THE DESIGN, IMPLEMENTATION, AND USE OF
LEDIT: A REAL-TIME EDITOR FOR LISP

by

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ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE
The reader need not have expert knowledge of the LISP programming language in order to benefit from reading this document. However, it is assumed that the reader has at least a basic acquaintance with LISP structures, functions, and terminology.

It is particularly important that the reader be familiar with property lists; as LEDIT is especially designed to help the user edit these LISP structures.

An excellent reference the reader may use to learn about or review LISP is *Let's Talk LISP*, by Laurent Siklossky [1]. *Anatomy of LISP*, by John Allen [2], is also highly recommended, especially for the more seasoned LISP programmer.

KEYWORDS: S-expression, atom, property list, editor, interactive, real-time, workspace, PEXPR, EXPR, LISP interpreter, pointer.
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Part 1: Motivation for the Design and Implementation of LEDIT

One of the most attractive features of the programming language LISP is that it fosters close and frequent interaction between the user and the computer. Despite LISP's extremely dynamic programming environment, editing programs or data is a considerably less dynamic activity on many LISP systems. Most often, editing function definitions or the data base requires leaving the LISP interpreter to use a conventional text editor. This is somewhat akin to using a draft horse to pull a Ferrari!

During a typical online programming session using a LISP interpreter, the user receives feedback from the machine--often and immediately. Normal procedure is to create small modules and test them as they are created.

In contrast, sessions employing other widely-used programming languages (especially batch-oriented systems) often result in a minimum of interaction between user and machine. Typically, the programmer codes the program, and the machine compiles it. Then the program is executed, and (eventually) the user receives the output.

Unfortunately, even in many LISP systems, the user is unable to sustain this continuous feedback relationship with the interpreter when the LISP program or database needs editing. Usually the programmer must leave the interpreter and use a system text editor. Leaving LISP is one problem; using a conventional text editor for LISP code presents another problem. Text editors are designed for
the basic structure composed of characters and lines. The basic structures of LISP are S-expressions, which have no relationship to characters and lines. So editing LISP with a text editor is somewhat artificial and inconsistent.

Since the need for editing is bound to arise, this drawback demands attention. The solution presented here is to introduce a LISP editor composed of LISP functions.

Thus, the fundamental purpose of this project was to design and implement such a real-time, workspace LISP editor. The main benefit expected was improvement (in terms of convenience and consistency) in the programming environment for the user of the LISP facilities available on the Itel ASR5 here at KSU.

1.1 DISADVANTAGES OF THE CURRENT LISP SYSTEM

Without a workspace editor, the user has two choices when she wishes to make changes in the function definitions or the data base in her current workspace:

(1) The user can retype the definition or property list with the desired changes. Certainly, this is a poor solution for the user—especially when long portions of code must be reentered.

(2) If the code has been stored in a file, another possibility for the user is to leave the LISP interpreter, use a conventional text editor to make corrections to the LISP file, recall the interpreter, and reload the altered file. In addition, once back in LISP mode, it may be necessary for the user to read the stream from a number of files and repeat some initialization to return to the
state the program was in when the user exited from the interpreter.

1.2 ADVANTAGES OF THE REAL-TIME LISP EDITOR

The in-core LISP editor provides the user with several advantages:

(1) There is no need to exit from the interpreter to correct functions or property lists. The user simply puts the editor into her workspace and uses its functions to make changes in the list structures there. It is possible for the user to do all her work without ever having to leave the LISP environment. This is compatible with the highly interactive nature of LISP.

(2) When combined with a pretty printer, the LISP editor makes it much easier to modify function definitions and property lists.

A pretty printer is a formatting device which makes LISP code display more readable. (A good example is [3].) For example, the following LISP code looks rather confusing:

(DEFUN COUNTATOMS (L) (COND ((NULL L) 0) ((ATOM L) 1) (T (PLUS (COUNTATOMS (CAR L)) (COUNTATOMS (CDR L))))).

A pretty printer would make the meaning of the expression much clearer by producing the following:

(DEFUN COUNTATOMS (L)
  (COND ((NULL L) 0)
       ((ATOM L) 1)
       (T (PLUS (COUNTATOMS (CAR L))
                (COUNTATOMS (CDR L))))).

The LISP editor operates on the basic structures of LISP: S-expressions—not on characters and lines as a text editor does. The user can have the editor clearly display the structure she wishes to concentrate on. Then changes which are particularly useful to the
LISP programmer can be made (e.g., group/ungroup S-expressions), as well as textual changes.

