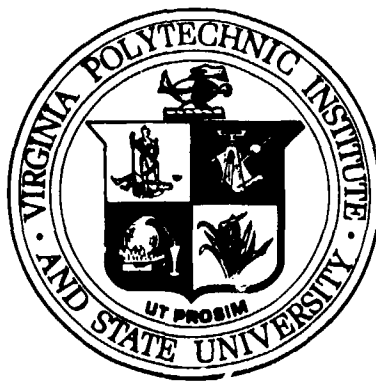
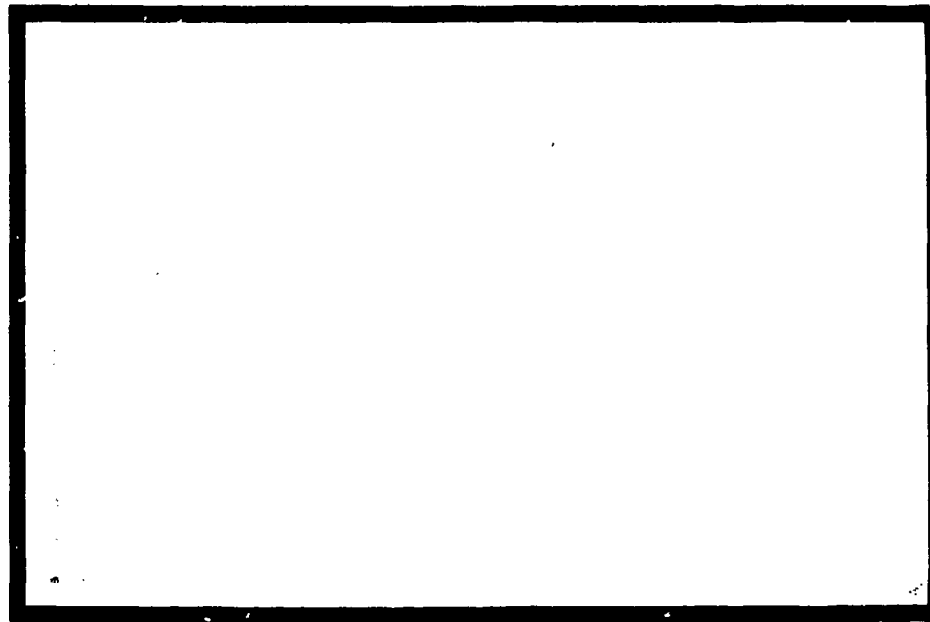


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SAM -- A CONFIGURABLE EXPERIMENTAL TEXT EDITOR
FOR INVESTIGATING HUMAN FACTORS ISSUES
IN TEXT PROCESSING AND UNDERSTANDING

Roger W. Ehrich



TECHNICAL REPORT

Prepared for
Engineering Psychology Programs, Office of Naval Research
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Work Unit Number NRSRO-101

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20. ABSTRACT

syntax that allows reasonably easy reconfiguration for special experiments. In particular, it is straightforward to insert the metering procedures required to measure specific aspects of human performance.

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INTRODUCTION

In order to perform behavioral studies relating to text processing applications it is necessary to have an editor that can be configured quickly for specialized experiments. Since most editors are inherently complicated, an organization is needed that experimenters can modify for behavioral studies without extensive programming experience. The result was an editor called SAM, which is a context oriented line editor with a number of novel features and creature comforts that computer people are not used to seeing on an editor. Some of these ideas come from years of discussion, others come from existing editors, and yet others had their origins in an editing/human factors seminar held in the Computer Science Department at Virginia Tech in the spring of 1980. Thus, SAM has some novel features, both in its external behavior and in its internal structure.

Appearance

One of SAM's most novel features is a queue, which is the mechanism by means of which lines may be moved around from location to location within a file or between files. SAM allows a user to open two files, called the PRIMARY and SECONDARY files, and the SWITCH command allows the user to flip back and forth between the two files. The queue is the means of transferring lines from one file to another, and with the queue one can accomplish such tasks as reversing line order and reordering sections of text in arbitrary order.

