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STARCAT, A SYSTEM TO ANALYZE INTERACTIVE CMS PERFORMANCE.(U)
1978 R C EVANS, L A MILLER N00014-72-C-0419
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RC 7072 (#30314) 4/18/78
Computer Science 27 pages

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Contract N00014-72-C-0419

RC-7072

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RC 7072 (#30314) 4/18/78
Computer Science 23 pages

STARCAT, A SYSTEM TO ANALYZE INTERACTIVE CMS PERFORMANCE

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ABSTRACT. This paper describes a software system named STARCAT - for STream Analysis of Responses by CATegory. The system analyzes sequences of user command strings that have been captured in a special timestamped CMS console file: user response times, URTs, and system response times, SRTs, are associated with each string; strings are assigned - by command name, environment, or experimenter-chosen groupings - into categories; and category statistics are reported for one, two, and three-string subsequences. STARCAT provides a new tool, valuable to various interface and system design studies, for the quantitative analysis of interactive terminal performance.

Some of this work was supported, in part, by the Engineering Psychology Program, Office of Naval Research.

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INTRODUCTION

The literature abounds with studies of the man-computer language interface (see Miller and Thomas, 1977 for a selected set). Findings in some detail have been published in regard to TSS, for example, concerning the characterization of interactive users and their command streams (Boies, 1974). However, there has not existed a convenient means to capture and analyze strings that users pass into CMS -- a means that can be easilly invoked during any user terminal session (or just as easilly turned off when the interval of interest ends). STARCAT was created to remedy that situation -- to make it easy to mine the rich vein of data that command streams constitute concerning the usage (perhaps usefullness and appropriateness as well) of the facilities available under the CMS master environment.

In addition to its outputs based upon user and system response times associated with single stream commands, STARCAT aggregates some statistics by command groupings - under classifications by command environment, command name, or by fiat of the experimenter (to reflect his particular perception of command function; this latter variability is not presently permitted to the general STARCAT user). The statistics STARCAT associates with these groupings become appealing descriptors of interactive usage patterns under CMS.

It is known, for the TSS system, that command usage and user response time profiles differ significantly over user groups, the degree of experience and 'sophistication' being an important correlate of the observed distinctions (Boies, 1974). We could thus predict, for example, that a STARCAT exploration of novice vs. experienced CMS usage would reveal that novice users visit common command classes with differing frequencies and exhibit characteristically distinct 'signatures' of response time distributions over the spectrum of available command classes. Experienced users will predictably do all things with less delay, use more commands of their own creation and fewer standard commands, visit the 'inform' categories less frequently, etcetera.

Such analyses of user sessions can do more than confirm expected variations in usage; they can provide quantitative control over (and critiques of) new system-design efforts intended to exploit such differences - for example, by tailoring available support facilities to the set of differences expected in the user profiles.

Interactive performance studies under CMS might well be framed in terms of either user variation, task variation, or environment variation (under the master CMS environment). Such studies would throw light on the nature of users, tasks, and environments respectively - that would in each case be pertinent to the improvement of system design or the optimization of available interfaces.

As examples: the leading CMS text editors (EDIT, EDITOR, and REDIT) might be revealingly compared within the context of, say, a 'document generation' experiment; or the document generation process might itself be taken as focus of interest, illuminated under a task-varying design within a fixed-environment; or a study might be undertaken to explore the user response time correlates of command complexity - syntactic and semantic. In any case, the elementary prerequisite for any such study is a convenient medium for the comparison of results; the STARCAT analysis capabilities provide exactly such a medium.

THE STARCAT HOW

As basic to its later analyses, STARCAT time-stamps two event types of special importance in the console command stream: the moments of terminal keyboard 'unlockings', when the system has completed execution of each previous user command; and the moments when the user presses the enter (or return) key to transmit new command strings to the system.

Time-stamping is achieved from within a slightly modified CMS nucleus. It induces in the basic output file, of filetype CONSOLE, a repeating pattern composed of four items: the time stamp on the terminal unlock event; the user command string; the time stamp on the command entry event; and, none or more records due to the system's execution of the command. (See Fig. 1) The timed items are related and summarized by functions of an APL workspace, STARCAT, in order to reveal clusterings of user response times over command categories, and over temporally sequential pairs and triplets of command categories.

A variety of output files are possible, suggesting a complicated user interface, but this is not actually the case. Having linked to and accessed the STARCAT system disk (EVANS 193), the user deals with only two commands: TIMEON, to start, and TIMEOFF, to end, the special session. (A small amount of information is also passed conversationally - see section on STARCAT ACCESS.)

The command categories which STARCAT finds of interest are based either upon the command name, the environment from within which the command was issued, or a classification derived from both. In the latter case, the results depend heavilly upon environment. For example, a command 'L ...' would be interpreted as a LISTFILE command if the governing environment were CMS , but would be interpreted as a LOCATE command if EDIT governed. The starcat logic thus requires special processors for each of the environments that are deemed of interest.

