely sprinkled with explicit references to any specific item (e.g. any character, word, graphic entity, or expression) within anybody's prior entry. (Note: the term "comment" is used here and in the following discussion in a very broad sense -- a comment is any entry which in some way points to a previous entry.) 6e4e2b

This commenting capability must be managed by the computer so that it does not matter if other people are simultaneously scanning the same material or affixing comments to the same items. 6e4e2b1

When creating a comment entry, he needs flexible aids and methods for arranging interspersed or concurrent display of the referenced passages, for designating the explicit entities he wishes to reference, and for suspending operations temporarily while he checks related material. 6e4e2b2

Conversely, he needs a way of seeing any comments that reference a passage he is inspecting. 6e4e2c

Categories might be defined by authorship, date of creation, text content, or assigned membership in predefined categories. 6e4e2c1

He also needs a great deal of control over this, however; much of the time he will not want to see any comments, or only comments falling into certain categories. 6e4e2c1a

He also needs considerable control over the way the system displays the comments that he wants to see -- in specified portions of the screen, in full-text or condensed form, etc. 6e4e2c1b

He needs the ability to set up "annunciator calls" to various people, or sets of people, to request their special attention (at some level of priority) to a given comment. 6e4e2d

All of the interactive-dialogue entries immediately become part of the super-document, imposing a potentially very complex comment network ("network" because comments can refer to comments in indefinite extension). 6e4e2e

It will be hard to keep track of the relationships among these comments and the substantive records about which the dialogue is oriented. 6e4e2e1

Their relationships need never be ambiguous, but consider the problem of trying to study such a structure to determine where we now stand in our developments and discussion, especially when it is the record of a complex system-design process and the interactive dialogue among very active people. 6e4e2e1a

This is about the most difficult central challenge in effectively augmenting a team -- that of developing computer aids, working methods, etc. to allow a skilled person to be highly effective in digesting the content and implications of such a record, and to develop a substantive next-stage design or plan that integrates the dialogue contributions. 6e4e2e2

Essentially similar techniques are required to augment any individual's central intellectual capability for synthesizing the next stage of development in a plan or design. To the extent that we are successful with this, we should be able to offer strong guidance for capability augmentation over wide ranges of individual and team activities. 6e4e2e2a

d. Conference Augmentation 6e4f

There is great potential value in direct augmentation of conferences and meetings. When people are gathered together to consider a proposal or argument, or to collaborate actively on a problem, there are many possibilities for the development of techniques and facilities to make their work more effective. 6e4f1

There is a wide range of possible approaches to conference augmentation. 6e4f1a

At one extreme, each participant would be an experienced NLS user and would have his own console; sophisticated facilities would be provided for "linking" the consoles in various ways to augment communication. 6e4f1a1

At the other extreme, there would be only a single console with a special operator; special techniques for integrating the NLS facility, the operator, and the conference participants into a working system would be needed. 6e4f1a2

Between these two extremes, a variety of intermediate approaches is possible. 6e4f1a3

For any of these approaches, a central problem is the development of conference procedures and the organization of on-line information; both procedures and information structures must be developed in such a way as to gain the greatest possible advantage from the computer facility. 6e4f1b

This development of conference procedures and information structures should be done experimentally, under actual usage conditions. 6e4f1b1

We have already experimented with augmenting meetings by having one person operate NLS as an on-line note-taker, where all participants can see the display (see Sec. II-A-3-b). 6e4f1b2

On the basis of recent experience, we plan to provide better facilities for groups of people working together at consoles and for small meetings where consoles are not available for everyone (or where not all participants are NLS users). This will permit experimentation with intermediate approaches lying between the two extremes described above. 6e4f2

The facility will consist of a meeting room equipped with projection TV, several appropriately designed consoles, and furniture designed so that three or four people may work at the consoles with ten or so less active participants.

6e4f2a

III HARDWARE SYSTEM

7

File (english,rfhdw,) in KDF under Guest, password WKE 7a

IV SOFTWARE SYSTEM

8

File (english,rpsft,) in KDF under Guest, password WKE

8a

V FUTURE PLANS

9

A. General 9a

Future directions for work in the ARC will be influenced by forces originating both inside and outside the Center. 9a1

Forces generated by our cumulative experience in the development of augmentation systems within the Center indicate some new directions for our own bootstrapped research effort. 9a1a

External forces are generated by our participation in the ARPA Network experiment and by an increased awareness for the need to communicate with the "outside world" -- people outside the Center who are engaged in related work. 9a1b

The internal forces and those generated by our Network participation combine to produce a shift in our internal research emphasis towards two specific activities: (1) team augmentation and (2) the development of a system design discipline. These are discussed below under "Shifts in Emphasis." 9a2

Increased awareness of the need to communicate and interact with the outside world will lead toward the development of a new area of specific concern, discussed below under "Transfer of Results." 9a3

The goals associated with research in team augmentation, with the development of a system design discipline, and with the transfer of results are related to one another within the ARC goal structure as described below in the section entitled "Short-Term and Long-Term Goals." 9a4

In the section "Selected Plans Under Other Sponsorship," we discuss the System Developer Interface Activity (SYDIA), for which we are seeking additional sponsorship. It is intended that this activity will be the primary effort in the area of the transfer of results. 9a5

B. Shifts in Emphasis 9b

Our plans reflect a maturing shift in emphasis in our research work. We plan to shift our emphasis toward two basic activities: (1) team augmentation and (2) the development of a system design discipline.

9b1

1. Team Augmentation 9b2

Whereas in the past we have given most of our attention to augmenting the individual worker, we are now focussing on the augmentation of a team of collaborating workers, each of whom is individually augmented. 9b2a

The high mobility and manipulative capability of a skilled "augmented individual" has a unique potential which can be realized when a number of augmented individuals join into a collaborative team. Not only can each individual move very rapidly through the joint working files to study them, enter new information, and update old material, but this power can be amplified by special computer aids, conventions, and skills that directly facilitate the processes of intercommunication and coordination. 9b2b

The contemplated efforts in "team augmentation" involve several facets: 9b2b1

(1) The development of conventions and procedures for organizing the working records of our plans, designs, objectives, design principles, schedules, etc., so as to give effective mutual "task orientation" to the members of a team by ensuring optimal accessibility of all information related to the team's objective. 9b2b1a

(2) The special development of a "Dialogue Support System" to facilitate the rapid evolution of these working records via dialogue among members of the design team. 9b2b1b

(3) The development of techniques to facilitate simultaneous remote collaboration among people at physically remote on-line terminals (of any sort), by giving them direct communication with one another, independent of their current individual work interactions with the computer. This includes provision, where feasible, for the following: 9b2b1c

(a) Video and/or voice intercommunication 9b2b1c1

(b) Easy and flexible control of means for duplicating, at any terminal, all or part of the type-out or display from another terminal 9b2b1c2

(c) Ready transfer of control of one terminal's computer interaction to another terminal's input devices. 9b2b1c3

These techniques will evolve within ARC under conditions of application to our own coordinated system-development work, and will be applied over a wide range of collaborative actions, from simple question-answering facilities to complex design work involving intense mutual participation by the team members. 9b2b2

As applicable techniques become effective within ARC, we will explore their use and value for the following: 9b2b3

(1) Support of Network Information Center (NIC) services such as teaching, question-answering, and some types of query servicing 9b2b3a

(2) Working collaboration between ARC staff and personnel at other Network sites 9b2b3b

(3) Working collaboration between people at remote Network sites, independent of ARC staff. 9b2b3c

2. Development of User- and Service-System Design Discipline 9b3

The functional features of the "user system" -- the large collection of computer aids available to an ARC worker -- have evolved with some ingenuity, a greal deal of cut-and-try experimentation under actual-usage conditions, and a certain special orientation offered by our overall research framework. However, up to now there has been a significant lack of objective, methodical engineering design for the overall user system. 9b3a

A user-system design discipline is definitely needed, and we intend to devote an increasing amount of effort toward developing such a discipline. 9b3a1

Like the user system, the "service system" -- the hardware and software underlying the features for augmenting users -- has evolved in an ad hoc fashion. 9b3b

Here there is also a significant need for a system-design discipline. 9b3b1

A system-design discipline would have a communicable, teachable, generally applicable framework supporting a coordinated set of concepts, terminologies, principles, methods, and special tools. 9b3c

C. Transfer of Results 9c

Behind these basic aspects of our work in the ARC (team augmentation and design disciplines) lies an essential feature of our long-term strategy, namely, the goal of producing results that will be of direct value to other groups of system developers -- in particular, to those who will be developing augmentation systems. 9c1

This is in contrast to being of direct value to customers who will want systems for their own direct use (e.g., to augment a manager, a designer, an editor, or a researcher). 9c1a

Display terminals, communication channels, and computer service are destined to become both cheap and plentiful, and it is certain that a very large number of organizations will want to use them. They must rely upon system developers who will need to be capable of the following: 9c2

(1) Analysis of system-usage environments 9c2a

(2) Design and implementation of a smooth, powerful, and coordinated system of user aids, conventions, methods, etc. 9c2b

(3) Training and "education" of new users, many of whom will be completely unfamiliar with the potential of this new technology 9c2c

(4) Subsequent monitoring of user performance so as to implement the changes necessary to track the evolution of users' attitudes, concepts, skills, usage habits, and wants. 9c2d

Although it is important to stimulate the eventual customers for augmentation systems, and to make them aware of the potential for these systems in their work, we feel that our results should be directed primarily toward helping system developers. Over the longer term, we plan to do this by pursuing the following goals: 9c3

Item 1: Making visible an advanced, integrated system, operating in a heavy-usage environment, that can orient system developers to the available cost-value tradeoffs 9c3a

Item 2: Developing an effective system-design discipline to aid in developing augmentation systems, whether or not these systems resemble ours 9c3b

Item 3: Maintaining thorough, highly current, comprehensive documentation, designed for quick location of relevant material 9c3c

Item 4: Establishing broad-band communication channels over which a dynamic interchange of information can take place, so that a maximum proportion of our knowledge can be quickly available in useful form 9c3d

Item 5: Offering, as a model, a complete prototype design of an augmentation system especially designed for augmenting system development. 9c3e

This system would be compatible with the system-design disciplines described above, and would include techniques for planning, analyzing, designing, programming, debugging, documenting, and teaching. 9c3e1

D. Short-Term and Long-Term Goals 9d

Our approach to the planned work will be as follows: 9d1

(1) Achieve the short-term goals implicit in the team augmentation activity, in the development of a system design discipline, and in the tasks itemized under Transfer of Results (Section V-C above) 9d1a

(2) Contribute to the long-term goal of directing our results for maximum benefit to future developers of augmentation systems. 9d1b

There is considerable overlap between short-term and long-term goals. 9d2

For instance, in the case of the transfer of results, the basic bootstrapping development of techniques within the ARC seems to guarantee a very good basic buildup toward Items 1, 2, 3, and 5 of Section V-C; our participation in the Network experiment contributes directly to Item 4; and the development of the NIC service will contribute toward Items 1 and 4. 9d2a

E. Selected Plans Under Other Sponsorship 9e

To pursue directly the itemized long-range goals of Section V-C, we currently have other plans under consideration, coordinated with those outlined in this proposal. These plans would be carried out under other sponsorship: 9e1

We are formulating plans for what we tentatively call the System Developer Interface Activity (SYDIA). We expect to be approaching representative candidates during 1970 with proposals for multiple sponsorship. The initial purpose of the SYDIA will be to develop the following: 9e1a

(1) A facility for an effective interchange of information, skills, orientation, etc. between ARC and the existing and potential community of augmentation-system developers 9e1a1

(2) The ability to assist other groups to transfer our system, or parts of it, directly into another hardware environment. 9e1a2

Later, with specific individual funding arrangements, we would expect to begin developing close interchange relationships with various system-development groups; hopefully, some groups would then adopt our augmented techniques for system-development work.

9e1b

GLOSSARY

10

ARC: Acronym for the Augmentation Research Center at Stanford Research Institute. 10a

ARPA: Acronym for the Advanced Research Projects Agency. 10b

Augmentation: Used in this report to indicate the extension of human intellectual and organizational capabilities by means of close interaction with computer aids and by use of special procedural and organizational techniques designed to support and exploit this interaction. 10c

Center: Another term used for the ARC. 10d

Console: As used here, this means specifically a user's control console for the ARC's On-Line System (NLS). The consoles presently in use consist of a display screen, a keyboard, a "mouse", and a "keyset." 10e

File: As used here, this refers to a unified collection of information held in computer storage for use with the On-Line System (NLS) or with TODAS. A file may contain text (natural language or program code), numerical information, graphics, or any combination of these. Conceptually, a file corresponds roughly to a hard-copy document. 10f

GENIE: Project GENIE, at the University of California at Berkeley, developed (under ARPA sponsorship) the timesharing software for the XDS940 computer used by the ARC. 10g

GODOS: Acronym for Graphics-Oriented Document Output System, a means for converting NLS/TODAS files to microfilm. GODOS is capable of handling the line drawings produced with the NLS graphics capability. 10h

IMP: Acronym for Interface Message Processor, a component used in the ARPA Network. 10i

Keyset: A device consisting of five keys to be struck with the left hand in operating the On-Line System (NLS). 10j

MOL: See MOL940. 10k

MOL940: A machine-oriented language for the XDS940 computer.

MOL940 (or simply MOL) was developed at ARC. 10l

Mouse: A device operated by the right hand in using the On-Line System (NLS). The mouse rolls freely on any flat surface, causing a cursor spot on the display screen to move correspondingly. 10m

NASA: National Aeronautics and Space Administration. 10n

Network: The planned Advanced Research Projects Agency network of research computer installations. 10o

NIC: The Network Information Center, to be incorporated in the ARPA network. The NIC will operate as a computer-assisted library service for information pertaining to the network, to be used by network members, and will be operated by ARC. 10p

NLS: See On-Line System. 10q

On-Line System (NLS): This is the ARC's principal and central development in the area of computer aids to the human intellect. As presently constituted, it is a display-oriented, timeshared, multiconsole system for the composition, study, and modification of files (see definition of "file"). A counterpart system, TODAS, operates from hard-copy terminals such as Teletypes and offers many of the same capabilities as NLS. 10r

PASS4: An output-processing program used to convert NLS/TODAS files to hard-copy format for output via one of a number of different devices. 10s

RADC: Acronym for Rome Air Development Center. 10t

SPL: Acronym for Special-Purpose Language. Specifically, this term is used for the SPL's developed at ARC for use in programming NLS. 10u

SRI: Acronym for Stanford Research Institute 10v

Statement: The basic structural unit of an NLS/TODAS file. A statement consists of an arbitrary string of text, plus graphic information. A file consists of a number of statements in an explicit hierarchical structure. 10w

TODAS: Acronym for the Typewriter-Oriented Documentation-Aid System. TODAS is a counterpart of NLS designed to operate from hard-copy terminals such as Teletypes. 10x

Tree Meta: A compiler-compiler system developed at ARC. 10y

TSS: Acronym for Time-Sharing System. Specifically, the system developed by Project GENIE for the XDS940 computer. 10z

XDS940: The computer facility used by ARC is based upon a Xerox Data Systems (formerly Scientific Data Systems or SDS) model 940 timsharing computer. 10a@

940: See XDS940.