SAM allows the user to edit syntactically incorrect commands, and most of the command operands are generalized to function upward or downward by supplying a signed operand. In the case of string operands, a single space or sign after the command name acts as the string delimiter. All commands, switches, and switch states can be specified by typing a unique prefix, and underscores may be used to separate multi-word commands.

SAM does not allow a user to type operands for commands that are incorrect. In fact, the user is warned aurally of erroneous input, and the number of bells heard is proportional to the severity of the error. If the command is correct but the operand is erroneous, the user is warned and is asked to complete the operand from the point where the erroneous input occurred. On the other hand, every effort is made to make sense of the user's input.

SAM is intended as a programming tool, although some may find its features amenable to certain text processing applications as well. The user is urged to make use of relative movements in locating information to be edited. Although it is easy to determine absolute line numbers and locate information by absolute addressing, the command structure is designed to minimize the use of absolute addressing.

Internals

SAM has 8300 lines of code, mostly FORTRAN 77, in 55 modules. Of these, the main storage system is manipulated with only 3 procedures - INSERT, DELETE, and NEXT. All messages are produced by one subroutine, and two subroutines - CPARSER and SPARSER, are responsible for all command and operand keywords. These are automatic completion algorithms that allow an experimenter to add, delete, and modify names simply by inserting them into alphabetized tables. Two subroutines - COMMAND and STORE - take care of the detailed handling of individual characters in edit and input mode. Finally, there are 11 modular parsers that plug into the code as needed to decode individual operands. These are table driven so that they may easily be modified by altering state transition tables. The rest of SAM consists of the code necessary to communicate with the user's terminal open and close files, and perform the actual editing functions.

In order to specialize SAM for an experiment, the experiment designer

- 1) Inserts the command names into an alphabetized list in CPARSER.
- 2) Selects the appropriate operand parser for each command from those provided (or modifies some of the existing parsers).
- 3) Selects the semantic routine for each command that actually performs the editing function. Functions not provided by SAM must be added, and this requires on the average about 50 lines of code per new command.
- 4) Decides what should be metered and inserts calls to the metering procedure in appropriate places.

The time required to modify SAM varies from a few hours for simple command renaming or elimination to a week or two if new commands are to be designed.

USING NATIVE SAM

Input mode

- CR The standard line terminator. When the cursor is at the left margin, it causes a mode change to edit mode.
- LF Line terminator (␣J on terminals without LF).
- ESC Escape character preceding any character except those trapped by VMS will cause that character to be entered as input.

Command mode

There are two classes of commands - immediate commands and standard commands. Immediate commands are single character commands that are executed immediately when a key is struck at the beginning of a new line. There are 6 immediate commands:

- . Type the the current line.
 - # Type the number of the current line.
 - + Move the line pointer to the next line and echo this line.
 - Move the line pointer to the previous line and echo this line.
 - ? Type the default help for SAM
- CR Switch between edit and input modes and give a bell signal.

There are 31 standard commands, and several of these have synonyms. In the following table, capital letters denote minimal prefixes, and underscores may or may not be used as punctuation, as desired.

=, REPEat
ANchor
A, AREa
APPend
C, CHange
CQ, CLear_queue
COMbine
D, DELETE
DS, DELETE_To_string
EL, EDit_line

File
 GS, GEt_secondary
 HELp
 HEX
 Locate
 Next
 PD, POP_And_delete
 POP
 Q, QUEUE
 QD, QUEUE_And_delete
 QUIT
 RETurn
 R, REPLace
 S, SWitch
 SAve
 SEt
 SPLit
 STatus
 T, TYPE
 TQ, TYPE_Queue
 nnn (Set pointer to line nnn)

Command Completion

Whenever a unique command prefix is detected, the command is completed automatically. The user need not be aware of this, since if the rest of the command is typed after completion, the extra characters are ignored.

Character Set

Six characters are trapped by the VAX terminal driver, and these characters have the normal VAX functions. These are

CNTRL	C	ETX	(Returns control to the command processor)
CNTRL	O	SI	(Cancels the current output operation)
CNTRL	Q	DC1	(XON=Resume output)
CNTRL	S	DC3	(XOFF=Suspend output)
CNTRL	X	CAN	(Cancels any read and purges type-ahead)
CNTRL	Y	EM	(Returns control to the command processor)

In addition, the editor uses the following characters.