The logic to track the governing environments does so by observing if each command belongs to a special set of environment-changing commands (APL, EDIT, EDITOR, RETURN, etc.); if so, a pushdown stack of environments is appropriately updated. The special commands may be thought of as triggers which throw the system into altered states. In some trivial sense all commands do so, but the ones singled out do so in the special sense of enabling/disabling extensive sets of commands. The environment-changing commands thus serve as portals between otherwise isolated usage domaines.

The CMS subenvironments that STARCAT presently deals with in detail are the chief ones for text editing - EDIT, EDITOR, and REDIT. (Editing commands may well predominate in interactive usage; on the TSS system, 75 percent of commands actually issued were found to be in this class: Doherty, Thompson, & Boise, 1972; and see Boise, 1974.)

The between-environment transitions that the system recognizes are indicated in FIGURE 8. The environments named E6IN, E7IN, and E8IN in that FIGURE are input modes for EDIT, EDITOR, and REDIT respectively.

STARCAT prepares its output reports by post-processing a special time-stamped console file of the terminal session's activity. Attending to each user command string and associated timestamps, it computes a user response time. Then - after consulting the current state of an 'environment switch' - it passes the command string on to a subprocessor which, in turn, resolves the string's 'command class' and - if the string is of the environment-changing type - updates the state of the governing 'environment switch'. By repeating these steps the system obtains arrays of string, response-time, and category items which are in one-to-one correspondence by index. These arrays are basic to the summary output reports that are generated.

The output files are described in some detail in the next section, but it may be noted here that some attention is given in the design of these reports to the notion that user command strings are important not only in isolation within the command stream but in relation to their neighbors as well. It is clear, for example, that the distributions of such temporally sequential pairs of EDIT commands as < LOCATE, INPUT>, < LOCATE, CHANGE >, and < LOCATE, LOCATE > tell more about the refined usage of the EDIT subcommands then do the individual distributions of LOCATE, INPUT, and CHANGE.

It may also be said - in favor of the attention that is given to pairs and triplets of command strings - that such accounting makes possible the investigation of notions of command facilitation and inhibitation: If a doubleton event,

... X, Y ...

is characteristically associated with an average user response time, T(<X,Y>), differing significantly from T(<X>) + T(<Y>) then it may be appropriate to consider X as facilitator or inhibitor of Y (depending upon direction of the inequality). Or perhaps Y might be given the active role; we do not imply that influences in the command stream work only in forward directions. The point is that STARCAT analyses provide the information necessary to detect such phenomena.

STARCAT OUTPUT FILES

FN CONSOLE file --

The user decides the filename, say FN, that all STARCAT output files will share (see CONVERSATIONAL SELECTION OF OPTIONS). The basic output file then gets named FN CONSOLE; it contains the raw time-stamped history of the terminal session.

FIGURE 1, in its right half, is an example of a possible FN CONSOLE file. Note its repeating record pattern: unlock-timestamp, command-string, command-entry-timestamp, <system-records>.

The remainder of this paper will contain frequent references to file FN CONSOLE, or FN CMDS, or some other file of filename FN; that name should be understood, wherever it occurs, as our substitute for the arbitrary name that the user has determined.

The STARCAT strategy is one of determining and capsulizing the time and category relationships in the FN CONSOLE data. These basic relationships are more readily perceived in FIGURE 2, where delays have been represented along a time axis and attributed to either system or user. The shaded pulses of FIGURE 2 represent those time intervals during which the system has blocked user access while it goes about effecting a previous user command. The degree of blocking is a function of the maximum size, N, of the console command stack, here shown as N = 1 for a 2741-type terminal. The width of each pulse is recorded as a system response time, SRT; user response times, URTs, are computed as those delays, after the keyboard has been opened, during which the user 'ponders' and finally enters a new command.

The times in FIGURE 2 have been derived from the timestamps of FIGURE 1 - translated to an origin representing the start of the session. Only the user typed lines are carried in FIGURE 2, not records that may have been typed by the system during lockout periods.

FN CMDS file --

The clarifying transformation from FIGURE 1 into FIGURE 2 is paralleled when STARCAT extracts its first summary output file, FN CMDS, from the information so primitively arranged in FN CONSOLE. FN CMDS, for the example being followed, is shown in FIGURE 3.

FIGURE 3 shows that FN CMDS preserves user entries and eliminates system-typed lines such as NEW FILE: and EDIT:. It displays commands in their order of occurence, and clock times have been converted into integer seconds of delay, by item and cummulatively since the start of the session, for both system and user activities. Each user command is framed, within a single record, by its bounding timed events: to its left by the time when the terminal was first receptive to a command, and to its right by the time when the system first received the command. Some additional inferences have been drawn from the data beyond those that are explicit in FIGURE 2; category names have been assigned to each command string (under the COMMAND, ENVIR, and CLASS headings).