10aa

REFERENCES

11

The following is a list of references specifically cited in the report. 11a

1. D. A. Evans, "Man/Computer Augmentation Systems for Qualitative Planning," Ph.D. Thesis, Department of Civil Engineering, Stanford University, Stanford, California (December 1969). 11b

2. "Specifications for the Interconnection of a Host and an IMP," Report No. 1822, Contract No. DAHC15-69-C-0179, ARPA Order No. 1260, Bolt Beranek and Newman Inc., Cambridge, Massachusetts (May 1969). 11c

3. D. C. Engelbart, W. K. English, and J. F. Rulifson, "Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 11d

4. D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer Augmented Management Techniques," Interim Technical Report RADC-TR-69-98, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (March 1969), AD 855 579. 11e

5. D. C. Engelbart and B. Huddart, "Research on Computer-Augmented Information Management," Technical Report ESD-TDR-65-168, Contract AF 19(628)-4088, Stanford Research Institute, Menlo Park, California (March 1965), AD 622 520. 11f

6. W. K. English, D. C. Engelbart, and B. Huddart, "Computer-Aided Display Control," Final Report, Contract NAS1-3988, SRI Project 5061, Stanford Research Institute, Menlo Park, California (July 1965), CFSTI Order No. N66-30204. 11g

7. D. C. Engelbart, W. K. English, and J. F. Rulifson, "Study For The Development of Human Intellect Augmentation Techniques," Interim Progress Report, Contract NAS1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March 1967). 11h

8. D. C. Engelbart, W. K. English, and J. F. Rulifson,

"Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 11i

9. D. C. Engelbart, "Human Intellect Augmentation Techniques," Final Report, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (July 1968), CFSTI Order No. N69-16140.

11j

10. W. W. Lichtenberger, "ARPAS: Reference Manual for Time Sharing Assembler for SDS 930," Document No. R-26, Office of Secretary of Defense, Advanced Research Projects Agency, Washington 25, D. C. (Revised 24 February 1967). 11k

11. R. House, D. Angluin, and L. P. Baker, "Reference Manual for NARP, an Assembler for the SDS 940," Document No. R-32, Office of Secretary of Defense, Advanced Research Projects Agency, Washington 25, D. C. (Revised 21 November 1968). 11l

12. R. E. Hay and J. F. Rulifson, "MOL940: A Machine-Oriented ALGOL-Like Language for the SDS 940," Technical Report 2, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (April 1968). 11m

13. R. W. Watson, "Introduction to Time-Sharing Concepts," Technical Progress Report No. 249-68, Project No. 78140, Shell Development Co., Emeryville, California (January 1969).

11n

BIBLIOGRAPHY

12

The following is a chronological list of documents published by the Augmentation Research Center. 12a

D. C. Engelbart, "Special Considerations of the Individual As a User, Generator, and Retriever of Information," Paper presented at Annual Meeting of American Documentation Institute, Berkeley, California (23-27 October 1960). 12b

D. C. Engelbart, "Augmenting Human Intellect: A Conceptual Framework," Summary Report, Contract AF 49(638)-1024, SRI Project 3578, Stanford Research Institute, Menlo Park, California (October 1962), AD 289 565. 12c

D. C. Engelbart, "A Conceptual Framework for the Augmentation of Man's Intellect," in Vistas in Information Handling, Volume 1, D. W. Howerton and D. C. Weeks, eds., Spartan Books, Washington, D.C. (1963). 12d

D. C. Engelbart, "Augmenting Human Intellect: Experiments, Concepts, and Possibilities," Summary Report, Contract AF 49(638)-1024, SRI Project 3578, Stanford Research Institute, Menlo Park, California (March 1965), AD 640 989. 12e

D. C. Engelbart and B. Huddart, "Research on Computer-Augmented Information Management," Technical Report ESD-TDR-65-168, Contract AF 19(628)-4088, Stanford Research Institute, Menlo Park, California (March 1965), AD 622 520. 12f

W. K. English, D. C. Engelbart, and B. Huddart, "Computer-Aided Display Control," Final Report, Contract NAS1-3988, SRI Project 5061, Stanford Research Institute, Menlo Park, California (July 1965), CFSTI Order No. N66-30204.* 12g

W. K. English, D. C. Engelbart, and M. L. Berman, "Display-Selection Techniques for Text Manipulation," IEEE Trans. on Human Factors in Electronics, Vol. HFE-8, No. 1, pp. 5-15 (March 1967). 12h

D. C. Engelbart, W. K. English, and J. F. Rulifson, "Study For The Development of Human Intellect Augmentation Techniques," Interim Progress Report, Contract NAS1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March

1967). 12i

J. D. Hopper and L. P. Deutsch, "COPE: An Assembler and On-Line-CRT Debugging System for the CDC 3100," Technical Report 1, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March 1968).

12j

R. E. Hay and J. F. Rulifson, "MOL940: A Machine-Oriented ALGOL-Like Language for the SDS 940," Technical Report 2, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (April 1968). 12k

D. C. Engelbart, W. K. English, and J. F. Rulifson, "Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 12l

D. C. Engelbart, "Human Intellect Augmentation Techniques," Final Report, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (July 1968), CFSTI Order No. N69-16140.* 12m

D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer-Augmented Management Techniques," Quarterly Progress Report 1, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (October 1968). 12n

D. C. Engelbart and W. K. English, "A Research Center for Augmenting Human Intellect," in AFIPS Proceedings, Vol. 33, Part One, 1968 Fall Joint Computer Conference, pp. 395-410 (Thompson Book Co., Washington, D.C., 1968). 12o

D. C. Engelbart and Staff of the Augmented Human Intellect Research Center, "Study for the Development of Human Intellect Augmentation Techniques," Semiannual Technical Letter Report 1, Contract NAS 1-7897, SRI Project 7079, Stanford Research Institute, Menlo Park, California (February 1969). 12p

D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer Augmented Management Techniques," Interim Technical Report RADC-TR-69-98, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (March 1969), AD 855 579. 12q

D. C. Engelbart and Staff of the Augmented Human Intellect Research Center, "Study for the Development of Human Intellect Augmentation Techniques," Semiannual Technical Letter Report 2, Contract NAS 1-7897, SRI Project 7079, Stanford Research Institute, Menlo Park, California (August 1969). 12r

*Note: Reports with AD numbers are available from Defense Documentation Center, Building 5, Cameron Station, Alexandria, Virginia 22314. Items marked with an asterisk may be obtained from CFSTI, Sills Building, 5825 Port Royal Road, Springfield, Virginia 22151; cost $3.00 per copy or 65 cents for microfilm.

12s

Appendix A: User Features of NLS and TODAS 13

File (casseres,nldes,) in KDF under Stone, password DGC 13a

Appendix B: Dialogue Support System 14

File (casseres,adss,) in KDF under Meisling, password DGC 14a

Appendix C: Hardware Description 15

File (english,hdwap,;) in KDF under English 15a

Appendix D: Technical Description of NLS 16

File (english,p2rome,) in KDF under Guest, password WKE 16a

':4868', 09/28/70 1538:24 MGC ; :ROMEF, 07/12/70 1911:18 DGC ; ['.LLL];
EDITING CHANGES DONE .DSN=1; .COD[21B]=114B; .DLS=1; .HLN=3; .ROM=1;
.RTJ=0; .PGN=0; .LSP=0; .HED="
4868 DGC 12JUL70
7101 ROME FINAL REPORT: Sec. I
INTRODUCTION"; .DPR=0;

ABSTRACT

1

This report covers two years of research in a continuing program in the Augmentation Research Center (ARC) of the Information Sciences Laboratory of Stanford Research Institute, supported by ARPA and RADC under Contract F30602-68-C-0286. 1a

Some of the work reported was also supported by ARPA and NASA under Contract NAS1-7897. 1a1

The research reported is aimed at the development of on-line computer aids for increasing the performance of individuals and teams engaged in intellectual work, and the development of techniques for the use of such aids. The report covers hardware and software development, applications in several areas relating to management of a community of workers who use on-line aids and to information management for such a community, participation in the ARPA computer network, and a summary of plans for the continuation of the research.

1b

PREFACE

2

The research described in this report represents conceptual, design, and development work by a large number of people; the program has been active as a coordinated team effort since 1963. The research reported here was a cooperative team effort involving the entire ARC staff. The following is an alphabetical listing of the current ARC staff: 2a

Geoffrey H. Ball, Walter L. Bass, Vernon R. Baughman, Mary G. Caldwell, Roberta A. Carillon, David Casseres, Mary S. Church, William S. Duvall, Douglas C. Engelbart, William K. English, Ann R. Geoffrion, Martin L. Hardy, Jared M. Harris, J. David Hopper, Charles H. Irby, L. Stephen Leonard, John T. Melvin, N. Dean Meyer, James C. Norton, Bruce L. Parsley, William H. Paxton, Jake Ratliff, Barbara E. Row, Martha E. Trundy, Edward K. Van de Riet, John M. Yarborough. 2a1

The following former ARC staff members also contributed to the research: 2b

Donald I. Andrews, Roger D. Bates, David A. Evans, Stephen R. Levine, Stephen H. Paavola, Helen H. Prince, Jons F. Rulifson, Elmer B. Shapiro, F. K. Tomlin.

2b1

CONTENTS 3

3q

ILLUSTRATIONS 4

4p

4ar

I INTRODUCTION

5

A. General 5a

The Augmentation Research Center (ARC) is a community of about 28 researchers, supported by several different contracts, in which all the research activity is aimed at (1) exploring the possibilities for augmenting the performance of intellectual work with the help of real-time computer aids and (2) the experimental development of computer aids and augmentation systems. 5a1

Several different coordinated research activities have been developed, sponsored by different contracts, to pursue the various aspects of this augmentation research. The aspects reported here are: 5a2

(1) The Management System Research Activity, which has been supported by RADC under this contract. 5a2a

(2) The development, operation, and maintenance of a real-time computer-display system, including both hardware and software aspects and participation in the ARPA computer network experiment. This has been supported by ARPA and RADC under this contract, and by ARPA and NASA under Contract NAS1-7897. The facility is dedicated solely to the ARC's activities. 5a2b

All the researchers within the ARC do as much of their work as possible at display consoles (depending on console availability and whether a specific task can appropriately be done at a console). Thus they serve not only as researchers but as the subjects for the analysis and evaluation of the augmentation systems that they are developing. 5a3

Consequently, an important aspect of the augmentation work done within the the ARC (for instance, of the RADC-supported Management Systems Research) is that the techniques being explored are implemented, studied, and evaluated with the advantage of intensive everyday usage within a coordinated working environment that is compatible with the particular techniques being studied. 5a4

This strategy, called "bootstrapping," is a key concept in much of our design philosophy. 5a5

B. On-Line Aid Systems in the Augmentation Research Center 5b

This section very briefly describes the two major augmentation systems available to workers in the Augmentation Research Center. These systems are the On-Line System (NLS) and the Typewriter-Oriented Documentation-Aid System (TODAS). 5b1

Appendix A is a more complete description of the user features of these systems; the reader who is not already acquainted with ARC's research will find that this appendix provides a useful background for the main body of the report. 5b1a

In addition, Appendix D gives a detailed description of NLS/TODAS implementation. 5b1b

1. The On-Line System (NLS) 5b2

NLS, as currently implemented, is essentially a highly interactive, display-oriented text-manipulation system. 5b2a

NLS is intended to be used on a regular, more or less full-time basis in a time-sharing environment, by users who are not necessarily computer professionals. The practices and techniques developed by users for exploiting NLS are as much a subject of research interest as the development of NLS itself. 5b2b

a. Structured Text 5b2c

All text handled by NLS is in "structured-statement" form. This special format is simply a hierarchical arrangement of "statements," resembling a conventional "outline" form. 5b2c1

A statement is simply a string of text, of any length; this serves as the basic unit in the construction of the hierarchy. Each paragraph and heading in this document is an NLS statement. 5b2c1a

b. Use of the System 5b2d

The creation of new text material as content for a file is achieved by typing the new material on a keyboard, under any of several possible NLS commands. 5b2d1

The study capabilities of NLS constitute its most powerful and unusual features. The following is a brief, condensed description of the operations that are possible. 5b2d2

The process of moving from one point in an NLS file to another, which corresponds to turning pages in hard copy, is called "jumping." A very large family of "jump" commands allows the user to specify locations in the file in a number of ways -- e.g., by specifically identifying a statement or by specifying a structural relationship to some other statement. 5b2d3

The NLS content analyzer permits automatic searching of a file for statements satisfying some content pattern specified by the user. The pattern is written in a special language as part of the file text. 5b2d4

A large repertoire of editing commands is provided for modification of the text in a file. 5b2d5

2. The Typewriter-Oriented Documentation-Aid System (TODAS) 5b3

TODAS is a text-handling system designed as a "typewriter" counterpart to NLS. TODAS can be operated from a Teletype or any other kind of hard-copy terminal, including terminals linked to the ARC timesharing computer facility (an XDS 940 with special hardware) through acoustic couplers and ordinary telephone lines (as opposed to NLS, which requires microwave transmission to achieve the necessary bandwidth for displays). 5b3a

3. Output Facilities 5b4

The facilities for producing hard-copy output from NLS/TODAS files include a line printer, a paper-tape-driven typewriter, and the Graphics-Oriented Document Output System (GODOS). 5b4a

The line printer, because of its speed of operation, is the routine means of producing hard copy for use within ARC. It is used heavily by all NLS/TODAS researchers. 5b4a1

The paper-tape typewriter is used for producing report-quality typing, such as this report. As it is relatively slow and inconvenient, it is not normally used except for final output of material to be published. 5b4a2

GODOS produces magnetic tape which is then turned over to an out-of-house facility where it is run on Stromberg-Carlson microfilm equipment to produce frames of microfilm (or microfiche) corresponding to pages of full-size hard copy. The advantage of this system is that it can handle drawings produced in NLS files by means of the NLS graphics capability. GODOS is still in the experimental stage and has not been used extensively. 5b4a3

4. This Report as an Example of NLS/TODAS Capability 5b5

The following discussion may be taken as a very rough indication of the power of NLS and TODAS as applied to a single specific problem -- namely, the writing, editing, and production of this report. 5b5a

The above descriptions of NLS and TODAS were produced by modification, using NLS, of the more detailed descriptions in Appendix A. 5b5b

The entire task of modification, including formatting, insertion into the body of the report, and all other details, required about half an hour of work by an NLS user who was already familiar with the contents of the descriptions. If the job had been done by someone who was not familiar with the material (but who was familiar with NLS) it might have taken fifteen minutes longer. 5b5b1

The original description was written for an earlier report and then kept available as an NLS/TODAS file in anticipation of future opportunities for using it. 5b5b2

Indeed, a considerable amount of the material in this report was developed by modification of existing files, and we may expect the new material generated for this report to continue in use as a collection of NLS/TODAS files for as long as it can be updated to reflect current reality. 5b5c

TODAS was used primarily for the task of entering new material into on-line files. Considerable portions of the material were put on line by a secretary using TODAS, working from handwritten material and from recorded dictation. 5b5c1

Finally, we may note that the writing of this report, using NLS and TODAS throughout, was achieved under considerable time pressure by a team consisting of about a dozen people, all of whom were doing other important work at the same time.