		CR	(Line terminator)
CNTRL	U	NAK	(Line delete)
		DEL	(Character delete)
		BS	(Character delete)
		ESC	(Escape)

CNTRL J TAB (Horizontal tabs)
 LF (Line terminator)

Any of these last 7 characters can be inserted into a line by preceding the character by ESC. In addition to the above characters, * is used to represent numerical infinity wherever the context makes sense.

Tabs

SAM has two types of tab stops, setable with the SET command. Pseudo tabs cause echoing of SP characters and insertion of SP characters into the text file. This feature facilitates indentation of programs. True tabs cause echoing of SP characters and insertion of HT into the text file.

Command pre-parsing

In edit mode, SAM checks for command validity as soon as a command is typed. If a command is invalid, two bells are given, and further typing is blocked. The user may backspace to make corrections or cancel the line. Valid commands:

- 1) May be preceded by non-printing characters
- 2) Must not contain spaces
- 3) May contain underscores for clarity
- 4) Must be a complete command or an unambiguous prefix
- 5) Must be followed by a non-digit if the command is a number
- 6) Must be followed by a non-letter if the command is a character string

Startup Command File

SAM has the capability for executing a startup command file when an editing session begins. This command file is executed just before SAM types EDIT or INPUT after the editor is invoked. When SAM is invoked, it searches the logical name tables in VMS

for the name, START_SAM. If this name is present, its translation is interpreted to be the name of the command file to be executed. As an example, suppose that init.sam was the command file to be executed. Then, the logical name assignment is made by typing the VMS command

```
ASSIGN init.sam START_SAM
```

Equivalently, this VMS command can be placed in the user's login.com.

All SAM commands can be executed by typing them in a file, one command per line. Any command line with improper syntax will be skipped.

COMMAND SUMMARY

=, REPEAt

Repeats the most recent successful command. Immediate commands cannot be repeated by using the repeat command.

A, AREa { N | * }

Displays the context of +N lines around the current line. If N is omitted, a default value dependent upon the terminal data rate is selected. The current line is unchanged.

ANchor

The location of the current line is saved by the editor. No matter what changes are made in the file, the RETURN command will return the editor to the anchored line unless it has been deleted.

APpend { STRING }

If no string is given, places the cursor at the end of the current line and enters temporary input mode. If a string is specified it is appended to the current line.

C, CHange { + | - | N | +N | -N | * | +* | -* } [D S1 { D S2 {
D } }]

On N lines, including the current line, replace string S1 with S2. The delimiter, D, may be any printing character that does not appear in either S1 or S2. The changes are made for the first, last, or all occurrences of S1, depending upon the setting of the change switch. The current line remains the same. The default is to change 1 line.

CQ, CLear_queue { N | * }

Clears the queue of the specified number of lines. If no N is specified, the entire queue is cleared.

COmbine

Appends the next line to the current line and replaces both by the single new line. The current line becomes the new line.

D, DELETE { + | - | N | +N | -N | * | +* | -* }

Deletes a specified set of lines including the current line. The current line becomes the next undeleted line in the direction of the deletions. The default is 1.

DS, DELETE_To_string [STRING | +STRING | -STRING]

Deletes lines, including the current line up to but not including the first line containing STRING. The command has no effect if no line containing STRING is found. Otherwise the current line becomes the one that contains STRING. The only characters that may precede STRING are a single SP, a sign, or a SP and a sign.

EL, EDit_line

Enters a special editing mode for the current line. Space to the point where a change is desired. Then type:

- C - Change current character and advance
- CR - Terminate edit line mode
- D - Delete current character and advance
- I - Insert string before next character
- R - Reverse the case of current character and advance
- CU - Re-edit the current line

File { + | FILENAME | +FILENAME }

Files the primary file and terminates the editor. If no FILENAME is specified the current file name is used. A new version number is generated if the + symbol is specified.

GS, GET_secondary [FILENAME]

Opens the named secondary file for editing. Any previously opened secondary file is eliminated from SAM's internal storage without writing it back out to permanent storage.

The secondary file can be stored permanently only by using the SAVE command.

HELp [COMMAND]

Types out a command list or provides help on a command if one is specified. If help is requested after making an error in a command operand, help will default to the help for that command. Help on SET command switches is available by typing, HELP SET <switch>.