COMMAND CLASSIFICATIONS UNDERLYING OTHER OUTPUT FILES

The COMMAND, ENVIR, and CLASS columns of FIGURE 3 represent different modes of classifying user command strings.

Entries found under the ENVIR heading are environment categories - names given to command environments from within which corresponding user commands have been issued: CMS, EDIT, etc. (In the example, E6IN appears; it names the EDIT input-mode environment.)

Entries under the COMMAND heading are category names derived directly from the command string, usually as its first token.

Entries found under the CLASS heading are category names that have been tabularly computed (using a table named CMD CLASSES) as a function of command string and issuing environment. The CLASS mode of determining categories is the *only one* of the three modes that gives an experimenter some means of controling category definitions (by changing table entries in the CMD CLASSES file); it thus is a fundamental mode for exploratory studies.

Three output files are available for each of the three modes of classification; thus, by choice of options (see CONVERSATIONAL SELECTION OF OPTIONS), a user may request as many as nine output files:

FN ENVIR1, FN ENVIR2, and FN ENVIR3 files --

Specification of the ENVIR option requests generation of the three named files, which are analyses of category groupings that have occurred in the data under the assumption of an environmental mode of classification.

FIGURE 4 displays these three output files, relative to our example data from FN CMDS. The single-occurance of categories is reported in file FN ENVIR1, the sequential occurance of category pairs in file FN ENVIR2, and the sequential occurance of category triplets in file FN ENVIR3. The most frequent environment of this simple example is seen to be EDIT, which is in fact the only environment with a tripleton frequency exceeding 1. The doubleton displays indicate that subsequences of an EDIT command followed by an EDIT-input command (E6IN) consume greater amounts of response time in this example than do doubleton subsequences that remain in EDIT.

Records of these files each contain a category ID, and a time, frequency and mean time associated with the category. Category time equals the sum of the URTs of command strings found instancing the category, category frequency equals the number of such strings, and mean time equals the ratio of the two. A field is included which contains the standard error of the mean, as estimated from the sample (the URTs of the strings that have been assigned into the category).

The FN CMDS file, of FIGURE 3, displayed command strings by order of their occurance. The order of the records in the FIGURE 4 files, and in any output files which summarize category events, is, by contrast, a matter of user choice (see CONVERSATIONAL SELECTION OF OPTIONS): the records may be ordered by decreasing mean time, by decreasing category frequency, by decreasing category time, or, finally, by order of occurance of the first observed instance of the category.

As a concrete example of the manner in which time and frequency entries are tallied for presentation in category reports, assume (as in the FIGURE 4 reports) that output records have been sorted by decreasing mean time, and that the entire command stream has consisted of:

command string sequence........... a, b, c, b, c
corresponding category sequence... A, B, C, B, C
and associated URTs............... 6, 3, 2, 4, 4

Then reports of singleton, doubleton, and tripleton groupings would include orderings of records as shown:

	TIME	FREQ	MEAN
SINGLETONS:			
A	6	1	6.00
B	7	2	3.50
C	6	2	3.00
DOUBLETONS:			
A B	9	1	9.00
B C	13	2	6.50
C B	6	1	6.00
TRIPLETONS:			
A B C	11	1	11.00
C B C	10	1	10.00
B C B	9	1	9.00

(The two decimal place display of means is unnecessary for such small frequencies, given that times are taken only to the nearest second; the format is retained, however, to cover the possibility of underlying software changes which will recover more accurate times.)

FN COMMD1, FN COMMD2, and FN COMMD3 files --

These output files, shown in FIGURE 5, are obtained by specifying the COMMD option; they are strictly analogous to the three ENVIR-type output files (above), differing only in that the categories involved are determined by the COMMAND classification scheme.

FN CLASS1, FN CLASS2, and FN CLASS3 files --

These output files, shown in FIGURE 6, are obtained by specifying the CLASS option. Once again, they differ from the files described above only in terms of the categories analyzed: in this case the categories are determined from the data on the basis of tabular entries in an internal file called CMD CLASSES. The data of the figure indicate few obvious frequency or mean time preferences, either among the singletons, doubletons, or tripletons displayed, as might be expected with so small a sample.

OTHER OUTPUT FILES --

With each run of the STARCAT system the user will get, in addition to his selection of output reports above, an output listing of a file named FN SYSTATS, shown for our example in FIGURE 7, which reports various system statistics that have been measured for each command string. Such items were contained in raw form in the timestamped records of FN CONSOLE (within binary fields occurring to the right of those shown in FIGURE 1).

Finally, it must be remarked that the field reserved in FN CMDS for the display of user command strings is only 24 characters wide. Should the user desire to obtain a simple file containing only URTs and command strings (through their 111th character) in temporal sequence, he may signify that option by entering a negative option code when asked to select his sort-type choice (see CONVERSATIONAL SELECTION OF OPTIONS). The additional report that he obtains will be a file named FN STRETCH.