5b5d

II MANAGEMENT SYSTEM

6

Our Management System Research Activity has involved three major areas of concentration. In practice these areas overlap considerably, so that there is an integrated research effort on many phases of management technique and theory that impinge upon the operation of ARC. For purposes of description, however, we discuss each area of concentration as if it were an independent effort. 6a

The three areas are: 6b

(1) Management-Information Operations -- research on techniques for using management information in the ARC environment, including the development of computer aids for the storage and manipulation of such information 6b1

(2) Organization Studies -- research on the ARC on-line community of workers and experimentation with organization structure and planning methods in the on-line community 6b2

(3) Team Augmentation and Dialogue Support-- research on augmenting a team or community of intellectual workers by means of systems that support the intellectual dialogue of the team. 6b3

A. Management-Information Operations 6c

1. Introduction 6c1

In accordance with our usual strategy, we have pursued our investigation of management-information operations by using NLS and TODAS to develop and provide aids for management of the ARC on-line community. 6c1a

There are many areas of potential application for on-line aids; we have chosen those which appear to be most useful operationally for experiments with the development of on-line aids. 6c1b

This section gives detailed descriptions of several applications that have been developed, illustrated with photographs of the NLS display screens to show sequences of information-manipulation operations. A familiarity with the basics of NLS is assumed; Appendix A is intended to provide the necessary information about NLS. 6c1c

In following the descriptions, it is worth keeping in mind that the speed with which NLS serves its users is an important part of its utility. The photographs indicate transitions that normally take only one or two seconds. This speed lends great power and flexibility to the relatively simple service functions performed by NLS. 6c1d

2. Project Costs 6c2

The most obvious area for application of on-line aids to management within ARC is project cost accounting. Considerable work has been done on the development of several cost-information files and of techniques for their use. 6c2a

a. Cost Records 6c2b

The Institute's accounting system provides ARC with detailed cost records for the various "SRI projects" (i.e., individual contracts) being carried out in ARC. 6c2b1

The primary inputs to SRI's system are (1) weekly time cards reporting hourly charges to various projects by individual staff members, and (2) non-labor costs charged directly to projects, including actual charges to projects and commitments (uncompleted orders). 6c2b1a

For each SRI project, the accounting system computes dollar costs based on actual salary data for each staff member's hours charged, adds payroll burden and overhead amounts at current rates, combines these costs with non-labor totals, adds appropriate fees, and totals all such charges each week on a cumulative basis. 6c2b1b

Current charges are reported to ARC each week on the Project Status Report. 6c2b1c

We need frequent and rapid access to project cost summary data for operational use, with less reference to lower-level details, except as the costs are first checked for reasonableness and accuracy. Therefore we decided to start by putting summary data on-line at ARC. As needed in the future, we can add more levels of detail. 6c2b1d

File HISCO 6c2b2

We first constructed a cost-history file for 1968-1969 costs on SRI projects ESU 7101 (RADC Contract F30602-68-C-0286) and ESU 7079 (NASA Contract NAS 1-7897). This file is called HISCO. 6c2b2a

We decided that the elements of HISCO would include the following for each of the two projects, on the basis of 4-week accounting periods (as used by SRI's accounting system): 6c2b2b

(a) Salary 6c2b2b1

(b) Burden 6c2b2b2

(c) Overhead 6c2b2b3

(d) Total cost 6c2b2b4

(e) Fee 6c2b2b5

(f) Total charges. 6c2b2b6

See Figs. II-1, II-2, and II-3. Each of these figures shows a display of one branch of the file, containing the information for a specific project and year. 6c2b2b7

We also needed a section showing combined salary costs and combined total charges for all of our projects (see Figs. II-4 and II-5). We put these costs in separate branches of the file. The last branch shows total costs for both projects combined. We retroactively studied existing records for all 1968 data and kept up the 1969 costs every 4 weeks, entering the new data by hand. 6c2b2b8

We experimented with the use of graphic representations by entering charts in HISCO. These charts showed the cumulative cost trends for each project in a separate branch of the file. 6c2b2c

We established links between tabular data and chart projections. This made it quite easy to refer to both formats alternately. 6c2b2c1

The use of graphics in HISCO gave some indication of the usefulness of such linking, but the existing package has limitations in the form of a few bugs and capacity that makes its use of marginal value. Work is currently under way to improve this capability. We also need local hard-copy output to make these features of real value. 6c2b2c2

HISCO was a testing ground for the first version of the NLS calculator package. As the file was updated, cost data were entered into new statements, and the calculator was used to check the cost data and to determine the total ARC project costs. 6c2b2d

This employed the ADD, SUBTRACT, MULTIPLY and DIVIDE capabilities and used the four holding registers. 6c2b2d1

The calculator package has an 'INSERT' command that inserts the current contents of the calculator's accumulator into the file text as indicated by a bug selection. Work with HISCO indicated that a 'replace' command would be very desirable. 6c2b2d2

The usual way of accessing HISCO was via pre-established links from other working files whenever the user had a question about recent costs. The VIEWSPECs in the link usually caused HISCO to be brought in with only high-level statements on display, showing only the headings for project name, combined salary, total charges, and total ARC costs (see Fig. II-6). 6c2b2e

The user could then select the project he was interested in (by the command JUMP TO ITEM) open up an additional level for viewing, and see column headings and numerical data (Figs. II-1, II-2, and II-3). 6c2b2e1

Then he could jump down through the accounting periods to the one he was looking for. 6c2b2e1a

If he was making a calculation (perhaps already started in the file he was working in before he linked to HISCO), he could then call the calculator and add, subtract, multiply or divide by any of the numbers in HISCO. His previous calculations while in the previous file would remain intact. 6c2b2e1b

If finished with HISCO, he could then return to the previous file (by the command JUMP TO FILE RETURN) and continue with the calculation, having found in HISCO the input number or numbers he was looking for. 6c2b2e1c

Such a sequence occurs very fast. Experience with HISCO seems to prove the value of having a simple calculator built into NLS, where it is instantly available when needed and can interact directly with data in an NLS file. 6c2b2e2

Desk calculators are available for most people who need to do basic arithmetic work, but when one is looking through extensive files for inputs to calculations, the conventional calculator is not nearly as useful as this on-line version. 6c2b2e2a

Summary: As an arena for experimentation, HISCO proved very valuable. Operationally, it was useful from time to time but revealed a need for more frequent updating of the summary data. Our experience with HISCO led to the development of a redesigned cost-history file called COSTS. 6c2b2f

File COSTS 6c2b3

This file is updated weekly, with 4-week and cumulative summaries. 6c2b3a

The COSTS file is referred to frequently, because the weekly inputs now show trends with considerable sensitivity. 6c2b3a1

We decided that the elements most useful to us for this year are the following: 6c2b3b

(a) Salary costs 6c2b3b1

(b) Total personnel costs 6c2b3b2

(c) Non-labor costs 6c2b3b3

(d) Total costs 6c2b3b4

(e) Total charges with fee 6c2b3b5

(f) Balance remaining 6c2b3b6

See Figs. II-7, II-8, and II-9. Figures II-7 and II-8 show the same branch of the file with different VIEWSPECs; Fig. II-8 displays one more level than Fig. II-7, and this level shows the weekly data. Figure II-9 shows the weekly data for another project. 6c2b3b7

We also decided to include funding information showing current totals, unfunded totals, and total contract amounts in the categories cost, fee, and total. 6c2b3b8

We use separate branches for each project and for total ARC project costs (Fig. II-10). The skeleton format for the file was set up in advance for the entire year of 1970. 6c2b3c

Our approach was to create a separate statement for each week, one level below the "total" statements for each 4-week period. For the second week of 1970 (which is in the first accounting period) the statement starts with a 2-1 and then, proceeding across the line, shows the amounts listed above in six columns (Figs. II-8 and II-9). 6c2b3c1

Before entering any actual data, the first top-level branch (containing some 70 statements) was copied within the file at the same level four or five times. Then each blank branch simply had the project name headings inserted for the project using that branch. We keep one extra blank format branch available in case any new projects should arrive. 6c2b3c2

Like HISCO, COSTS is usually reached through a link from some other working file, perhaps while a study of near-future costs is in progress, or from an ongoing proposal cost estimate. Again the file is usually entered with only the top-level statements or project headings showing (see Fig. II-11). 6c2b3d

If a particular project is of interest, that branch is selected and another level opened for view. The second level shows period-by-period subtotals in each cost category (Fig. II-7). If weekly data are desired, another level is opened by changing the VIEWSPECs (Fig. II-8) and a particular week is selected by the command JUMP TO ITEM. 6c2b3d1

The statement for each week has the week ending date as its name. The reason for this is not only so that the statement for a particular week can be accessed by the JUMP TO NAME command using the ending date, but also so that the date may optionally be suppressed from the display. NLS has the capability of suppressing all statement names from the display. 6c2b3d1a

The normal way of looking at the file is with names suppressed; thus the dates do not clutter the display; however, a user who needs to know the ending date for a particular week can see it by executing a single command. 6c2b3d1a1

To access the information for another project within COSTS, one executes JUMP TO RETURN twice to see the top-level statements again (Fig. II-11). 6c2b3d2

One can move very quickly and accurately through a file that is set up in this fashion, even without any familiarity with the information it contains. 6c2b3e

The primary function of COSTS is to show a consistent week-by-week progression of costs for each project by category. The file can also be used for study purposes, through the use of content-analyzer patterns, some of which are stored in the header statement (see Fig. II-12, which is the same as Fig. II-11 but with different VIEWSPECs). Any other patterns can be created as needed. 6c2b3f

This allows a user to extract special categories of information from the file very quickly. For example, a user may easily create a display showing all project costs for the eighth week of 1970, for each ARC project. It is also possible to output such a "filtered" display via a line printer, thus obtaining hard copy of a special-purpose extract from the total file. 6c2b3f1

The content analyzer is helpful when using the calculator on all the data for one week, project by project, to find total ARC charges by category. 6c2b3g

When only one week's data are displayed, one can add items down each column and insert the answer in the "ARC total" space. One can then clear the accumulator, and add down the next column. This is done very rapidly through bug selection of input numbers and keyset entry of commands -- ADD, ADD, ADD, ADD, INSERT, CLEAR, ADD, ADD, ADD, ADD, INSERT, CLEAR, and so forth. 6c2b3g1

Figures II-13 and II-14 are before/after photos of this process. 6c2b3g2

The COSTS file is now operationally useful to us, and we expect it to be useful for future experimentation with automatic processing techniques. 6c2b3h

b. Estimates 6c2c

Proposals 6c2c1

Another use of the system is in creating proposal cost estimates. We first estimate the amount of effort required for the proposed work. To estimate the cost of this effort, we make reference to various on-line files. The estimating process typically proceeds along the following lines. 6c2c1a

Personnel Costs 6c2c1b

The estimator loads a special file, maintained by himself, which is a directory to all of his other files and perhaps to a few files belonging to other people. Figures II-15 and II-16 are two displays of a user's file directory. In Fig. II-15, only first-level statements are shown; these are used for establishing categories. In Fig. II-16, another level is shown, containing the actual directory listings in each category. 6c2c1b1

This "file directory" contains links to each of the files that it lists. In the present case the files probably would be cost histories, personnel listings, previous special studies of costs, and other administrative information. 6c2c1b1a

He loads a previous cost estimate, makes a working copy of it, changes the heading to reflect the name of the new proposal estimate, and eliminates the amounts from the old estimate. 6c2c1b2

This produces a blank cost estimate format. If any items from the old estimate are inappropriate, they are easily deleted; new items are easily added as separate statements. When the format is ready, it is output as a new file. 6c2c1b2a

He can then load a file that lists names of people in the group and some projection of expected additions. Figures II-17, II-18, and II-19 show portions of such a file. 6c2c1b3

Using this personnel-listing file, he obtains information about labor categories.

A branch containing content-analyzer patterns is kept in the file. These can be easily reached by jumping to a link which causes all the patterns to be displayed (Fig. II-20). 6c2c1b3a

Each pattern will select some particular category of statements from the file. For example, the estimator will need to know which people have the status of Senior Professional. 6c2c1b3a1

He selects the appropriate pattern with the command EXECUTE CONTENT ANALYZER, and then jumps on a link which turns on the content analyzer, starting the search at the beginning of the branch containing personnel listings and restricting the search to that branch. 6c2c1b3a1a

This produces a display showing only the listing of senior professionals in the group. This set of statements can then be transferred to the new proposal cost estimate file. 6c2c1b3a1b

Other patterns can be used to extract sets of statements according to other criteria -- for example, all the hardware or software people in the group (Figs. II-21 and II-22). 6c2c1b3a1c

Thus the estimator can select, by labor category, representative people who may be involved with the proposal; as he selects them, he can transfer their names and the information that goes with them to the file where he is building up his estimate. 6c2c1b4

At present we do not keep individual salary information on line, although we could do this if we added some security measures. Calculations for the average salary category, based on the specific people contemplated, are made off-line at present. 6c2c1b4a

These average salary amounts are inserted into the on-line cost estimate. The calculator is used to multiply numbers of man-months times average salaries per month to determine total salary costs per labor category and overall direct labor totals. All of this is achieved within the actual file that will become the finished estimate. 6c2c1b4b

The payroll burden and overhead rates are checked for currency and inserted into the estimate, using the calculator to apply them to the direct labor. At this point the labor portion of the estimate is completed. 6c2c1b5

Non-Labor Costs 6c2c1c

A typical estimate will involve some travel costs, some consultant costs, and some report costs. Data supporting the cost of consultants may be checked by reviewing current consultants' costs by project and by consultant. These are kept in a separate file and reached through a link for review. The data may be copied into the estimate if some of the information is of use. 6c2c1c1

Report production costs are estimated using current Institute schedules, which are based primarily on the number of pages expected in the end product. These computations can be made using the calculator, and the existing cost factors from the last proposal, checked for current applicability. 6c2c1c2

In addition, there may be plans to add equipment in the proposal. In this case, the estimator will use an equipment study written in another file by the people involved in hardware design. 6c2c1c3

The equipment costs contained in the special study are summarized in total and reached by a link. The special study can be viewed and updated as appropriate and can be copied to go with the proposal as an appendix or used later for back up. 6c2c1c3a