(3) Another benefit of this type of editor is particularly appealing to programmers who find the nested parentheses annoying. A very helpful side effect of using LISP functions to edit LISP structures is that the editor will not accept unbalanced parentheses!

1.3 FACTORS WHICH INFLUENCED THE EDITOR DESIGN

Several factors influenced the design of LEDIT:

(1) Since line-by-line terminals are most commonly available here, the editor is designed for that type of line-oriented device. (Examples of editors for screen-oriented display include [4] and EMACS [5].)

(2) The available functions give the programmer the power to do most of the operations available in a conventional text editor. However, the most useful are the LISP-oriented operations.

In addition, LISP editor commands which perform functions equivalent to text editor functions (e.g., QUIT, FILE, CH) have formats similar to the text editor commands. This was done because most users in the student environment will be very accustomed to using conventional text editors; the similarity should make using both types of editors less confusing.

(3) The editor presented here has a relatively uncomplicated design. Readability and ease of implementation were the primary concern; a major goal was for the code to serve as an example for anyone wishing to add a workspace editor to a LISP system. It can
be easily altered, shortened, or extended. In fact, this particular editor is based on a very simple one presented by Charniak-Riesbeck-McDermott in their book *Artificial Intelligence Programming* [6]. Their basic editor was used as a foundation and extensively modified and enlarged to produce LEDIT.

4. This editor contains a facility which enables the user to define her own edit commands using combinations of existing commands. This provides an elementary example of how a user may tailor an editor to suit her needs. (EMACS [5] provides an excellent example of this feature.)

5. It is possible to make the editor a collection of functions and global edit variables. In this type of situation, the edit functions can be called in the same way other LISP functions are invoked. Thus, edit commands may be interspersed with testing.

   This is certainly in keeping with the exploratory attitude of LISP, which we are trying to encourage. However, for safety's sake, LEDIT was designed to be a single main function which contains the edit variables within its scope and calls the edit functions as it is driven by the input of edit commands. This design allows the user to abort the editing if necessary.

   LEDIT also causes a conceptual shift from LISP to 'edit mode.' Editing is done while in 'edit mode,' and testing is done when the user 'returns' to LISP.

6. Because this editor is intended primarily for student users, there is extensive error checking in the functions. The error checks include explanatory messages to the user.

7. One source of potential problems was insoluble on this
system. Commands and arguments are put into the input buffer by the LISP READ function. The interpreter executes the functions when the user enters a carriage return.

Problems can arise if the user does not enter the proper number of arguments with a command, because the editor has no way of distinguishing between a command and an argument. It simply interprets by the order in which atoms are entered. So, there is the possibility that the editor will misinterpret all subsequent input contained in the buffer after an error has occurred.

The best solution to this problem is to have the editor abort all commands in the input buffer after an error condition is encountered. Unfortunately, this is not possible on our system, as there is no way to test for a carriage return.

The only way to check for end of line of input commands and arguments is to have the user place some special delimiter at the end of each line. It was decided that this would be too irritating for the user. In any event, it is unlikely that serious damage will be done if this problem arises; in most cases the editor will merely issue a series of error messages for each misinterpreted command. In addition, the safety valve of aborting the edit version is always available to the user in case of serious trouble. The decision was made to favor user convenience over safety in this particular case.

Conclusion

The primary reason for implementing this real-time LISP editor was to improve the LISP user's programming environment. The purely mechanical aspects of editing should be easier and less time-
consuming when the programmer can use LEDIT instead of a conventional text editor. In addition, the conceptual shift from 'LISP mode' (which requires the user to think in S-expressions) to a text editor (which requires the user to think in characters and lines) will not be necessary when LEDIT is available.

The main factor which influenced the design of this particular implementation of a real-time LISP editor was that it serve as an example for anyone wishing to implement the same type of system. The code was designed to be as self-explanatory as possible. There is no 'clever' programming; only standard LISP functions are used. Thus, the code can be easily transferred to any machine with a basic LISP interpreter.

On the existing system here at Kansas State University, LEDIT is rather expensive to run with the interpreter. A LISP compiler will make the editor operate much more efficiently.

The program is designed to allow easy extensibility. So, it is easy to include more edit functions if the implementer wishes to. The define edit command facility, in particular, is one which can certainly be extended (e.g., allow edit functions which can take arguments). Another desirable feature which may be added with relatively little trouble is the ability to put parts from one property list into another during editing. The program is also easily modified; it will not be difficult for the implementer to tailor the editor to fit the kinds of editing most frequently needed.
Part 2. Overview of LEDIT

In general, the purpose of the edit functions is

(1) to move the edit pointer (a sort of cursor) to subexpressions of the main list being edited and

(2) to make desired changes in the subexpressions.