SEGMENTATION OF THE FN CONSOLE FILE

A user may wish to produce analyses for only certain parts of the terminal session. STARCAT provides that a segment, or non-overlapping segments, of the basic FN CONSOLE file may be separately analyzed. To receive reports relativized to such disjoint blocks, the user may prepare a file of name FN SEGMENTS - prior to the issuance of the TIMEOFF command, or as an afterthought with intent to later issue a RETIME command - which contains records that identify and name the segments:

```
If the nth segment is located (strictly) between
user command strings begining with characters
    XXXX and YYYY, respectively,
and filenames common to reports dealing with that
segment are to be
    FNO
then the nth record of FN SEGMENTS should be
    FNO   XXXX YYYYY  (in free format).
```

As an example, let us assume that during a terminal session run under STARCAT a user has surrounded two blocks of special interest with the (arbitrary) string delimiters shown here:

```
                 .
                 .
                 .
      STARTA   ...
      (here the first block of interest,
       to be named BIG, let us say)
      ENDA    ...
                 .
                 .
                 .
      BBB
      (here the second, final, block of interest,
       to be named LITTLE, let us say)
      CCC
                 .
                 .
                 .
```

Then, in order to direct STARCAT to confine its analyses to the delimited segments, the user should prepare a file of arbitrary filename (but agreeing in name with his choice for the console file, say EXAMPLE) and filetype SEGMENTS; it should contain the following records:

```
    BIG    STARTA  ENDA
    LITTLE  BBB     CCC
```

By identifying EXAMPLE as the filename to be assigned to the console file (during the conversational exchange that follows the TIMEOFF command), the user informs the system that the EXAMPLE SEGMENTS proscriptions are to govern.

Should he then go on to select all possible outputs, the user would obtain the following files on his A-disk:

EXAMPLE CONSOLE -- the timestamped record of the entire session;

BIG STRETCH -- URTs and full command strings for the BIG segment;
BIG CMDS -- abreviated command strings, their related URTs, SRTs, and assigned categories, all for the BIG segment;
BIG ENVIR(1,2, and 3) -- environmental category analyses for the BIG segment;
BIG COMMD(1,2, and 3) -- category analyses by command string name, for the BIG segment;
BIG CLASS(1,2, and 3) -- category analyses by class names from table, for the BIG segment;

and

LITTLE STRETCH, LITTLE CMDS,...(correspondingly).

STARCAT ACCESS

Access to the STARCAT system requires linkage and access to the EVANS 193 disk; since use of the system involves crossing and recrossing IPL boundaries, it is recommended that would-be users insert the access protocol within their PROFILE EXECS, in somesuch form as:

```
Q V 393
&IF &RETCODE ¬= 0 EXEC LINKWAIT EVANS 193 393 RR
EXEC ACCWAIT 393 D/A
```

(Access must be to a read extension of the A disk - so that a stacked)LOAD STARCAT command, needed below the level visible to the user, can take effect as an APL system command.)

Three commands control the use of the system, only the first two of which are essential:

TIMEON -- to start a session.

TIMEOFF < FN <SAVE> > -- to end a session, supply filename, FN, for output files, and stipulate whether or not the output files other than the basic FN CONSOLE are, once printed, to be retained. If arguments are not supplied, they are requested conversationally; if FN is supplied, then SAVE must be stipulated to retain other than the FN CONSOLE output.

RETIME FN <SAVE> -- to recreate, print, <and save> the summary output files associated with a previously created file, FN CONSOLE, if they had not then been retained.

The following page indicates the entire input that the system requires of a user, either as explicit commands or as replies to prompts. (The meaning of the conversational options is detailed in the STARCAT OUTPUT section of this paper.)

```
CONVERSATIONAL SELECTION OF OPTIONS
  (user lines are xxxxx-ed)

TIMEON         (xxxxx)

When words TIMED SYSTEM appear,
     please type TIME:
TIMED SYSTEM

TIME           (xxxxx)
(Here the user session - at least 3 user commands.)
TIMEOFF        (xxxxx)

NO FILES CHANGED
CON FILE ... TO ... COPY 01 NOHOLD
Enter FN <SAVE> (where FN = filename of console file):

ANAME SAVE     (xxxxx)

Output category options are:
     0 - skip summaries;
     1 - summaries by CLASS;
     2 - summaries by COMMD;
     3 - summaries by ENVIR.
Enter one, two, or three option codes (separated by spaces):

3    1 2       (xxxxx)

Output sort-type options are:
     1 - decreasing average time;
     2 - decreasing freq / decreasing time;
     3 - decreasing time / decreasing freq; and,
     4 - order of occurance of 1st category instance.
Enter one option code (for all output summaries):

-1             (xxxxx - neg opts to prt FN STRETCH)
-------- -------- -------- -------- --------
PLEASE WAIT FOR REPEAT DISPLAY OF THIS LINE:
******** (RETURN TO STANDARD CMS) ********
R;
(For the remainder, the system operates under EXEC and
  stacked-command control to post-process the terminal
  session console file :)
     vs apl release ...
clear ws
     saved ...
R;
PRT FILE ... FOR ... COPY 02 NOHOLD
******** (RETURN TO STANDARD CMS) ********
R;

CMS 3.14 - ...
               (xxxxx - user carriage return)
R;
```

CONCLUDING WORD

We have introduced a software system that we believe can profitably be used in many design and interface studies. The system has had but little trial by fire; we hope that readers will be prompted to try it out and return their reactions to us.