In this fashion, various information is gathered from various files and transferred into the developing cost estimate. Figures II-23, II-24, and II-25 show various portions of a completed on-line cost estimate as actually used for a recent ARC proposal. 6c2c1c4

Working Forecasts 6c2c2

Operational Use of Estimates 6c2c2a

As the project progresses, proposals and estimates can also be used as guides for management of the project. It is useful to forecast the expected project costs on either a four-week period or monthly basis. 6c2c2a1

This can be done by creating a new file using the type of format that the COSTS file uses. We insert total figures from the cost estimate, using the calculator to determine average rates and specific estimated amounts, and insert answers into the file as it builds. This month-by-month estimate can be reached through a link from working cost files, from the original estimate, or any other file where the question of monthly estimated project costs may arise. 6c2c2a2

c. Purchase-Order Processing 6c2d

In making an estimate of costs for new equipment being constructed at ARC, reference to previous cost information is very useful. We have constructed a purchase-order/requisition processing file which contains a separate statement for each item purchased for the past two years at ARC. Figure II-26 shows a portion of this file. 6c2d1

Each statement contains the following information about each purchase: 6c2d2

(1) Total price 6c2d2a

This is entered as the statement name. 6c2d2a1

At present this is not used as an NLS name, but as a way of eliminating information from the screen at will, keeping a consistent location in columnar form for such totals. 6c2d2a2

(2) Description of item 6c2d2b

(3) Vendor 6c2d2c

(4) Number of units purchased and price per unit 6c2d2d

(5) Purchase Requisition number 6c2d2e

(6) Date requisition sent 6c2d2f

(7) Purchase Order number when order is placed 6c2d2g

(8) Date order is placed 6c2d2h

(9) Project or account charged 6c2d2i

(10) Date order is received 6c2d2j

(11) When the order is completed, it is marked with the special code *comp*. This can be detected by a content-analyzer pattern. 6c2d2k

All outstanding orders are contained at a second level under a single branch (see Fig. II-27); therefore the distinction between outstanding and completed orders is easy to see just by reference to level. To reduce clerical error, we consider an order completed when the *comp* pattern is inserted and the statement is moved to its alphabetical position on the top level. 6c2d3

This file can be searched using the content analyzer in some interesting ways. We can ask for all items purchased from a particular vendor on any particular project and see only those. If we wonder about the unit price of a thermal wire stripper, model 2W-1, we can quickly get that information. If we wonder what we purchased on PR A08927, that comes simply by executing a content analyzer pattern specifying the number. We can see all outstanding orders charged to a particular project quickly. Figure II-28 shows a content-analyzer pattern that has been temporarily written into the file, for finding any entries pertaining to orders for relays under Project 7101. Figure II-29 shows a view generated by using this pattern. 6c2d4

This file is useful, then, from a project-administration standpoint, from the standpoint of following a purchase requisition from the order stage through completion, and also for providing backup information for cost estimates. 6c2d4a

This file can also be used as a tickler file by inserting a pattern in the "outstanding requisitions" branch which shows the date we feel we should follow up on the order. Each day one can ask for all those items that have the current date as a follow-up date. 6c2d4b

This file is kept up-to-date by the secretary of the hardware group, who is most involved with requisitioning. She does this updating entirely with TODAS. 6c2d5

d. Summary on the Systematic Use of Project Cost Files 6c2e

One by one each of these files might be interesting. As a combination, quickly available to many users, their utility seems remarkable. 6c2e1

A cost study, as discussed above, can rely on all previous project costs as recorded in the system and can draw on those files for inputs. One can draw on the personnel roster file by labor category, work interest or as extended into a skills inventory. 6c2e1a

We can browse through the purchase-order file, reflecting the current or previous costs per item. We can link to activity-planning files to see which people are involved with various ongoing tasks and to see on what tasks we are contemplating certain equipment purchases. We can link to proposal cost estimates for month-by-month cost projections. 6c2e1b

These files can be accessed in any order, from any direction, at any time, with only a few keystrokes by the user. They are also accessible remotely through the use of TODAS, thereby giving mobility to the user with less load on the system. 6c2e2

Our main objective in making cost studies is to arrive at solid sets of projections or other answers as quickly and effectively as possible. Direct on-line access to input information is extremely helpful. 6c2e3

3. Activity Planning and Status 6c3

a. Introduction 6c3a

Section II-B-2 describes the experimental establishment of a TODAS Development Activity and discusses its method of operation. One facet of TODAS work is the extensive experimental use of on-line files as aids in conducting meetings and formulating plans. This section gives some details on the construction and use of these files. 6c3a1

b. Planning and Status Files for TODAS Development Activity 6c3b

File UPLAN 6c3b1

The planning file for the TODAS Development activity contains a branch with comments on how to use the file, a branch for content-analyzer patterns, and a branch containing actual task plans. 6c3b1a

The task-planning branch has, as substatements, task categories which include documentation plans, teaching plans, design plans, META plans, and inactive task plans. The levels under these categories contain separate task plans, such as "TODAS REFERENCE GUIDE DEVELOPMENT," "USER EXPERIMENTS RELATED TO TODAS," and "TEXT MANIPULATION SYSTEMS BIBLIOGRAPHY." 6c3b1a1

Each task branch contains comments by the task leader on the following: 6c3b1a1a

(1) Description of the task, with links to other working files used in its development 6c3b1a1a1

(2) Comments on the relationship of the task to other ARC tasks 6c3b1a1a2

(3) Estimates of people involved (with levels of effort and timing) 6c3b1a1a3

(4) Status comments 6c3b1a1a4

UPLAN is linked to from another file called UMEET (described below), which is used for on-line note-taking during meetings of the TODAS group. Portions of UPLAN can be temporarily copied into UMEET for use during meetings. 6c3b1b

UPLAN contains a blank task format in a separate branch. Whenever a new task is added, this branch is copied into the appropriate planning area (such as documentation plans). Then the name of the task is inserted as a heading along with the initials of the task leader. 6c3b1c

Certain items in this file are useful in content-analysis searches. The most useful are the initials of people involved in tasks, the milestones, the estimates, and the status. To make content-analysis searches more consistent, asterisks are placed before such items. 6c3b1d

With an appropriate pattern, one can then ask a question such as "What is the involvement of a particular person in this activity?" task by task. All branches with estimates containing the specified initials and an asterisk will then be shown. The same branches show expected levels of effort. 6c3b1d1

Since this is the only information displayed on the screen, it is relatively easy to see potential conflicts in the allocation of a person's time between tasks for this activity or to make a hard copy of this displayed information on the line printer. 6c3b1d2

The content analyzer can also return statements commenting on the status of tasks, so that a quick survey of all such comments can be made. This is particularly useful for coordination of several tasks and for preparing for meetings of the group. 6c3b1e

When many people try to update the same file, serious problems are created. This is a well-known situation (discussed further in Appendix B). If two people are both working on the file, one person's work may be lost when someone else who has been using the file writes his copy back out on the disc. Therefore we tried to introduce a convention where people place a signal of some sort in the file when it is in use. 6c3b1e1

This procedure was not well used, probably because people were generally in too much of a hurry. Therefore, some work was lost. We found that it was easier, with the present file-handling limitations, to have research assistants do the updating on the file, gathering information from various people as needed. 6c3b1e2

Part of the description for a task involves the specification of significant milestones, if possible. The task leader has to have some idea of important milestones during the progress of the work and must develop some feeling for whether these milestones are occurring within the resources expected to be allocated to the task. 6c3b1f

We tried an on-line task-planning chart, showing 10-week periods where milestones could be marked for each task. Milestones were indicated by showing an NLS name for each milestone statement (see Fig. II-30). Therefore, viewing this task-planning chart on a display, we could "JUMP TO NAME", selecting one of the milestone points on the chart, and a description of the milestone and its relationship to the task would then be displayed. A "JUMP TO RETURN" brought back the planning chart. 6c3b1f1

This shows some promise of being useful in the future, but some refinements in display techniques and milestone selection are necessary before it can become operational. 6c3b1f1a

Another use of the content analyzer is to search for entries made "since or before" a certain date, or for entries made by certain people. This makes it easy to see who has been updating the file recently, and what they have done to it. 6c3b1f2

This is of less importance for a person who is updating his own file, for he probably remembers the kinds of things he has changed. When many people work on the same file, it is helpful to know who has been changing it and in what areas they have been working. 6c3b1f2a

File UMEET 6c3b2

We created a separate file called UMEET for plans and notes from the TODAS activity meetings. 6c3b2a

This file is similar to the UPLAN file in format. On-line note-taking by a research assistant, as practiced in the user system and software groups, has proven quite useful for recording important parts of discussions during meetings. The on-line note taker has not been a distracting influence in meetings; in fact, she has contributed at times. She is available for finding information in the file and for recording special ideas in other files upon request during the meetings. 6c3b2a1

Meetings are conducted with hard-copy agenda distributed before each meeting. The on-line notetaker has an on-line version of the same agenda in front of her. As the discussion proceeds, she makes her notes right in the on-line agenda. 6c3b2a2

Items left for discussion in following meetings, or as special questions to be resolved before the next meeting, can be marked by the note-taker and retrieved from the file for later study. 6c3b2a2a

When the meeting is completed, the notes are condensed to a meaningful summary, distributed to the participants, and displayed on a bulletin board. In other words, the agenda for a particular meeting is developed, during the meeting, into minutes of the meeting. A copy of the unaltered agenda is also kept. 6c3b2a3

Successive meeting agenda and minutes are kept in one file (see Fig. II-31). This permits us to search for discussions of various topics and to receive answers in chronological order.

6c3b2a4

B. Organization Studies 6d

Our organizational studies have centered on two topics. The first of these is the study of the "On-Line Community" -- our own ARC group seen as a unique example of a small, close community of workers who make intensive use of on-line computer aids in their daily work. 6d1

The second area of concentration has been the implementation of two experiments on organization structure and planning methods in such a community. 6d2

1. On-Line Community 6d3

Our study of the On-Line Community is described here in terms of the total working environment of the group and the structuring of staff roles within the group. 6d3a

a. Environment 6d3b

We consider the total working environment, for purposes of this study, to consist of the physical environment and the "user environment." The latter is a general term intended to indicate the existence, availability, and performance of the numerous on-line aids used by the group. 6d3b1

Physical Environment 6d3b2

We have changed the basic work room or laboratory configuration from isolated one-man offices and a remote shop and computer/work room to one-man offices opening directly onto an open, courtyard-like work area. We still use a remote shop and computer room due to building layout restrictions. The consoles were moved out of the offices into this central working area. We have put in separate lighting circuits so we can turn off lights in different parts of the room, reducing reflections on the displays. Within the work area, the consoles can easily be regrouped to permit users to work cooperatively. 6d3b2a

One effect of this was to change the personal interaction pattern dramatically, simply by increasing the amount of interaction. 6d3b2a1

A second effect was to permit much more effective utilization of the display facility; the facility is much more "available" than it otherwise would have been. 6d3b2a2

Within the general work area, the consoles (which are of several different designs offering different advantages) are set up in varying configurations, with differing arrangements for lighting, seating, proximity to other consoles, etc. In general, the individual configurations can be quickly and flexibly altered as various needs arise. As a result, an individual who is about to start a working session at a console has a considerable choice of immediate conditions. Figure II-32 shows four views of consoles in the work area, in actual use for various modes of work. 6d3b2a3

A further modification to the physical environment was the addition of light movable partitions, for visual privacy. These are low enough so that a person, when sitting, does not see other people working but can, by standing or moving his chair two or three feet, contact 4 or 5 other people working at consoles. Most people apparently prefer to partition off only the front of their work stations. Partitions are rarely moved into positions completely surrounding the work stations. When seclusion is wanted, people tend to work in the Herman Miller experimental office, which is isolated from the general work area by high partitions. 6d3b2b

The Herman Miller office has also become the place where the system is demonstrated to visitors. Visitors have the feeling that they are inside the working environment, and no one else is bothered by the visitors' presence. 6d3b2b1

We have adopted the practice of holding some types of meetings in the Herman Miller area around one or two displays, with a research assistant taking on-line notes. 6d3b2c

We have found that display viewing is difficult, and multiple-participant access to the system ineffective, with meetings of more than three or four people. 6d3b2c1

On the basis of our experiences with such meetings, we are now redesigning the conference facility (see Sec. II-C-2-d). 6d3b2c2

We have found that it is highly desirable to make use of the system both night and day. Night access to our work area is inconvenienced to some extent by the existing security measures, particularly when we wish to work with non-SRI personnel, such as consultants. A much more open and accessible working environment would be greatly preferred. 6d3b2d

We see great practical utility in having a maximally flexible physical environment. Each time we have increased the flexibility of the environment, work interaction has increased without any damaging increase in social interaction. 6d3b2d1

User Environment 6d3b3

During these two years we have provided a useful, though still evolving, on-line text editing and file manipulation system, NLS. This system provides new tools for personal and group use. Appendix A describes NLS in considerable detail from a user's point of view. Appendix D is a technical description of NLS. 6d3b3a

We have also developed the Typewriter-Oriented Documentation-Aid System, TODAS (see Appendix A). This provides some of the same features as NLS but can be used remotely by people not physically in the facility. TODAS will produce considerably less load on the timesharing system than NLS. We have experimented with remote use of TODAS using portable typewriter terminals with acoustic couplers. The resulting mobility, with direct access to all of our files, shows interesting possibilities for team collaboration, together or physically remote. 6d3b3b

With the introduction of TODAS, we have provided more opportunity for people to interact with the ARC files from their offices, although some of the processes are slower. There has not yet been widespread use of TODAS, but this will change with improvement in service capacity of the system and addition of new features to TODAS. Availability of several 30-character/second typewriter terminals will also greatly increase the value of TODAS. 6d3b3b1

b. Staff Functions and Activities Within ARC 6d3c

Activities we have identified as basic include the following: 6d3c1

(1) Hardware 6d3c1a

(2) Software 6d3c1b

(3) Management System Research 6d3c1c

(4) User System Research 6d3c1d

(5) ARPA Network Participation 6d3c1e

(6) Operational Management of ARC. 6d3c1f

Staff functions for each activity involve the specification, design, implementation, documentation, evaluation, and maintenance process as new system features are added. 6d3c1g

As we hire hardware and software people, research assistants, and secretaries, our policy has been that a person's capabilities must go beyond any narrow specialization. A highly skilled systems programmer must have additional background before he can be used effectively in this group. 6d3c2

We need people who are capable of both long- and short- range planning, participating in goal and subgoal setting, and contributing to the the design, implementation, and other processes. 6d3c3

For most ARC work it is important that people be primarily oriented toward designing and building tasks and less toward contemplative and reflective ones. However, since our work mixes both research and development modes we must be capable of acting in either capacity at different stages in the implementation of any given task. It is also a requirement that people have the ability to focus on different levels of the endeavor, alternating modes frequently as the needs arise. 6d3c4

2. Experiments on Internal Activity Structure 6d4

We conducted two experiments on the use of augmented methods for planning work. These experiments were conducted with a newly established group, the TODAS development group, and with a well-established, fairly tight-knit group, the software group.