HEX [MNEMONIC | hh | ddd]

If no operand is specified, the ASCII mnemonics for the characters in the current line are given. If the operand is an ASCII mnemonic, a 2 digit hex number, or a 3 digit decimal number, all 3 representations are returned. If the character is a control character, the terminal control code is also returned.

Locate [STRING | +STRING | -STRING]

Locates the first line containing the specified string. There is no effect if the string is not found. The only characters that may precede STRING are a single SP, a sign, or a SP and a sign. The number of lines traversed in locating the desired line is printed on the terminal.

Next { + | - | N | +N | -N | * | ** | -* }

Moves the current line pointer N lines in the specified direction. The default is 1.

PD, POP_And_delete { + | - | N | +N | -N | * | ** | -* }

Pops the specified number of lines from the queue into the text after the current line and deletes the popped lines from the queue. The current line is the last one popped from the queue. The default is 1. Upward pops will result in reversed line order.

POP { + | - | N | +N | -N | * | ** | -* }

Pops the specified number of lines from the queue into the text after the current line. The current line is the last one popped from the queue. The default is 1. Upward pops will result in reversed line order.

Q, QUEUE { + | - | N | +N | -N | * | ** | -* }

Places the specified number of lines, starting with the current line, onto the queue. The current line becomes the line following the last one placed on the queue. The default is 1.

QD, QUEUE_And_delete { + | - | N | +N | -N | * | ** | -* }

Places the specified number of lines, starting with the current line, onto the queue and deletes them from the text. The current line becomes the one after the last one deleted in the direction of the deletion. The default is 1.

QUIT

Leave the editor without writing files to permanent storage. If changes have been made, the user is asked to verify the request.

RETurn

Makes the editor return to the anchored line. The number of lines traversed in returning to the anchored line is printed on the terminal.

R, REPLace { + | - | N | +N | -N | * | +* | -* }

Deletes the specified lines, starting with the current line and enters input mode. If the deletion was an upward deletion, the inserted lines go above the current line. The current line becomes the last inserted line. The default is 1.

S, SWitch

The editing environment is toggled back and forth between the PRIMARY and SECONDARY files.

Save [+ | FILENAME | +FILENAME]

Files the current working file (PRIMARY or SECONDARY). If no FILENAME is specified the current file name is used. A new version number is generated if the + symbol is specified. The current file name will become the name of the file just written.

Set [SWITCH [STATE] | SWITCH [LIST]]

Allows the user to alter the internal behavior of the editor. A LIST is a sequence of numbers separated by SPACES. If a number or state is omitted, the editor default value is used. The SWITCHes and their STATEs are

ANsi_tabs Sets tabs in every 8 columns.
ARea { nnn } Sets the default context for the ARea command.
Bells { on | off } Sets audible notification of syntactic errors.
CHange { first | last | all } Affects the CHange command.
CLear_tabs { LIST } Clears tabs at specified locations.
CONvert_tabs { on | off } Sets echo of true tabs to SP characters.
Default_tabs { nnn } Tab in column 9 and pseudo tabs every nnn.
First_column { nnn } Sets the first column for editing commands.
Hard_copy { on | off } Sets echoing for hard copy terminals.
LAST_column { nnn } Sets the last column for editing commands.
Line_length { nnn } Sets the maximum line length for files.
PARENthesis_count { on | off } Sets paren counting in input mode.
PSEUDO_tabs { LIST } Sets pseudo tabs at specified positions.
Screen_width { nnn } Sets the terminal line length.
TABS { LIST } Sets true tab stops at specified positions.
TEK { on | off } Sets screen handling for Tektronix terminals.
Upper_case { on | off } Sets conversion to upper case.

SPlit { STRING }

Splits the current line into two lines using the cursor if STRING is not specified or before STRING if STRING is specified. The current line will be the second part of the split line. The only character that can precede STRING is a single SP.

SStatus

Displays current file names, identifies the working file, prints the current file lengths, and displays the state of the editing switches.

T, TYPE { N | * }

Types on the screen the specified lines, starting with the current line. The current line is the last one typed. The default is 1.