Further details will be supplied, upon request, to to any users who wish to make their own modifications to the system. For the general users, who may just want a first go at it, we mention, finally, the following limitations:

-- virtual storage of >= 768K is assumed;
-- users are expected to avoid multiple commands per line;
-- timestamping occurs from within the CMS nucleus, hence is defeated by entries into the CP environment; and, finally,
-- the tracking of environments may be defeated by user execs which change environments during their execution.

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ACKNOWLEDGEMENTS

Our thanks to V.Nelson for showing us how a special CMS nucleus is created; to W.Daniels for indicating where- and to some degree how - to include our CMS modifications; and, to J. Waldbaum and L. Junker for suggesting the inclusion of the system statistics of the FN SYSTATS output file.

```
                                ***SYST 12/15/7709:24:40
*console test                   *console test
                                ***USER 12/15/7709:24:47
                                ***SYST 12/15/7709:24:55
edit tst file                   edit tst file
                                ***USER 12/15/7709:25:00
NEW FILE:                       NEW FILE:
EDIT:                           EDIT:
                                ***SYST 12/15/7709:25:03
input                           input
                                ***USER 12/15/7709:25:10
INPUT:                          INPUT:
                                ***SYST 12/15/7709:25:11
this is a test                  this is a test
                                ***USER 12/15/7709:25:17
                                ***SYST 12/15/7709:25:17
rec number 2                    rec number 2
                                ***USER 12/15/7709:25:24
(carriage return here)          ***SYST 12/15/7709:25:24
                                ***USER 12/15/7709:25:25
EDIT:                           EDIT:
                                ***SYST 12/15/7709:25:26
up                              up
                                ***USER 12/15/7709:25:28
THIS IS A TEST                  THIS IS A TEST
                                ***SYST 12/15/7709:25:29
$move 1 down 1                  $move 1 down 1
                                ***USER 12/15/7709:25:37
                                ***SYST 12/15/7709:25:38
up                              up
                                ***USER 12/15/7709:25:40
REC NUMBER 2                    REC NUMBER 2
                                ***SYST 12/15/7709:25:42
change/2/1                      change/2/1
                                ***USER 12/15/7709:25:50
REC NUMBER 1                    REC NUMBER 1
                                ***SYST 12/15/7709:25:51
file                            file
                                ***USER 12/15/7709:25:55
R;                              R;
```

FIGURE 1
LEFT: USUAL CONSOLE FILE
RIGHT: CORRESPONDING STARCAT OUTPUT FILE, FN CONSOLE

```
                 0|                                   SRT = 0
                  |
                  | *console test
                 7|----------------    URT = 7
                  ////////////////|
                  ////////////////|
                  ////////////////|
                15|----------------                   SRT = 8
                  |
                  | edit tst file
                20|----------------    URT = 5
                  ////////////////|
                23|----------------                   SRT = 3
                  |
                  |
                  | input
                30|----------------    URT = 7
                  ////////////////|
       -        31|----------------                   SRT = 1
      | |         |
      |T|         | this is a test
      |I|       37|----------------    URT = 6   SRT negligible
      |M|         |
      |E|         |
      | |         | rec number 2
      |I|       44|----------------    URT = 7   SRT negligible
      |N|         | (car. ret.)
      | |       45|----------------    URT = 1
      |S|         ////////////////|
      |E|       46|----------------                   SRT = 1
      |C|         | up
      |O|       48|----------------    URT = 2
      |N|         ////////////////|
      |D|       49|----------------                   SRT = 1
      |S|         |
      | |         |
       -          | $move 1 down 1
                57|----------------    URT = 8
                  ////////////////|
                58|----------------                   SRT = 1
                  | up
                60|----------------    URT = 2
                  ////////////////|
                62|----------------                   SRT = 1
                  |
                  | change/2/1
                70|----------------    URT = 8
                  ////////////////|
                71|----------------                   SRT = 1
                  | file
                75|----------------    URT = 4
```

FIGURE 2 -- DELAYS IN THE EXAMPLED FN CONSOLE DATA
(SRT = SYSTEM RESPONSE TIME; URT = USER RESPONSE TIME.)