6d4a

a. TODAS Development Activity Planning 6d4b

A part of ARC user system research involves the specification, design, implementation, teaching, use, and evaluation of new features being added to TODAS as related to anticipated ARC and ARPA Network needs. 6d4b1

The TODAS planning experiment was initiated along these lines: 6d4b2

We first developed a strategy for use as the group formed and for encouraging it to make further plans directed toward ARC and TODAS-related goals. The steps considered necessary for the group were: 6d4b2a

(1) Identify both internally and externally generated goals 6d4b2a1

(2) Agree on structure and mode of operation of the TODAS group, with the following features: 6d4b2a2

(a) A group representive reporting to the ARC Manager and to external activities 6d4b2a2a

(b) A team approach to tasks and planning, with one leader for each task 6d4b2a2b

(c) Investigation of decision techniques. 6d4b2a2c

(3) Plan tasks for the group and for the indiviuals in the group (including tasks already in progress, where applicable). We were to do this according to the following outline: 6d4b2a3

(a) Build an easily visible collection of task alternatives, to be modified as appropriate after analysis and review. 6d4b2a3a

(b) Identify and use the skills in the group, securing other needed skills if not available in the group. 6d4b2a3b

(c) Estimate participants' level of effort and the timing involved, assessing the net effect of the combined plans. 6d4b2a3c

(4) Meet periodically to review progress, usually every two weeks. 6d4b2a4

Meetings were intended to be open to interested staff of ARC, with use of an agreed upon format. 6d4b2a4a

Special discussion meetings (and other forms of communication) for "help" when special problem situations arose were also anticipated. 6d4b2a4b

(5) Maintain a TODAS "information center" on-line and off-line. The basic files were the following: 6d4b2a5

(a) File FD: File Directory for TODAS-oriented links. This file also contains links to TODAS group participants' personal file directories and links to the following files: 6d4b2a5a

(b) File UMEET: Meeting plans and notes 6d4b2a5b

(c) File UPLAN: Task plans and status notes 6d4b2a5c

(6) Communicate status of TODAS work to the ARC Manager and the ARC staff. 6d4b2a6

Having determined this strategy, appropriate initial participants were contacted and the group was established. 6d4b2b

The group started having meetings and developed a meeting strategy that contained the following elements: 6d4b3

(1) A "facilitator," whose role includes the following: 6d4b3a

(a) Preparation of the meeting plan, with inputs from the rest of the group 6d4b3a1

(b) Guidance during the meeting to ensure that all important items are discussed 6d4b3a2

(c) Providing an orderly way for new or unexpected items to be discussed as appropriate, or deferred. 6d4b3a3

This role was rotated among the membership of the group from meeting to meeting, depending on the expected agenda subjects. 6d4b3a4

(2) A "process watcher," whose role involves attention to processes in operation during the meeting. This includes verbal and nonverbal interactions between people, decision processes, etc. 6d4b3b

This was done to give the participants added insight about less obvious features of the meeting. 6d4b3b1

This role was rotated among the membership of the group from meeting to meeting, depending on the expected agenda subjects. 6d4b3b2

(3) An on-line note taker, whose role includes the following: 6d4b3c

(a) Distribution of the meeting plan and preparation of the meeting notes outline before the meeting 6d4b3c1

(b) Careful recording of important discussions and points made during the meeting 6d4b3c2

(c) Retrieval of needed information from on-line files during the meeting 6d4b3c3

(d) Summarizing the meeting notes and distributing them after the meeting 6d4b3c4

The role of the on-line note-taker was filled by two research assistants on an alternating basis. This provided flexibility and ensured that an experienced note-taker was available for each meeting. Information gained at these meeting was valuable to the note-takers in their other day-to-day work. 6d4b3c5

(4) Regular participants 6d4b3d

(5) Invited specialists 6d4b3e

(6) A meeting plan and agenda 6d4b3f

(7) Relevant documents produced on-line by any member 6d4b3g

Distribution of documents was arranged before each meeting. Documents included descriptions of design changes in TODAS, drafts of teaching documents, etc. 6d4b3g1

(8) Tentative plan for the following meeting 6d4b3h

(9) An evaluation of the utility of the meeting.

6d4b3i

Notes from meetings were kept on an evolutionary basis as separate branches in one file, UMEET, and also in hard copy for distribution to all members and to a bulletin board. 6d4b3j

Planning 6d4b4

We made an easily accessible listing of tasks in progress and under consideration, in a separate file called UPLAN (described above in Sec. II-A-3-b), which can be modified by individual task leaders or by research assistants. 6d4b4a

This file helped increase the extent to which meetings were used to evaluate and redesign tasks, instead of to report information that would not be changed by group interaction. 6d4b4a1

It facilitated the exchange of reportorial information outside the meetings, when individuals could give their full attention to the file. 6d4b4a1a

It was also available during meetings for reference or modification. 6d4b4a1b

Another use of the file was to communicate information to people not directly involved in the activity, i.e., the ARC Manager and others in ARC. 6d4b4a2

Most of the planning dealt with scheduling and patterns for necessary interaction between tasks and task leaders. 6d4b4b

The short-term goals appeared firm enough that we chose not to divert our resources to longer-term goals while this activity was starting. 6d4b4c

Interaction 6d4b5

Since this group included people who were involved with other ARC activities such as software, the Network Information Center, and Management Science Research (MSR), it explored some interaction between activities. 6d4b5a

It also provided an opportunity for the activity members to be involved in a smaller group than the ARC as a whole. This changed the group dynamics considerably. 6d4b5b

The process of identifying internally generated goals stimulated exploration of personal needs of the members of the group to increase solidarity, mutual liking, understanding, respect, and the desire to cooperate. 6d4b5c

Although social interaction initiated at early meetings was beneficial in developing a cohesive working group, progress evaluation at various times indicated that it could then be more effectively continued outside of group meetings to allow more focus on the primary group tasks related to TODAS. 6d4b5c1

b. Software Activity Planning 6d4c

The software activity is directed toward the design and implementation of new system software features. 6d4c1

Strategy 6d4c2

This was the second experiment, following the initial results of the TODAS experiment described above. In the two years of the contract, the software group has progressively become more integrated into the total ARC functioning and has doubled in size. One result is that more tasks that depend upon each other are being performed concurrently. The need for each member of the software group to be aware of the progress and design modifications of the tasks undertaken by every other member of the group has increased significantly as the size of the group has grown. 6d4c2a

Preplanning by the MSR and group management team included those features found to be most useful from the TODAS activity experiment. 6d4c2b

It recognized the existence of leadership responsibilities already in effect, and formalized them. 6d4c2b1

The same meeting format was used as for the TODAS group. We found immedately that there was more interest in task discussion and plan reformulation and less interest in social interaction and group process than in the TODAS group. As a result, changes made in the planning procedure simplified the documentation to include only essential elements needed for communication by the group members. We also went through the process of listing all current and planned tasks in one consistent format in a file called SOFTP. This resulted in a preliminary listing of 30 critical and separate tasks, with truly distributed task leadership. 6d4c2c

Leadership 6d4c3

Leadership was minimal at the group level, and sufficient because of high motivation to complete tasks on schedule. The strongest leadership was at the task level. 6d4c3a

This experiment is still in progress. Longer-range goal and task planning, with better integration with other ARC activity planning, are currently being developed. 6d4c3b

c. Summary Comments on Planning Experiments 6d4d

Active community teamwork, warm human relationships, and good work attitudes are necessary for our organization to function effectively. We must encourage and develop feelings of trust and common goal appreciation so that our people can work closely together over a long period of time, with so much of themselves open to view to others and with such interrelated and challenging tasks to be undertaken. We found that the TODAS group benefited from the initial energy spent on interpersonal relationships, although there was eventually more effort applied to these factors than we found useful for task accomplishment. A careful balance between application of social and work-oriented energy is a necessity. 6d4d1

Although the TODAS experiment was not successful in all respects, it was an experiment where the particular people involved stand a better chance of succeeding in a future experiment with a reoriented group. 6d4d2

Software meetings were judged by participants and outside observers as extremely efficient and effective in meeting predetermined goals. While little attention was paid to interpersonal variables, group morale was strengthened by the meeting procedure. Uncertainties in task definition and individual responsibilities were clarified. The feedback was reported to be useful rather than either flattering or critical. This, again, was a chance for the participants to be involved in a smaller group than ARC. This contributed to the higher morale. 6d4d3

We feel that the techniques developed for meeting and task planning and for on-line note-taking will be useful as they evolve in future activity planning. We need to learn more about realizing the potential of improved interpersonal relationships in ARC, while expending only a reasonable amount of effort in doing so. 6d4d4

3. Observations From Study of On-Line Community 6d5

a. Use of Public Files 6d5a

The use of public files containing the work of many individual people seems to be well accepted by the group. 6d5a1

Far more communication potential exists in this environment than has yet been realized, although some people have started in some interesting ways. 6d5a2

Our need for development of a Dialogue Support System is clear. 6d5a3

Work habits of the on-line community staff also need development so that they can use the power of existing features and information in the system. 6d5a4

Now is the time for further work on methodology and procedures for use of the system, with the continued parallel evolution of the system itself. 6d5a4a

b. System Dependence by the Group 6d5b

As we augment, we find that it seems less desirable to use conventional tools for many tasks. 6d5b1

This is a problem to be resolved for good use of resources and for the purpose of not overlooking appropriate conventional tools where they can still be very effective. 6d5b2

The various ways that information now gets into the system are: 6d5b3

(1) Direct: 6d5b3a

(a) On-line NLS or TODAS use by originator: 6d5b3a1

Entry of new material 6d5b3a1a

Duplication and/or modification of existing information 6d5b3a1b

(b) On-line NLS or TODAS note-taking at discussions

6d5b3a2

(2) Indirect: 6d5b3b

(a) Transcription sources: 6d5b3b1

Handwritten 6d5b3b1a

External documents 6d5b3b1b

Stenographic dictation 6d5b3b1c

Recordings 6d5b3b1d

Individual use of dictating equipment 6d5b3b1d1

Tape recordings of group meetings 6d5b3b1d2

(b) Transcription processes: 6d5b3b2

Direct NLS use 6d5b3b2a

Direct TODAS use 6d5b3b2b

Paper tape 6d5b3b2c

We are working toward a better assessment of which tools are most appropriate for the various tasks to be performed in ARC. 6d5b4

c. Miscellaneous Observations 6d5c

This is a work-oriented group. Most people work long hours, usually at an intense rate; little time is spent not actually working. 6d5c1

There are many more work opportunities for the group and for most individuals than there are resources -- in terms of both time and funds. 6d5c2

Group and personal work management involves many difficult choices of tasks to be performed, postponed, or dropped. 6d5c2a

The group frequently sets goals at higher levels than it is likely to attain. 6d5c3

This is partly because we want the new features that will make the system more powerful; we are users of our own results. 6d5c3a

Sometimes, also, we overassess the potential power of the system, forgetting that it still has limitations, particularly in the area of consistently good service levels. This problem is getting a great deal of attention, however. 6d5c3b

The interrelatedness of the on-line community tasks makes planning very difficult, but obviously more necessary. 6d5c4

C. Team Augmentation and Dialogue Support 6e

Our efforts in management research have been centered on the attempt to developing a more closely integrated, participatory way of organizing people, efforts, and resources toward specific goals than is provided by classical management theory. 6e1

Toward this goal, we are currently focusing our attention on the problem of improving the management of a working system-development team, using our own organization as the subject of experimentation. This involves two facets of augmentation -- namely, individual augmentation and team augmentation. 6e2

Individual augmentation is simply our continuing effort to provide ways of improving the working capability of individual members of a team. 6e2a

Team augmentation involves the development of improved means for coordinating the efforts of individuals and for integrating their individual contributions into coherent team action. 6e2b

1. Recent Efforts 6e3

A portion of our recent MSR effort has been invested in formulating a "team-augmentation" approach. The initial emphasis is strongly oriented toward the means for communicating and collaborating effectively on issues embedded within a complex and evolving problem domain. 6e3a

An important facet of this approach has been a preliminary study for a "Dialogue Support System" (DSS) -- a special system of coordinated features which could support the communication and integration of collaborative dialogue among team members. 6e3b

Appendix B is a more detailed discussion of this formulation, as extracted from the PhD thesis of David A. Evans (see Ref. 1).

6e3b1

2. Future Approaches to Team Augmentation 6e4

Experimentation with roles, record-keeping conventions, collaboration procedures, decision-making practices, documentation, etc. will be a rich domain for exploratory MSR work. 6e4a

The following discussion of fast editing and publication, "super-documents," and augmented conferencing gives a view of some features needed for team augmentation. 6e4b

a. Fast Editing and Publication 6e4c

Our already fast editing techniques will continue to evolve, and we plan to concentrate early upon automatic production, from our on-line files, of hard copy having a very flexible composition of text, diagrams, tables, equations, footnotes, and indices. 6e4c1

The design of hard-copy formatting conventions must be related directly to the way in which the associated file material can be studied and manipulated on-line. 6e4c1a

b. "Super-Documents" 6e4d

We have been doing research leading to the development and production of very large, very complex documents containing numerous sections whose details are highly interdependent. These documents will be subject to frequent updating. This will involve further work on techniques for creating and using special indices, footnotes, reader-supportive comments, cross-references, etc. 6e4d1

We currently have quite powerful techniques for aiding an individual or a small report-writing team to produce documents of the usual research-report size and complexity. Part of our approach to team augmentation will be the expansion of these techniques to allow for much greater scope and complexity in documents and much more fluid interaction among the team members who create them. 6e4d2

A team tackling a complex system-development project must provide itself with the highest possible visibility over its working environment -- i.e., over the following factors: 6e4d3

Planning: plans, contingency alternatives, resource commitments, status, criticisms 6e4d3a

Design: designs, design principles, constraints, estimates, analyses, supportive data, relevant needs and possibilities 6e4d3b

Operation: roles, task definitions, assignments, policies, operational procedures and conventions. 6e4d3c

We intend to develop and keep up to date a large, detailed, highly cross-referenced and well-indexed "super-document" that contains just such a description of our own project-team activity. Our techniques for facilitating its modification and republication will be under constant evolutionary pressure. 6e4d4

c. Collaborative Use of On-Line File Systems 6e4e

On-line access by collaborators to each other's files, as provided by a number of today's time-sharing systems, leaves much to be desired in supporting effective dialogue. 6e4e1

An effective dialogue-support system is essential to team augmentation. Hand in hand with the "super-document" facility described above must go some such ability as the following: 6e4e2

Any team member at a display console can study swiftly any portion of the super-document's structured files. Our current system is fairly good for this purpose, but not yet adequate for dialogue study. 6e4e2a