TQ, TYPE_Queue { N | * }

Types on the screen the specified lines from the queue. The default is 1.

N

Sets the line pointer to the line whose current line number is N. 0 is the empty line above the file, and * is the empty line below the file, since * represents numerical infinity.

SAM's STORAGE SYSTEM

Although numerous procedures support SAM's storage system, only three are used to enter or retrieve information. These are

```
INSERT (direction)
NEXT   (status,increment)
DELETE (status,increment)
```

where status is a byte that determines when the line pointer is at the top or bottom of the file and the other variables are of type *2.

INSERT requires that the line to be inserted is in the global array, input_buffer, and that icnt, the line length, be set to the line length. NEXT and DELETE return the current line to the input_buffer. The arguments can be positive or negative, and it is not possible to alter or delete the two special lines, TOF: and BOF: that are always present in the file.

The storage system itself is a virtual storage system that consists of three data structures -- the page tables, working storage for both primary and secondary files, and a queue. Upon entering SAM a delay is observed as the files are opened and as the source files are moved into the storage system. Once in the storage system, files can be edited very quickly. Source files are closed as soon as the storage system has been loaded, and the only open files are SAM internal files. If the system crashes or if the user exits with a çY, the internal files remain intact and current up to the last time the editor paged. Upon reentry, SAM

notices the presence of these undeleted internal files and asks the user if he wishes to recover them.

SAM requires a minimum of 18 pages of disk storage and at least 36 pages if both primary and secondary files are to be used.

The Page Table

The page table is a physically sequential list of the numbers of the pages of working storage. Each entry is a *2 page number, and a 0 byte separates currently allocated pages from free pages. A number of procedures are provided for entering and accessing information in the page table. These are:

READ_PT	(n)
WRITE_PT	(n)
INIT_PT	(n)
QUERY_PT	(status,code,n,logical,physical,length)
ENTER_PT	(n,length)
SIZE_PT	(n,begin,current,end,total)
RESTORE_PT	(n)
EXPAND_PT	(status,n,physical)
SHRINK_PT	(n,pages)
READ_WORK	(n,page)
WRITE_WORK	(n,page)

Page Contents

Each page of working storage consists of 109 24-byte fragments. Each text line occupies several fragments, depending upon its length. Each fragment has a *2 length field and both forward and backward pointers. The length field of the first fragment of a line contains the line length, and other fragments of a line have a length field containing -1. The backward

pointer of the first fragment of the first line of a page and the forward pointer of the last fragment of the last line of a page contain 0. No page in the storage system may be entirely empty.

Also stored with each page are the following *2 variables:

- fline - Pointer to the first fragment of the first line
- ffree - Pointer to the free space list
- nlines - The number of lines in the page
- nfree - The number of free fragments
- lline - Pointer to the first fragment of the last line

In addition to the variables above associated with a page, there are other global variables that contain important information.

These include:

- cfile - The number of the currently active file
- cfrag - Pointer to the first fragment of the current line
- cptr - The number of the current line in the page
- cline - The number of the current line in the file

Paging

When an insertion is attempted in a page that is full, a procedure called SPLIT removes several lines from the current page, including the current line, and places them in a new page. The new page will contain between 10% and 50% of the lines from the old page. The advantage of the page table is that a line can be retrieved quickly from any location in the file and that deletions are also very fast, no matter how many lines are deleted. In the first implementation there is no provision for merging pages that have low occupancy. Under the assumptions that lines occupy an average of two fragments and assuming 75% page occupancy, the storage system will hold 32,767 lines, which is the address space of the editor.

The page tables for both the primary and secondary files consist of single 1534 byte records, and working storage has up to 766 pages of 3071 bytes for each file. Working storage makes use of direct access so that pages may be located without reading through the entire file.

File Recovery

SAM's internal working files are deleted upon normal exit from the editor. Should the system crash or should the user inadvertently leave SAM by typing ϕY , the internal files are not deleted. Upon reentry into SAM, if these files are present, SAM will ask whether the user wishes to continue editing them. The user should respond with an immediate subcommand, y or n. The working files are updated only when the editor pages. Normally the SAVE command would be used if the user wishes to guarantee the currency of the work, though SAM can be forced to page by typing the SWITCH command.