SECS BY SYSTEM	SYSTEM TOTAL	KEYBOARD OPENS AT	AND THE USER ENTERS THIS STRING	SECS BY USER	USER TOTAL	COMMAND	ENVIR	CLASS
0	0	09:24:40	*CONSOLE TEST	7	7	*CMT	CMS	2COMMENT
8	8	09:24:55	EDIT TST FILE	5	12	EDIT	CMS	2NEWENV
3	11	09:25:03	INPUT	7	19	INPUT	EDIT	6NEWENV
1	12	09:25:11	THIS IS A TEST	6	25	THIS	E6IN	9MODIFY
0	12	09:25:17	REC NUMBER 2	7	32	REC	E6IN	9MODIFY
0	12	09:25:24	CRET	1	33	CRET	E6IN	9NEWENV
1	13	09:25:26	UP	2	35	UP	EDIT	6POINTER
1	14	09:25:29	$MOVE 1 DOWN 1	8	43	$MOVE	EDIT	6MODIFY
1	15	09:25:38	UP	2	45	UP	EDIT	6POINTER
2	17	09:25:42	CHANGE/2/1	8	53	CHANGE	EDIT	6MODIFY
1	18	09:25:51	FILE	4	57	FILE	EDIT	6NEWENV
3	21	09:25:58	TIMEOFF	3	60	TIMEOFF	CMS	2EXEC

MEAN SECONDS PER CMD: BY SYSTEM, 1.91 ; BY USER, 5.00 .
(USER TOTAL/ SYSTEM TOTAL = 74.07/ 25.93 = 2.86)

FIGURE 3 -- OUTPUT FILES, FN CMDS

SINGLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 60 ; FREQ = 12 ; AV TIME = 5.00

CATEGORY IDENTIFICATION			TIME SECS.	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
		EDIT	31	51.67	6	50.00	5.17	1.07
		CMS	15	25.00	3	25.00	5.00	.94
		E6IN	14	23.33	3	25.00	4.67	1.52

DOUBLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 110 ; FREQ = 11 ; AV TIME = 10.00

CATEGORY IDENTIFICATION			TIME SECS.	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
	EDIT	E6IN	13	11.82	1	9.09	13.00	.00
	CMS	CMS	12	10.91	1	9.09	12.00	.00
	CMS	EDIT	12	10.91	1	9.09	12.00	.00
	EDIT	EDIT	42	38.18	4	36.36	10.50	.43
	E6IN	E6IN	21	19.09	2	18.18	10.50	1.77
	EDIT	CMS	7	6.36	1	9.09	7.00	.00
	E6IN	EDIT	3	2.73	1	9.09	3.00	.00

TRIPLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 151 ; FREQ = 10 ; AV TIME = 15.10

CATEGORY IDENTIFICATION			TIME SECS.	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
EDIT	E6IN	E6IN	20	13.25	1	10.00	20.00	.00
CMS	CMS	EDIT	19	12.58	1	10.00	19.00	.00
CMS	EDIT	E6IN	18	11.92	1	10.00	18.00	.00
EDIT	EDIT	CMS	15	9.93	1	10.00	15.00	.00
EDIT	EDIT	EDIT	44	29.14	3	30.00	14.67	1.44
E6IN	E6IN	E6IN	14	9.27	1	10.00	14.00	.00
E6IN	EDIT	EDIT	11	7.28	1	10.00	11.00	.00
E6IN	E6IN	EDIT	10	6.62	1	10.00	10.00	.00

FIGURE 4 -- OUTPUT FILES, GROUPINGS BY ENVIRONMENT CATEGORIES

SINGLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 60 ; FREQ = 12 ; AV TIME = 5.00

CATEGORY IDENTIFICATION			TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
		$MOVE	8	13.33	1	8.33	8.00	.00
		CHANGE	8	13.33	1	8.33	8.00	.00
		*CMT	7	11.67	1	8.33	7.00	.00
		INPUT	7	11.67	1	8.33	7.00	.00
		REC	7	11.67	1	8.33	7.00	.00
		THIS	6	10.00	1	8.33	6.00	.00
		EDIT	5	8.33	1	8.33	5.00	.00
		FILE	4	6.67	1	8.33	4.00	.00
		TIMEOFF	3	5.00	1	8.33	3.00	.00
		UP	4	6.67	2	16.67	2.00	.00
		CRET	1	1.67	1	8.33	1.00	.00

DOUBLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 110 ; FREQ = 11 ; AV TIME = 10.00

CATEGORY IDENTIFICATION			TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
	INPUT	THIS	13	11.82	1	9.09	13.00	.00
	THIS	REC	13	11.82	1	9.09	13.00	.00
	*CMT	EDIT	12	10.91	1	9.09	12.00	.00
	EDIT	INPUT	12	10.91	1	9.09	12.00	.00
	CHANGE	FILE	12	10.91	1	9.09	12.00	.00
	UP	$MOVE	10	9.09	1	9.09	10.00	.00
	UP	CHANGE	10	9.09	1	9.09	10.00	.00
	$MOVE	UP	10	9.09	1	9.09	10.00	.00
	REC	CRET	8	7.27	1	9.09	8.00	.00
	FILE	TIMEOFF	7	6.36	1	9.09	7.00	.00
	CRET	UP	3	2.73	1	9.09	3.00	.00

TRIPLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 151 ; FREQ = 10 ; AV TIME = 15.10

CATEGORY IDENTIFICATION			TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
INPUT	THIS	REC	20	13.25	1	10.00	20.00	.00
*CMT	EDIT	INPUT	19	12.58	1	10.00	19.00	.00
EDIT	INPUT	THIS	18	11.92	1	10.00	18.00	.00
$MOVE	UP	CHANGE	18	11.92	1	10.00	18.00	.00
CHANGE	FILE	TIMEOFF	15	9.93	1	10.00	15.00	.00
THIS	REC	CRET	14	9.27	1	10.00	14.00	.00
UP	CHANGE	FILE	14	9.27	1	10.00	14.00	.00
UP	$MOVE	UP	12	7.95	1	10.00	12.00	.00
CRET	UP	$MOVE	11	7.28	1	10.00	11.00	.00
REC	CRET	UP	10	6.62	1	10.00	10.00	.00

FIGURE 5 -- OUTPUT FILES, GROUPINGS BY COMMAND CATEGORIES

SINGLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 60 ; FREQ = 12 ; AV TIME = 5.00

CATEGORY IDENTIFICATION	TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
6MODIFY	16	26.67	2	16.67	8.00	.00
2COMMENT	7	11.67	1	8.33	7.00	.00
9MODIFY	13	21.67	2	16.67	6.50	.35
6NEWENV	11	18.33	2	16.67	5.50	1.06
2NEWENV	5	8.33	1	8.33	5.00	.00
2EXEC	3	5.00	1	8.33	3.00	.00
6POINTER	4	6.67	2	16.67	2.00	.00
9NEWENV	1	1.67	1	8.33	1.00	.00

DOUBLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 110 ; FREQ = 11 ; AV TIME = 10.00

CATEGORY IDENTIFICATION	TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
6NEWENV 9MODIFY	13	11.82	1	9.09	13.00	.00
9MODIFY 9MODIFY	13	11.82	1	9.09	13.00	.00
2COMMENT 2NEWENV	12	10.91	1	9.09	12.00	.00
2NEWENV 6NEWENV	12	10.91	1	9.09	12.00	.00
6MODIFY 6NEWENV	12	10.91	1	9.09	12.00	.00
6POINTER 6MODIFY	20	18.18	2	18.18	10.00	.00
6MODIFY 6POINTER	10	9.09	1	9.09	10.00	.00
9MODIFY 9NEWENV	8	7.27	1	9.09	8.00	.00
6NEWENV 2EXEC	7	6.36	1	9.09	7.00	.00
9NEWENV 6POINTER	3	2.73	1	9.09	3.00	.00

TRIPLETON CATEGORIES

TOTAL OF CATEGORY TIMES = 151 ; FREQ = 10 ; AV TIME = 15.10

CATEGORY IDENTIFICATION	TIME	PERCENT OF TOT.	FREQ.	PERCENT OF TOT.	MEAN TIME	ST. ERR OF MEAN
6NEWENV 9MODIFY 9MODIFY	20	13.25	1	10.00	20.00	.00
2COMMENT 2NEWENV 6NEWENV	19	12.58	1	10.00	19.00	.00
2NEWENV 6NEWENV 9MODIFY	18	11.92	1	10.00	18.00	.00
6MODIFY 6POINTER 6MODIFY	18	11.92	1	10.00	18.00	.00
6MODIFY 6NEWENV 2EXEC	15	9.93	1	10.00	15.00	.00
9MODIFY 9MODIFY 9NEWENV	14	9.27	1	10.00	14.00	.00
6POINTER 6MODIFY 6NEWENV	14	9.27	1	10.00	14.00	.00
6POINTER 6MODIFY 6POINTER	12	7.95	1	10.00	12.00	.00
9NEWENV 6POINTER 6MODIFY	11	7.28	1	10.00	11.00	.00
9MODIFY 9NEWENV 6POINTER	10	6.62	1	10.00	10.00	.00