Whenever he wishes -- as though he were pencil-marking his private draft with marginal comments, underlines, encircled passages, arrows, etc. -- he can introduce "comments" that are freely sprinkled with explicit references to any specific item (e.g. any character, word, graphic entity, or expression) within anybody's prior entry. (Note: the term "comment" is used here and in the following discussion in a very broad sense -- a comment is any entry which in some way points to a previous entry.) 6e4e2b

This commenting capability must be managed by the computer so that it does not matter if other people are simultaneously scanning the same material or affixing comments to the same items. 6e4e2b1

When creating a comment entry, he needs flexible aids and methods for arranging interspersed or concurrent display of the referenced passages, for designating the explicit entities he wishes to reference, and for suspending operations temporarily while he checks related material. 6e4e2b2

Conversely, he needs a way of seeing any comments that reference a passage he is inspecting. 6e4e2c

Categories might be defined by authorship, date of creation, text content, or assigned membership in predefined categories. 6e4e2c1

He also needs a great deal of control over this, however; much of the time he will not want to see any comments, or only comments falling into certain categories. 6e4e2c1a

He also needs considerable control over the way the system displays the comments that he wants to see -- in specified portions of the screen, in full-text or condensed form, etc. 6e4e2c1b

He needs the ability to set up "annunciator calls" to various people, or sets of people, to request their special attention (at some level of priority) to a given comment. 6e4e2d

All of the interactive-dialogue entries immediately become part of the super-document, imposing a potentially very complex comment network ("network" because comments can refer to comments in indefinite extension). 6e4e2e

It will be hard to keep track of the relationships among these comments and the substantive records about which the dialogue is oriented. 6e4e2e1

Their relationships need never be ambiguous, but consider the problem of trying to study such a structure to determine where we now stand in our developments and discussion, especially when it is the record of a complex system-design process and the interactive dialogue among very active people. 6e4e2e1a

This is about the most difficult central challenge in effectively augmenting a team -- that of developing computer aids, working methods, etc. to allow a skilled person to be highly effective in digesting the content and implications of such a record, and to develop a substantive next-stage design or plan that integrates the dialogue contributions. 6e4e2e2

Essentially similar techniques are required to augment any individual's central intellectual capability for synthesizing the next stage of development in a plan or design. To the extent that we are successful with this, we should be able to offer strong guidance for capability augmentation over wide ranges of individual and team activities. 6e4e2e2a

d. Conference Augmentation 6e4f

There is great potential value in direct augmentation of conferences and meetings. When people are gathered together to consider a proposal or argument, or to collaborate actively on a problem, there are many possibilities for the development of techniques and facilities to make their work more effective. 6e4f1

There is a wide range of possible approaches to conference augmentation. 6e4f1a

At one extreme, each participant would be an experienced NLS user and would have his own console; sophisticated facilities would be provided for "linking" the consoles in various ways to augment communication. 6e4f1a1

At the other extreme, there would be only a single console with a special operator; special techniques for integrating the NLS facility, the operator, and the conference participants into a working system would be needed. 6e4f1a2

Between these two extremes, a variety of intermediate approaches is possible. 6e4f1a3

For any of these approaches, a central problem is the development of conference procedures and the organization of on-line information; both procedures and information structures must be developed in such a way as to gain the greatest possible advantage from the computer facility. 6e4f1b

This development of conference procedures and information structures should be done experimentally, under actual usage conditions. 6e4f1b1

We have already experimented with augmenting meetings by having one person operate NLS as an on-line note-taker, where all participants can see the display (see Sec. II-A-3-b). 6e4f1b2

On the basis of recent experience, we plan to provide better facilities for groups of people working together at consoles and for small meetings where consoles are not available for everyone (or where not all participants are NLS users). This will permit experimentation with intermediate approaches lying between the two extremes described above. 6e4f2

The facility will consist of a meeting room equipped with projection TV, several appropriately designed consoles, and furniture designed so that three or four people may work at the consoles with ten or so less active participants.

6e4f2a

III HARDWARE SYSTEM

7

File (english,rfhdw,) in KDF under Guest, password WKE 7a

IV SOFTWARE SYSTEM

8

File (english,rpsft,) in KDF under Guest, password WKE

8a

V FUTURE PLANS

9

A. General 9a

Future directions for work in the ARC will be influenced by forces originating both inside and outside the Center. 9a1

Forces generated by our cumulative experience in the development of augmentation systems within the Center indicate some new directions for our own bootstrapped research effort. 9a1a

External forces are generated by our participation in the ARPA Network experiment and by an increased awareness for the need to communicate with the "outside world" -- people outside the Center who are engaged in related work. 9a1b

The internal forces and those generated by our Network participation combine to produce a shift in our internal research emphasis towards two specific activities: (1) team augmentation and (2) the development of a system design discipline. These are discussed below under "Shifts in Emphasis." 9a2

Increased awareness of the need to communicate and interact with the outside world will lead toward the development of a new area of specific concern, discussed below under "Transfer of Results." 9a3

The goals associated with research in team augmentation, with the development of a system design discipline, and with the transfer of results are related to one another within the ARC goal structure as described below in the section entitled "Short-Term and Long-Term Goals." 9a4

In the section "Selected Plans Under Other Sponsorship," we discuss the System Developer Interface Activity (SYDIA), for which we are seeking additional sponsorship. It is intended that this activity will be the primary effort in the area of the transfer of results. 9a5

B. Shifts in Emphasis 9b

Our plans reflect a maturing shift in emphasis in our research work. We plan to shift our emphasis toward two basic activities: (1) team augmentation and (2) the development of a system design discipline.

9b1

1. Team Augmentation 9b2

Whereas in the past we have given most of our attention to augmenting the individual worker, we are now focussing on the augmentation of a team of collaborating workers, each of whom is individually augmented. 9b2a

The high mobility and manipulative capability of a skilled "augmented individual" has a unique potential which can be realized when a number of augmented individuals join into a collaborative team. Not only can each individual move very rapidly through the joint working files to study them, enter new information, and update old material, but this power can be amplified by special computer aids, conventions, and skills that directly facilitate the processes of intercommunication and coordination. 9b2b

The contemplated efforts in "team augmentation" involve several facets: 9b2b1

(1) The development of conventions and procedures for organizing the working records of our plans, designs, objectives, design principles, schedules, etc., so as to give effective mutual "task orientation" to the members of a team by ensuring optimal accessibility of all information related to the team's objective. 9b2b1a

(2) The special development of a "Dialogue Support System" to facilitate the rapid evolution of these working records via dialogue among members of the design team. 9b2b1b

(3) The development of techniques to facilitate simultaneous remote collaboration among people at physically remote on-line terminals (of any sort), by giving them direct communication with one another, independent of their current individual work interactions with the computer. This includes provision, where feasible, for the following: 9b2b1c

(a) Video and/or voice intercommunication 9b2b1c1

(b) Easy and flexible control of means for duplicating, at any terminal, all or part of the type-out or display from another terminal 9b2b1c2

(c) Ready transfer of control of one terminal's computer interaction to another terminal's input devices. 9b2b1c3

These techniques will evolve within ARC under conditions of application to our own coordinated system-development work, and will be applied over a wide range of collaborative actions, from simple question-answering facilities to complex design work involving intense mutual participation by the team members. 9b2b2

As applicable techniques become effective within ARC, we will explore their use and value for the following: 9b2b3

(1) Support of Network Information Center (NIC) services such as teaching, question-answering, and some types of query servicing 9b2b3a

(2) Working collaboration between ARC staff and personnel at other Network sites 9b2b3b

(3) Working collaboration between people at remote Network sites, independent of ARC staff. 9b2b3c

2. Development of User- and Service-System Design Discipline 9b3

The functional features of the "user system" -- the large collection of computer aids available to an ARC worker -- have evolved with some ingenuity, a greal deal of cut-and-try experimentation under actual-usage conditions, and a certain special orientation offered by our overall research framework. However, up to now there has been a significant lack of objective, methodical engineering design for the overall user system. 9b3a

A user-system design discipline is definitely needed, and we intend to devote an increasing amount of effort toward developing such a discipline. 9b3a1

Like the user system, the "service system" -- the hardware and software underlying the features for augmenting users -- has evolved in an ad hoc fashion. 9b3b

Here there is also a significant need for a system-design discipline. 9b3b1

A system-design discipline would have a communicable, teachable, generally applicable framework supporting a coordinated set of concepts, terminologies, principles, methods, and special tools. 9b3c

C. Transfer of Results 9c

Behind these basic aspects of our work in the ARC (team augmentation and design disciplines) lies an essential feature of our long-term strategy, namely, the goal of producing results that will be of direct value to other groups of system developers -- in particular, to those who will be developing augmentation systems. 9c1

This is in contrast to being of direct value to customers who will want systems for their own direct use (e.g., to augment a manager, a designer, an editor, or a researcher). 9c1a

Display terminals, communication channels, and computer service are destined to become both cheap and plentiful, and it is certain that a very large number of organizations will want to use them. They must rely upon system developers who will need to be capable of the following: 9c2

(1) Analysis of system-usage environments 9c2a

(2) Design and implementation of a smooth, powerful, and coordinated system of user aids, conventions, methods, etc. 9c2b

(3) Training and "education" of new users, many of whom will be completely unfamiliar with the potential of this new technology 9c2c

(4) Subsequent monitoring of user performance so as to implement the changes necessary to track the evolution of users' attitudes, concepts, skills, usage habits, and wants. 9c2d

Although it is important to stimulate the eventual customers for augmentation systems, and to make them aware of the potential for these systems in their work, we feel that our results should be directed primarily toward helping system developers. Over the longer term, we plan to do this by pursuing the following goals: 9c3

Item 1: Making visible an advanced, integrated system, operating in a heavy-usage environment, that can orient system developers to the available cost-value tradeoffs 9c3a

Item 2: Developing an effective system-design discipline to aid in developing augmentation systems, whether or not these systems resemble ours 9c3b

Item 3: Maintaining thorough, highly current, comprehensive documentation, designed for quick location of relevant material 9c3c

Item 4: Establishing broad-band communication channels over which a dynamic interchange of information can take place, so that a maximum proportion of our knowledge can be quickly available in useful form 9c3d

Item 5: Offering, as a model, a complete prototype design of an augmentation system especially designed for augmenting system development. 9c3e

This system would be compatible with the system-design disciplines described above, and would include techniques for planning, analyzing, designing, programming, debugging, documenting, and teaching. 9c3e1

D. Short-Term and Long-Term Goals 9d

Our approach to the planned work will be as follows: 9d1

(1) Achieve the short-term goals implicit in the team augmentation activity, in the development of a system design discipline, and in the tasks itemized under Transfer of Results (Section V-C above) 9d1a

(2) Contribute to the long-term goal of directing our results for maximum benefit to future developers of augmentation systems. 9d1b

There is considerable overlap between short-term and long-term goals. 9d2

For instance, in the case of the transfer of results, the basic bootstrapping development of techniques within the ARC seems to guarantee a very good basic buildup toward Items 1, 2, 3, and 5 of Section V-C; our participation in the Network experiment contributes directly to Item 4; and the development of the NIC service will contribute toward Items 1 and 4. 9d2a

E. Selected Plans Under Other Sponsorship 9e

To pursue directly the itemized long-range goals of Section V-C, we currently have other plans under consideration, coordinated with those outlined in this proposal. These plans would be carried out under other sponsorship: 9e1

We are formulating plans for what we tentatively call the System Developer Interface Activity (SYDIA). We expect to be approaching representative candidates during 1970 with proposals for multiple sponsorship. The initial purpose of the SYDIA will be to develop the following: 9e1a

(1) A facility for an effective interchange of information, skills, orientation, etc. between ARC and the existing and potential community of augmentation-system developers 9e1a1

(2) The ability to assist other groups to transfer our system, or parts of it, directly into another hardware environment. 9e1a2

Later, with specific individual funding arrangements, we would expect to begin developing close interchange relationships with various system-development groups; hopefully, some groups would then adopt our augmented techniques for system-development work.

9e1b

GLOSSARY

10

ARC: Acronym for the Augmentation Research Center at Stanford Research Institute. 10a

ARPA: Acronym for the Advanced Research Projects Agency. 10b

Augmentation: Used in this report to indicate the extension of human intellectual and organizational capabilities by means of close interaction with computer aids and by use of special procedural and organizational techniques designed to support and exploit this interaction. 10c

Center: Another term used for the ARC. 10d

Console: As used here, this means specifically a user's control console for the ARC's On-Line System (NLS). The consoles presently in use consist of a display screen, a keyboard, a "mouse", and a "keyset." 10e

File: As used here, this refers to a unified collection of information held in computer storage for use with the On-Line System (NLS) or with TODAS. A file may contain text (natural language or program code), numerical information, graphics, or any combination of these. Conceptually, a file corresponds roughly to a hard-copy document. 10f

GENIE: Project GENIE, at the University of California at Berkeley, developed (under ARPA sponsorship) the timesharing software for the XDS940 computer used by the ARC. 10g

GODOS: Acronym for Graphics-Oriented Document Output System, a means for converting NLS/TODAS files to microfilm. GODOS is capable of handling the line drawings produced with the NLS graphics capability. 10h

IMP: Acronym for Interface Message Processor, a component used in the ARPA Network. 10i

Keyset: A device consisting of five keys to be struck with the left hand in operating the On-Line System (NLS). 10j

MOL: See MOL940. 10k

MOL940: A machine-oriented language for the XDS940 computer.

MOL940 (or simply MOL) was developed at ARC. 10l

Mouse: A device operated by the right hand in using the On-Line System (NLS). The mouse rolls freely on any flat surface, causing a cursor spot on the display screen to move correspondingly. 10m

NASA: National Aeronautics and Space Administration. 10n

Network: The planned Advanced Research Projects Agency network of research computer installations. 10o

NIC: The Network Information Center, to be incorporated in the ARPA network. The NIC will operate as a computer-assisted library service for information pertaining to the network, to be used by network members, and will be operated by ARC. 10p

NLS: See On-Line System. 10q

On-Line System (NLS): This is the ARC's principal and central development in the area of computer aids to the human intellect. As presently constituted, it is a display-oriented, timeshared, multiconsole system for the composition, study, and modification of files (see definition of "file"). A counterpart system, TODAS, operates from hard-copy terminals such as Teletypes and offers many of the same capabilities as NLS. 10r

PASS4: An output-processing program used to convert NLS/TODAS files to hard-copy format for output via one of a number of different devices. 10s

RADC: Acronym for Rome Air Development Center. 10t

SPL: Acronym for Special-Purpose Language. Specifically, this term is used for the SPL's developed at ARC for use in programming NLS. 10u

SRI: Acronym for Stanford Research Institute 10v

Statement: The basic structural unit of an NLS/TODAS file. A statement consists of an arbitrary string of text, plus graphic information. A file consists of a number of statements in an explicit hierarchical structure. 10w

TODAS: Acronym for the Typewriter-Oriented Documentation-Aid System. TODAS is a counterpart of NLS designed to operate from hard-copy terminals such as Teletypes. 10x

Tree Meta: A compiler-compiler system developed at ARC. 10y

TSS: Acronym for Time-Sharing System. Specifically, the system developed by Project GENIE for the XDS940 computer. 10z

XDS940: The computer facility used by ARC is based upon a Xerox Data Systems (formerly Scientific Data Systems or SDS) model 940 timsharing computer. 10a@

940: See XDS940.