I/O Services

All of SAM's i/o services are provided through assembly language subprograms that call the VAX Record Management System. The lowest level procedures are:

EXPAND_FNAME
OPENER
CLOSER
READ_SRC
WRITE_SRC
PAGEIO
STACK

SAM ignores all fixed control fields of text input files, but it writes sequentially numbered fixed control fields into its output files. The fixed control accounts for the sequential statement numbers that appear when a SAM-edited file is printed.

SAM's COMMAND ANALYZER

Parsers

SAM has 13 modular parsers, 2 of which are table-driven keyword analyzers and the remainder of which are finite state parsers. The keyword analyzers are

C_PARSER
S_PARSER

and the operand parsers are

CHANGE
EMPTY
FILE
HEX
NUMBER
POS_NUMBER
SIGNED_NUMBER
SIGNED_FILE
STRING
SIGNED_STRING
SWITCH

The operand parsers are adequate for parsing all command operands, and if new commands are created, these parsers can be used. C_PARSER and S_PARSER are used to decode command names and switches, respectively, on the basis of unique prefix. New command names or switches can be added simply by including them in alphabetized tables.

Syntax

One of the most difficult aspects of the design of SAM's syntax was determining a rule for delimiting a string. Except in the CHANGE command where string delimiters are printing

characters, a string operand is delimited from preceding characters by a single space. Also, if it makes sense, other implied delimiters can be used. For example, L90 makes sense because 9 is not part of any command containing characters; therefore 9 must be the first character of the operand string for the LOCATE command. Lab, however, appears to the syntax analyzer as an invalid command.

SAM's SCREEN HANDLER

SAM's character handling is one of its most important features, and SAM relies heavily upon full duplex communications. SAM interprets characters one by one as they are typed, and the response to each character is computed individually. While SAM has been implemented to be terminal independent, three broad classes of terminals - scrolling CRT's, non-scrolling but paged terminals, and hardcopy terminals - are supported. Two procedures do most of SAM's character interpretation:

STORE
COMMAND

STORE does character handling for input mode, and COMMAND does character handling in edit mode. These procedures are supported by three bottom level i/o procedures

PUT_CHARS
XMITCHARS
GET_CHARS

and the following service procedures:

ECHO
SCREEN
TYPE_LINE
MSG
NEXT_TAB
TYPE_NUMBER
UPPER
QUIT
CLASS

In input mode, each character is interpreted, echoed, and stored as necessary in the input buffer by STORE. In addition, STORE keeps track of the physical location of each character on the screen so that it knows how to backspace over tabs and so that if

physical screen wraparound occurs, the screen line count can be updated. When SAM is called it sends an escape sequence to test for a Tektronix 4012/13 display. If the display is a Tektronix, SAM remembers the fact and does special screen handling, since the Tektronix will not scroll. If hardcopy or Tektronix mode is set, prompting and backspace handling change since no selective erase is possible on such terminals. Also, in Tektronix mode, each time the screen is cleared, a dither in the range 0 to 19 is subtracted randomly from the cursor's vertical home position to reduce screen degeneration.

In edit mode, character handling changes slightly. Every nonprinting character in the command input buffer is echoed as a SP character so that the user can tell exactly how many characters are in the buffer. As characters are typed, C_PARSER attempts to locate the end of the command. When it does, if the command is ambiguous or in error, the user is notified and, in the latter case, prevented from further typing. If the command is correct, no further parsing occurs until the line is complete. If the operand parser finds an error, the command line is rewritten up to the point where the error was detected so that the user can correct the command.

All user messages are transmitted to the terminal by the MSG subroutine. Thus, it is straightforward to change the communication from SAM to the user.

Screen clearing and special functions are provided by the SCREEN subroutine which, for the Tektronix, checks the line count each time it is called to determine whether there is space on the screen for the next line. Since ECHO is the only procedure in SAM to echo linefeed characters, ECHO is chiefly responsible for counting lines. STORE, COMMAND, and TYPE_LINE also increment the line count if physical wraparound occurs, since they keep track of screen location. TYPE_LINE has principal responsibility for calling SCREEN to test for available screen space. SCREEN must be called directly at all other points in SAM where output is sent to the screen with other output services.

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