FIGURE 6 -- OUTPUT FILES, GROUPINGS BY CLASS CATEGORIES

USER COMMAND	ITS CLASS	VCPU IN MILLISECS CHANGE	VCPU IN MILLISECS TOTAL	TCPU IN MILLISECS CHANGE	TCPU IN MILLISECS TOTAL	PRT LINES CHNG	PRT LINES TOT	SIOS CHNG	SIOS TOT	PAGE RDS CHNG	PAGE RDS TOT
*CONSOLE TEST	2COMMENT	70	70	160	160	0	0	74	74	20	20
EDIT TST FILE	2NEWENV	25	95	87	247	0	0	14	88	32	52
INPUT	6NEWENV	2	97	15	262	0	0	0	88	6	58
THIS IS A TEST	9MODIFY	0	97	7	269	0	0	0	88	3	61
REC NUMBER 2	9MODIFY	1	98	14	283	0	0	0	88	8	69
CRET	9NEWENV	1	99	7	290	0	0	0	88	0	69
UP	6POINTER	2	101	11	301	0	0	0	88	5	74
$MOVE 1 DOWN 1	6MODIFY	77	178	113	414	0	0	15	103	29	103
UP	6POINTER	1	179	7	421	0	0	0	103	0	103
CHANGE/2/1	6MODIFY	2	181	12	433	0	0	0	103	4	107
FILE	6NEWENV	31	212	122	555	0	0	56	159	32	139

FIGURE 7 -- OUTPUT FILES, SYSTEM STATISTICS (FN SYSTATS)

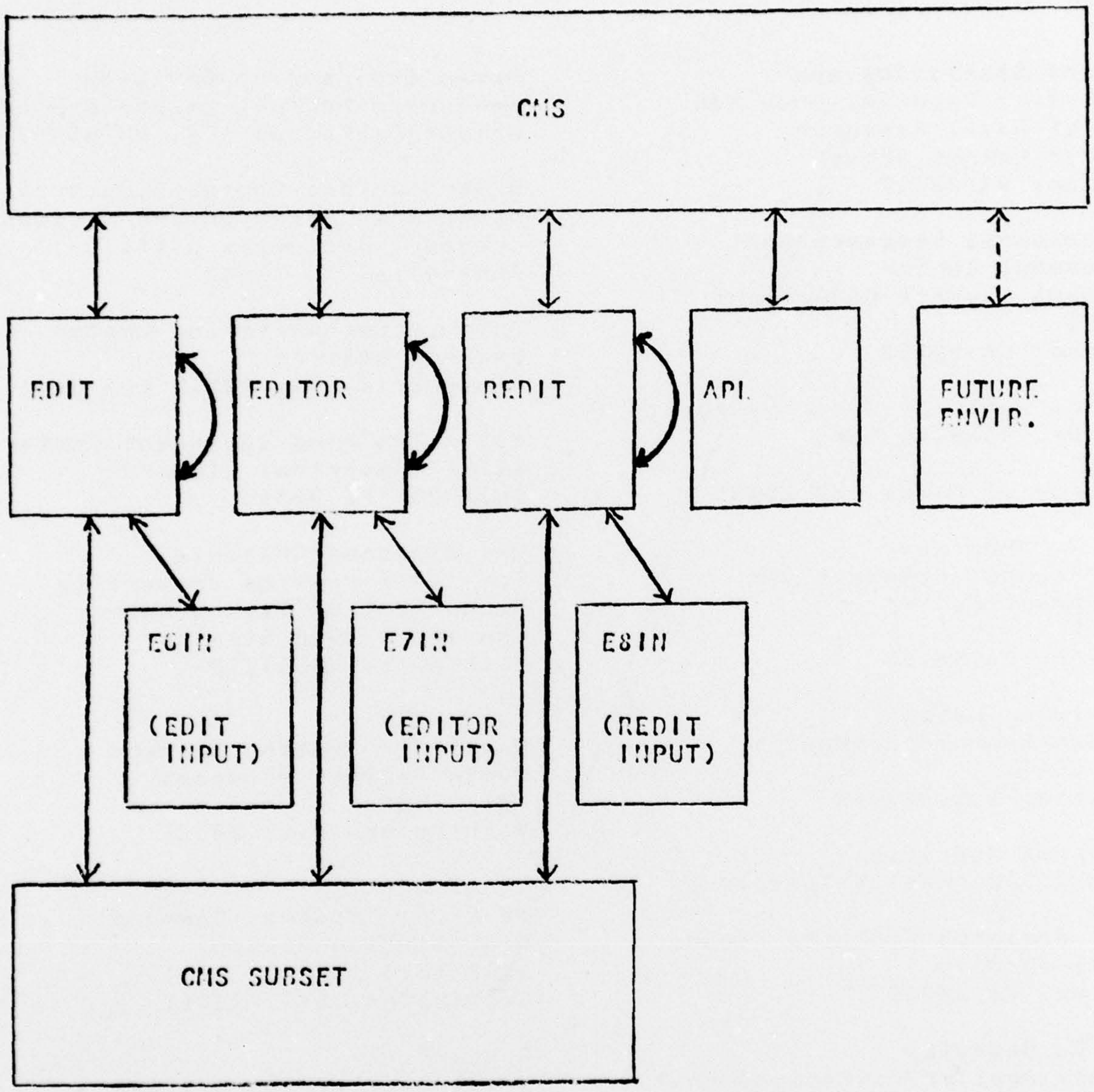

FIGURE 8 -- STARCAT ENVIRONMENT TRANSITIONS

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