10aa

REFERENCES

11

The following is a list of references specifically cited in the report. 11a

1. D. A. Evans, "Man/Computer Augmentation Systems for Qualitative Planning," Ph.D. Thesis, Department of Civil Engineering, Stanford University, Stanford, California (December 1969). 11b

2. "Specifications for the Interconnection of a Host and an IMP," Report No. 1822, Contract No. DAHC15-69-C-0179, ARPA Order No. 1260, Bolt Beranek and Newman Inc., Cambridge, Massachusetts (May 1969). 11c

3. D. C. Engelbart, W. K. English, and J. F. Rulifson, "Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 11d

4. D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer Augmented Management Techniques," Interim Technical Report RADC-TR-69-98, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (March 1969), AD 855 579. 11e

5. D. C. Engelbart and B. Huddart, "Research on Computer-Augmented Information Management," Technical Report ESD-TDR-65-168, Contract AF 19(628)-4088, Stanford Research Institute, Menlo Park, California (March 1965), AD 622 520. 11f

6. W. K. English, D. C. Engelbart, and B. Huddart, "Computer-Aided Display Control," Final Report, Contract NAS1-3988, SRI Project 5061, Stanford Research Institute, Menlo Park, California (July 1965), CFSTI Order No. N66-30204. 11g

7. D. C. Engelbart, W. K. English, and J. F. Rulifson, "Study For The Development of Human Intellect Augmentation Techniques," Interim Progress Report, Contract NAS1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March 1967). 11h

8. D. C. Engelbart, W. K. English, and J. F. Rulifson,

"Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 11i

9. D. C. Engelbart, "Human Intellect Augmentation Techniques," Final Report, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (July 1968), CFSTI Order No. N69-16140.

11j

10. W. W. Lichtenberger, "ARPAS: Reference Manual for Time Sharing Assembler for SDS 930," Document No. R-26, Office of Secretary of Defense, Advanced Research Projects Agency, Washington 25, D. C. (Revised 24 February 1967). 11k

11. R. House, D. Angluin, and L. P. Baker, "Reference Manual for NARP, an Assembler for the SDS 940," Document No. R-32, Office of Secretary of Defense, Advanced Research Projects Agency, Washington 25, D. C. (Revised 21 November 1968). 11l

12. R. E. Hay and J. F. Rulifson, "MOL940: A Machine-Oriented ALGOL-Like Language for the SDS 940," Technical Report 2, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (April 1968). 11m

13. R. W. Watson, "Introduction to Time-Sharing Concepts," Technical Progress Report No. 249-68, Project No. 78140, Shell Development Co., Emeryville, California (January 1969).

11n

BIBLIOGRAPHY

12

The following is a chronological list of documents published by the Augmentation Research Center. 12a

D. C. Engelbart, "Special Considerations of the Individual As a User, Generator, and Retriever of Information," Paper presented at Annual Meeting of American Documentation Institute, Berkeley, California (23-27 October 1960). 12b

D. C. Engelbart, "Augmenting Human Intellect: A Conceptual Framework," Summary Report, Contract AF 49(638)-1024, SRI Project 3578, Stanford Research Institute, Menlo Park, California (October 1962), AD 289 565. 12c

D. C. Engelbart, "A Conceptual Framework for the Augmentation of Man's Intellect," in Vistas in Information Handling, Volume 1, D. W. Howerton and D. C. Weeks, eds., Spartan Books, Washington, D.C. (1963). 12d

D. C. Engelbart, "Augmenting Human Intellect: Experiments, Concepts, and Possibilities," Summary Report, Contract AF 49(638)-1024, SRI Project 3578, Stanford Research Institute, Menlo Park, California (March 1965), AD 640 989. 12e

D. C. Engelbart and B. Huddart, "Research on Computer-Augmented Information Management," Technical Report ESD-TDR-65-168, Contract AF 19(628)-4088, Stanford Research Institute, Menlo Park, California (March 1965), AD 622 520. 12f

W. K. English, D. C. Engelbart, and B. Huddart, "Computer-Aided Display Control," Final Report, Contract NAS1-3988, SRI Project 5061, Stanford Research Institute, Menlo Park, California (July 1965), CFSTI Order No. N66-30204.* 12g

W. K. English, D. C. Engelbart, and M. L. Berman, "Display-Selection Techniques for Text Manipulation," IEEE Trans. on Human Factors in Electronics, Vol. HFE-8, No. 1, pp. 5-15 (March 1967). 12h

D. C. Engelbart, W. K. English, and J. F. Rulifson, "Study For The Development of Human Intellect Augmentation Techniques," Interim Progress Report, Contract NAS1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March

1967). 121

J. D. Hopper and L. P. Deutsch, "COPE: An Assembler and On-Line-CRT Debugging System for the CDC 3100," Technical Report 1, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (March 1968).

12j

R. E. Hay and J. F. Rulifson, "MOL940: A Machine-Oriented ALGOL-Like Language for the SDS 940," Technical Report 2, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (April 1968). 12k

D. C. Engelbart, W. K. English, and J. F. Rulifson, "Development of a Multidisplay, Time-Shared Computer Facility and Computer-Augmented Management-System Research," Final Report, Contract AF 30(602)4103, SRI Project 5919, Stanford Research Institute, Menlo Park, California (April 1968), AD 843 577. 12l

D. C. Engelbart, "Human Intellect Augmentation Techniques," Final Report, Contract NAS 1-5904, SRI Project 5890, Stanford Research Institute, Menlo Park, California (July 1968), CFSTI Order No. N69-16140.* 12m

D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer-Augmented Management Techniques," Quarterly Progress Report 1, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (October 1968). 12n

D. C. Engelbart and W. K. English, "A Research Center for Augmenting Human Intellect," in AFIPS Proceedings, Vol. 33, Part One, 1968 Fall Joint Computer Conference, pp. 395-410 (Thompson Book Co., Washington, D.C., 1968). 12o

D. C. Engelbart and Staff of the Augmented Human Intellect Research Center, "Study for the Development of Human Intellect Augmentation Techniques," Semiannual Technical Letter Report 1, Contract NAS 1-7897, SRI Project 7079, Stanford Research Institute, Menlo Park, California (February 1969). 12p

D. C. Engelbart, W. K. English, and D. A. Evans, "Study for the Development of Computer Augmented Management Techniques," Interim Technical Report RADC-TR-69-98, Contract F30602-68-C-0286, SRI Project 7101, Stanford Research Institute, Menlo Park, California (March 1969), AD 855 579. 12q

D. C. Engelbart and Staff of the Augmented Human Intellect Research Center, "Study for the Development of Human Intellect Augmentation Techniques," Semiannual Technical Letter Report 2, Contract NAS 1-7897, SRI Project 7079, Stanford Research Institute, Menlo Park, California (August 1969). 12r

*Note: Reports with AD numbers are available from Defense Documentation Center, Building 5, Cameron Station, Alexandria, Virginia 22314. Items marked with an asterisk may be obtained from CFSTI, Sills Building, 5825 Port Royal Road, Springfield, Virginia 22151; cost $3.00 per copy or 65 cents for microfilm.

12s

Appendix A: User Features of NLS and TODAS 13

File (casseres,nldes,) in KDF under Stone, password DGC 13a

Appendix B: Dialogue Support System 14

File (casseres,adss,) in KDF under Meisling, password DGC 14a

Appendix C: Hardware Description 15

File (english,hdwap,;) in KDF under English 15a

Appendix D: Technical Description of NLS 16

File (english,p2rome,) in KDF under Guest, password WKE 16a

'¡4868', 09/28/70 1538:24 MGC ; :ROMEF, 07/12/70 1911:18 DGC ; ['.LLL];
EDITING CHANGES DONE .DSN=|; .COD[21B]=114B; .DLS=1; .HLN=3; .ROM=1;
.RTJ=O; .PGN=O; .LSP=O; .HED="
4868 DGC 12JUL70
7101 ROME FINAL REPORT: Sec. I
INTRODUCTION"; .DPR=O;

III HARDWARE SYSTEM

1

A. Introduction 1a

This section reviews the current status of the ARC computer facility and describes the hardware development that has been done during the course of this contract. 1a1

The first part briefly describes the computer facility, including both the computer as leased from XDS and the special equipment that has been added by ARC. 1a1a

The second part discusses modifications and improvements to the facility that have been planned and are now in progress. 1a1b

The third part presents some comments on features of the system design and discusses some of the reliability and maintenance experience. Because of its unique design, the display system is emphasized. A summary of maintenance costs for the display-generator and television portions of the system is included. 1a1c

B. The Computer Facility 1b

The configuration of the ARC computer facility has been relatively stable over the past two years. There have been some peripheral additions, in particular the ARPA Network interface and an external core system; these are discussed below. 1b1

The current facility is shown in Figs. III-1 and III-2. 1b2

1. The Leased Computer 1b3

Figure III-1 is a block diagram of the facility as leased from XDS. 1b3a

A central processor with timesharing hardware operates from a 64K memory in 4 banks with 24-bit words and a cycle time of 1.8 microseconds. 1b3b

On channels sharing memory access with the CPU are 3 magnetic tape drives, a paper-tape station, and communications equipment for 16 Teletypes. 1b3c

A second memory buss provides direct access to memory for the RADs (Rapid Access Devices, i.e., drums) and the non-XDS portion of the facility, designated "Special Devices Channel" in Fig. III-1. 1b3d

There are three drums on the system, operating from a common controller and accessing memory through an XDS device called a Direct Access Commmunications Channel (DACC). Each drum has a capacity of 500,000 24-bit words, a transfer rate of 120,000 words per second, and an average latency of 17 milliseconds. 1b3d1

2. Special Devices Channel 1b4

Figure III-2 is a block diagram of the portion of the facility that has been put together by ARC. The following sections describe the major units. 1b4a

a. Executive Control 1b4b

The executive control provides an interface to the 940 through the Memory Interface Connection (MIC). It acts as a multiplexer that allows asychronous access to core by any of the 6 devices connected to it. 1b4b1

The executive control decodes computer input/output instructions and passes them along as signals to the various devices. It accepts interrupts from the devices, synchronizes them, and passes them along to the computer. 1b4b2

It accepts addresses and requests for memory access from the various devices, determines relative priority among them, and synchronizes their access to 940 core. 1b4b3

The executive control includes extensive debugging and monitoring aids. It allows the monitoring of data and addresses for any selected device and permits "off-line" operation of any of the devices. 1b4b4

b. Disc File System 1b4c

The disc file system consists of a Bryant Model 4061 disc file and associated controller. The system has a capacity of 32 million words, an average access time of 185 milliseconds, and a data transfer rate of 43,000 words per second. A relatively simple field modification will double the present capacity. 1b4c1

The disc controller was designed and built by Bryant to interface with the executive control. Specifications for the controller were developed jointly by Bryant, Project GENIE at UC Berkeley, and SRI. 1b4c2

c. Display System 1b4d

The display system consists of two identical subsystems, each with a display controller, a display generator, and 6 high-resolution 5-inch CRTs. A closed-circuit television system carries display images from the CRTs to television monitors in the working area. 1b4d1

The display controllers were designed and built at SRI. They access and process "command tables" that are resident in 940 core. 1b4d2

A command is roughly associated with a user and points to a "display list" in the user's core space. The display list in turn points to buffers containing actual display instructions (commands to the display generator to produce images). 1b4d2a

The display controller handles all core accessing, including memory mapping for the user's core space. It passes the display instructions along to the display generator. 1b4d2b

The display generators and CRTs were purchased from Tasker Instruments to SRI's specifications. They have general character and vector capabilities. 1b4d3

Presentations for each of the 6 CRTs are generated sequentially, and unblank signals from the display controllers select one or more of the CRTs at a given time. 1b4d3a

A high-resolution (875-line) closed-circuit television system transmits display pictures from each CRT to a television monitor at a corresponding work-station console. (Figure II-32 shows several work-station designs.) 1b4d4

d. Input Device Control 1b4e

In addition to the television monitor, each work station has a keyboard, binary keyset, and mouse. Appendix A describes the use of these devices. 1b4e1

The state of these input devices is read by the input device controller at a preset interval (about 30 milliseconds) and written into a fixed table in 940 core. 1b4e2

Bits are added to information from the keyboards, keysets, and mouse switches to indicate when a new character has been received or when a switch has changed state during the sample period. A new character or switch change causes an interrupt to be issued at the end of the sample period. 1b4e2a

Mouse coordinates are digitized by an A/D converter and formatted by the input device controller as beam-position instructions to the display generator. A user program may include the mouse coordinates, as written by the input device controller, as part of a display list. This allows the mouse position to be continually displayed without attention from the CPU. 1b4e2b

e. Line Printer 1b4f

The line printer is a 96-character drum printer leased from Data Products Corporation (Model M600-11A). With the 96 characters, printing speed is 340 lines per minute. 1b4f1

The line printer controller processes print buffers of arbitrary length (single line buffers are normally used) that have been set up in core by a controlling program. Operation of the printer controller is described in Appendix C. 1b4f2

f. Network Interface 1b4g

The network interface provides communication between the 940 and an Interface Message Processor (IMP) on the ARPA Computer Network. The interface operates from message buffers in 940 core. Messages to the Network are read by the interface from these buffers and transmitted to the IMP. Similarly, messages received from the IMP are written into buffer space in 940 core. Instructions from the 940 enable the system for receiving messages and control the sending of messages. A "linked-buffer" scheme permits flexible memory allocation. 1b4g1

Operation of the network interface is described in more detail in Appendix C. The interface message processor and its communications protocol are discussed in detail in Ref. 2. 1b4g2

C. Modifications in Progress 1c

Two modifications to the facility that will provide significant improvement in service are now being implemented. These are an external core system and faster drums. In addition, an accurate clock system is being added. 1c1

1. External Core System 1c2

The external core system has been completed and will be integrated into the facility in the near future. 1c2a

The primary purpose of this core system is to provide storage for display regeneration. Display buffers are presently in "frozen pages" in 940 core -- a significant factor in limiting system response, since thay take up space that could otherwise be used for swapping. (See Sec. IV for a discussion of factors affecting response.) 1c2b

Figure III-3 shows the special devices channel as it will be reconfigured when the core system is integrated. 1c2c

The inter-core controller controls transfer of data between external core and 940 core. It has two modes of operation: 1c2c1

(1) A block transfer mode allows the transfer of blocks of up to 2048 words between any two locations in the two cores. (Note that transfer can be between two locations in the same core.) 1c2c1a

(2) A short transfer mode allows the transfer of short, fixed-length buffers between fixed locations in 940 core and external core. This mode is easier to set up than the block transfer, and requires fewer memory accesses for control. It will be used for such functions as transferring single characters or other control information between the two core systems. 1c2c1b

The operation of the inter-core controller is described in more detail in Appendix C. 1c2c1c

The external core itself currently consists of a single 32,000-word bank with access switching to allow access by up to eight devices. Provisions are included in the design for expansion to 16 devices and two core banks of 64,000 words each. The core cycle time is 1.5 microseconds and the word length is 24 bits. 1c2c2

The interface to external core has been designed so that it is identical to the interface to 940 core (through the Executive Control). A device may be simply plugged into either core system. 1c2c2a

As shown in Fig. III-3, we will initially be operating both display systems, the network interface, and the line printer from external core. These are the devices that need constant buffers for relatively long periods and therefore require frozen pages when operating from 940 core. 1c2c3

2. Faster Drums 1c3

From the system response studies (see Sec. IV) it is apparent that a primary factor in response is the swapping bandwidth. To improve response (and add more users), we are in the process of replacing the XDS drums with Univac FH-432 drums. 1c3a

These drums rotate at 7200 RPM, giving a transfer rate of 365,000 words per second (as compared to 120,000 for the present drums) and an average access time of about 4 milliseconds. 1c3a1

In addition, we are formatting the new drums in a way that will allow a page transfer to begin at any position on the drum. Since a 2048-word page fills two-thirds of a band, this will give an average page transfer time of about 8 milliseconds. 1c3a2

The interface for the drums will be designed and built by ARC. It will connect to the 940 through a second Memory Interface Connection (MIC), replacing the current RAD-DACC combination shown in Fig. III-1. 1c3b

3. Clock System 1c4

An accurate clock system is being added to assist us in system measurements. 1c4a

This clock system provides two types of time information -- absolute and relative -- that are written into fixed locations in 940 core at regular intervals. 1c4a1

Absolute time consists of binary representations of year, month, day, hour, minute, and second. 1c4a1a

Relative time information consists of a single 24-bit number, incremented and written into core every 100 microseconds. 1c4a1b

The long-term drift on the clock will be less than 1 second in 250 days. 1c4a2

A more complete description of the clock system is given in Appendix C. 1c4b

D. Notes on System Design and Reliability 1d

1. Display System 1d1

The display system in use is somewhat unusual in that it uses central display-generating equipment and a closed-circuit television system to distribute images to the working area. This approach to a display system was chosen on the basis of cost and flexibility. A description of the system and of considerations that went into its design is given in an earlier report (Ref. 3). 1d1a

We now have considerable experience in operating this system and are still very pleased with the basic approach, but we have had some problems with the component equipment involved. 1d1b

The closed-circuit television system offers several distinct advantages over other means of producing displays at a work station. 1d1b1

The system is extremely flexible as to the location and design of working consoles, since only a television monitor and a video line are required to present the display at each console. This allows freedom to experiment with different types of consoles (Ref. 4) and to move consoles about without cabling problems. 1d1b1a

The video signal is inverted to provide a black-on-white display. This presentation is usable in higher ambient light conditions than the usual bright-on-dark presentation, and flicker in the display image (due to low generation rates) is much less noticeable to the user. 1d1b1b

With proper adjustment of the television camera, a significant storage time can be obtained on the vidicon surface. This greatly reduces the flicker effect that is present in the original CRT presentation. With this system we find it possible to regenerate displays at about 20 cycles per second. 1d1b1c

Maintenance features are another significant advantage. 1d1b2

The display equipment at the actual work station is quite simple, consisting of only a television monitor which can be replaced by a spare for maintenance. 1d1b2a

The display-generating equipment, which requires more complex maintenance and repairs, is located centrally in the computer room. This makes it very easy to maintain an uncluttered office environment in the working area. 1d1b2b

Furthermore, since there is not a fixed one-to-one relationship between display-generating equipment and work stations, when a portion of the display system is down for repairs the working consoles that remain operative may be freely selected on the basis of current needs. 1d1b2c

Having two identical display systems, from display controller through actual monitors, has been a major factor in maintaining up-time in spite of the unexpectedly high level of maintenance required on the system. 1d1b2d

The use of video to distribute display images offers several other possibilities that we have not yet fully exploited. 1d1b3

For the television monitor on which the image is presented, a wide range of accessory equipment is commercially available. For example, we have used high-quality projection television at the Fall Joint Computer Conference in 1968 and at the ASIS Conference in 1969. It is possible to use multiple TV monitors or intermediate-size projection equipment for smaller groups. This will be a major factor in the team-augmentation work to be carried out under the next contract. 1d1b3a

The video capability offers additional flexibility in the images that may be used on the screen. For example, in the conferences mentioned above, live TV pictures of the people and equipment involved were freely used, mixed with the computer-generated image. This, again, will be a significant factor in team collaboration at a distance where pictures of the people involved can be used, either mixed or inserted with the computer-generated image. 1d1b3b

Another use of the video that will become increasingly important is the viewing of microfiche documents. Many systems are now available and more are coming on the market for the storage, retrieval, and viewing of microfiche on closed-circuit television.

1d1b3c

2. Maintenance Experience 1d2

a. General 1d2a

In general the reliability of the facility has been very good; the computer up-time has been extremely high. The reliability of the disc-file system has been fair. We had a period of several months of above-normal error rate, and 5 days down while clocks were rewritten; however, the troubles now seem to have been corrected. 1d2a1

One notable exception to this has been the line printer. 1d2a1a

We originally bought a Potter chain printer which turned out to have marginal print quality and was very unreliable. We had great difficulty in getting maintenance from Potter, and we finally replaced the unit with a Data Products drum printer. Like the Potter printer, this has 96 printing characters with upper- and lower-case alphabet. The print quality is excellent and so far it has been very reliable. 1d2a1a1

b. Display System 1d2b

We have spent more effort on maintenance of the display system than any other part of the facility; since it is somewhat unusual, we will discuss some of the problems encountered and summarize the maintenance costs. 1d2b1

One of the basic limitations of the system is the lack of enough total light on the vidicon surface. This means that many design factors are marginal. The Tasker CRTs run at such high intensity that their life is relatively short. This high intensity also causes difficulties in maintaining good focus over the entire image. To operate with these low light levels, the vidicons must be quite sensitive; since sensitivity drops off with age, they have a relatively short useful life. 1d2b1a

Because the writing speed of the Tasker display generators is lower than expected, we still have a flicker problem when all 6 screens on the system in use are reasonably full of text. To some extent we are able to compensate for this by careful adjustment of the vidicon beam current and target, but this adjustment needs frequent attention. We have considered longer-persistance phosphors on the TV monitors and will experiment with this in the near future. 1d2b1b

In addition to these difficulties there are some basic weaknesses in the design of the Tasker system and the television system. 1d2b2

(1) Tasker System 1d2b2a

Sockets for circuit cards are not of high quality. This results in contact-resistance problems, especially in the analog circuitry. 1d2b2a1

Deflection circuitry, with its many adjustments, is so hard to get at that it is left in a partially assembled state. 1d2b2a2

Logic circuits still do not have all pull-up problems corrected, resulting in a narrow range on the clock. 1d2b2a3

The active deflection-sensing circuit requires frequent adjustment. 1d2b2a4

The focus vs. beam position circuits perform very poorly. 1d2b2a5

(2) Television System 1d2b2b

The preamplifier tubes on the television cameras tend to be very noisy. These tubes must initially be selected for low noise to get really good pictures, and their life is very short. 1d2b2b1

We are currently in the process of replacing all of the preamplifier circuit boards with a new solid-state circuit now delivered in new GE cameras of this type. This circuit uses an FET preamplifier with very low noise and hopefully no problems in reliability. 1d2b2b1a

Controller power supplies are poorly designed and require too frequent replacement of parts. 1d2b2b2

c. Maintenance Costs 1d2c

The following is a summary of the costs for maintenance of the display and television systems for the past year. Both include the frequent "tuning" necessary to maintain good picture quality. These are the costs for maintaining 6 operating work stations, but some effort has been spent on the equipment not in regular use. We expect this to go up about 50 percent when 12 stations are in operation. 1d2c1

TV System			1d2c2
Labor	25,665		1d2c2a
Vidicons	3,365		1d2c2b
Picture Tubes	895		1d2c2c
Preamp Tubes	1,200		1d2c2d
All other parts	1,040		1d2c2e
Total		32,165	
Tasker System			1d2c3
Labor	7,905		1d2c3a
CRT's	3,000		1d2c3b
Miscellaneous	200		1d2c3c
Total		11,105	1d2c3c1

Note: The Tasker system is maintained at a "keep-it-going-well-enough-so-people-can-work" level, and it lives with many weaknesses. 1d2c3d

3. Hardware Design and Construction Techniques 1d3

a. Logic Design Aids 1d3a

The wirelist generator program described in an earlier report (Ref. 3) is still being used. The input format, diagnostic aids, and general form of the program are essentially the same as in the past. In the past the wirelist output was used to produce documentation that aided a technician in hand wiring; now it produces a punched tape that in turn controls a semiautomatic wire-wrapping machine. This wire-wrapping service is obtained from a local supplier and results in more accurate wiring, lower wiring cost, and faster turnaround in going from logic equations to finished wiring. 1d3a1

Regarding accuracy, no misplaced wires have been found to date, although a very minor number of broken wires and wires shorted to pins have been observed. 1d3a1a

The wiring itself costs about 23 cents per wire. Also, above the cost of running the basic wirelist generator program, there is an additional cost of 20 cents per wire for preparing the paper tape used to control the wire-wrapping machine. 1d3a1b

Turnaround time for wire-wrapping is short, typically less than a week for a design containing 400 integrated circuits. Of course, this is subject to considerable variation, depending on the work load of the company performing the wire-wrapping. 1d3a1b1

Most of the general comments in the previous report concerning the utility of the wirelist generator program still hold. 1d3a1c

However, experience has shown the desirability of maintaining a fairly complete set of logical schematics, complete with circuit locations and pin numbers, in addition to the designer's sketches and listings provided by the wirelist generator. 1d3a1c1

The previous report on this contract (Ref. 3) implied that the sketches and listing were sufficient for equipment maintenance and trouble-shooting. This is true as long as the original designer performs the maintenance. With the inevitable turnover of personnel that takes place on a long-term project, someone other than the designer eventually becomes responsible for keeping a given device operating. Under this circumstance, a schematic is an invaluable aid. 1d3a1c1a

b. Construction Techniques 1d3b

The construction techniques of the most recent units can be seen in Fig. III-4. The hardware implementation consists of an array of sockets that will directly accept a dual inline packaged integrated circuit (commonly called a "DIP"). The arrays of DIPs are mounted perpendicular to the horizontal plane on the front of the rack in which they are mounted. The circuit arrays can be pulled out for access. Wiring connections are made directly to the pins of the sockets. This scheme has several advantages. 1d3b1

First, the cost is low. The previous construction technique used printed-circuit boards for mounting the integrated circuits. Thus the cost of mounting the circuits on the board and the cost of the board itself were incurred. 1d3b1a

Second, there is greater flexibility in the location of a given circuit type. With the integrated circuits mounted on printed-circuit boards, a complete board consisting of up to 12 circuits would have to be used in cases where only 1 circuit was actually needed. 1d3b1b

Thirdly, an individual DIP can be removed and replaced. This is a great aid in the maintenance of a device. A DIP with a suspect circuit can quickly be removed and replaced by one that is known to be good. 1d3b1c

In addition to the techniques of hardware realization of the basic logic design, many other details of the hardware design are important. 1d3b2

One feature that the hardware must provide is some means of access to both the integrated circuits and the wiring -- this feature is an absolute necessity during initial checkout and is an aid in later maintenance and changes. 1d3b2a

In providing access to the external core, the multiplex switch posed a particularly difficult problem, since 34 cables connect to it. In order to allow easy access to this unit, the mounting system shown in Fig. III-4 was developed. 1d3b2a1

A very flexible cable is used, with a rather elaborate method of strain relief and cable guidance. Although the original mechanical design was quite expensive, requiring about 3 months of a design draftsman's time, past experience has shown the difficulty of maintaining equipment that did not have easy access. To date this design cost has been spread over several units and its anticipated use in future units will reduce the per-unit cost for the design. The expense of hand-fabricating the parts for a pull-out drawer is estimated to be around $300, which is slightly less than $1 per socket. 1d3b2a2

In the recent equipment, light-emitting diodes (LEDs) have been used instead of incandescent lights for panel indicators. The results have been very satisfying. 1d3b3

The LEDs have a higher initial cost (about $3 each) than the incandescent lights previously used. The lights, however, have a limited life while the lifetime of the LEDs is essentially infinite. This leads to essentially zero maintenance and replacement cost for the LEDs. 1d3b3a

This long service life also means that the expensive sockets required by the incandescent units, in order to facilitate their replacement, can be eliminated. Indicators were mounted simply by drilling holes in the front panel and retaining the LEDs with RTV silicone rubber. 1d3b3b

A further cost saving is effected since these lights are driven directly from the logic, saving not only the cost of the drivers themselves but also the cost of the extra sockets and wiring they would require. 1d3b3c

The LEDs have a relatively narrow viewing angle and less intensity than the incandescent lights, but we have found them entirely satisfactory in use. 1d3b3d

c. Typical Construction Costs 1d3c

A fairly careful study was made of the actual cost of the ARPA Network interface. This is typical of the type of control unit that is now being built. 1d3c1

Hardware and Construction -- the figures are given on a per-socket basis. Technician time involved in construction is included. 1d3c2

Frame, connectors, IC sockets, etc.	$3.50	1d3c2a
Mounting hardware	$2.00	1d3c2b
Computer time (preparing wire-wrapping control tape, 35 cents per wire and an average of 6.8 wires per socket)	$2.40	1d3c2c
Integrated circuits (average)	$2.00	1d3c2d
Wire-wrapping (25 cents/wire and 6.8 wires/socket)	$1.60	1d3c2e
Total hardware and construction (per socket)	$11.50	1d3c2f
Total hardware and construction cost for Network interface (600 sockets)	$6900.00	1d3c2g

Design 1d3c3

The design cost is expressed in man-days for a design engineer. 1d3c3a

Initial design	10 days	1d3c3a1
Preparation of equations	10 days	1d3c3a2
Drawings and documentation	10 days	1d3c3a3
Final assembly and debug	20 days	1d3c3a4
Total days	50	1d3c3a5

':4869', 09/28/70 1659:20 MGC ; :RFHDW, 07/12/70 1808:56 DGC ; EDITING
CHANGES DONE .COD[2|B]=||4B; .PGN=56; .DSN=1; .LSP=0; .DLS=1; .RTJ=0;
.HLN=3; .HED=" 4869 DGC 12JUL70
7101 ROME FINAL REPORT: Sec. III
HARDWARE SYSTEM"; .DPR=0;