Essentially, the editor enables the user to tell the editor where to go and what to do when it gets there. Since the primary structures in LISP are S-expressions, the edit pointer moves from one S-expression to another, and edit commands work on the S-expressions pointed to by the edit pointer.

The user calls the editor by simply calling the function LEDIT (see Figure 2.1) with two arguments:

(1) the name of the atom whose property list is to be edited and

(2) the name of the property whose value is to be edited (or nothing if the user wishes to edit the whole property list of the atom). From this point until the user terminates the editing, the user is in edit mode.

The edit function can be called recursively (See Figure 2.1); i.e., while in edit mode, the user may edit another property list and then return to edit the previous list.

Command processing is a continuous loop of <read command--execute command>. The user may enter as many commands as she wishes on a line; the editor will process each one in the order in which they are placed into the input buffer.

Because edit lists may be quite long, nothing except error messages is displayed by the editor—unless the user requests a printout of the portion she wishes to concentrate on.
IEDIT

Initialize basic editor structure and variables;
LOOP

EDIT_NEW_SEXPR
Initialize (or restore) edit markers for expression;
LOOP

PROCESS (COMMAND)
COMMAND

Until END;

Until DONE

If COMMAND = EDIT,
PROCESS calls EDIT_NEW_SEXPR.
Thus S-expressions may be edited recursively.

Figure 2.1
There is only one edit variable which is global. This is the variable which saves names of edit commands defined by the user. This variable is global so that user-defined edit commands may be used throughout the LISP session—not just during execution of the edit function in which the command was defined. All others are local to the edit function and global to the functions it calls. Of course, saved altered property lists are available to the entire workspace.

--------
- LEDIT -
--------

LEDIT is a PEXPR which allows the user to invoke the editor by typing

(LEDIT <atom-name> opt:<property-name>).

[OPT: here denotes an argument which may be omitted.]

The reason LEDIT is a PEXPR is to remove the necessity for the user to type quotes before the parameters. The work of setting editor variables and calling the command processor is done by LEDIT. The major editor variables are all local to LEDIT and global to the editing functions it calls. The body of the LEDIT function is a loop which edits property lists until the *EXPRESSIONS* stack is empty.

---------------------
- EDIT_NEW_SEXPR -
---------------------

Initially, this function places the *EXPRESSION* currently being edited (if there is one) onto the *STORED_EXPRESSIONS* list. Then, if PROPERTY_NAME is not nil, EDIT_NEW_SEXPR calls
PROPERTY_LIST_TO_EDIT to locate the given property on the given atom's property-list. If PROPERTY_NAME is not nil, the atom's whole property-list will be the expression to be edited. The rest of the function is a loop which reads a command, processes the command, and stops when the command FIND is received.

- INITIALIZE_EDIT_MARKERS -

This function uses FIND_PROPERTY to retrieve a list which contains the marker to the actual property_list being edited. For example:

Atom A has the following property-list:

\[
\text{atom} \quad \text{property-list} \\
\{ A \quad (P1 \quad (M \quad N) \quad P2 \quad (Q \quad R) \quad P3 \quad (X \quad Y)) \}
\]

The command (EDIT A P2) will store

\[(M \quad N) \quad P2 \quad (Q \quad R))\] on the list *ORIGINAL_EXPRESSIONS*.

marker to P2's place on plist

The command (EDIT A) will store

\[
\{ A \quad (P1 \quad (M \quad N) \quad P2 \quad (Q \quad R) \quad P3 \quad (X \quad Y)) \}
\]

This is done so that the first element on the edit list can be modified. The actual value of *EXPRESSION* will be exactly the property list or part of the property list which the user specifies. In the example above, *EXPRESSION* will have the values

\[(P2 \quad (Q \quad R)) \quad \text{and} \quad (P1 \quad (M \quad N) \quad P2 \quad (Q \quad R) \quad P3 \quad (X \quad Y)), \text{respectively.}\]
The edit markers *EDIT* and *LEVEL* are both now initialized to *EXPRESSION*. A top marker is placed on the *EDIT_POSITIONS* stack. The specified atom and prop-names are stored on the stacks *ATOM_NAMES* and *PROP_NAMES*, so that they can be restored in case of recursive editing.

----------
- PROCESS -
----------

This function recognizes the edit command which is in the input buffer and calls the appropriate edit function to execute the command. The structure of PROCESS is that of a basic CASE statement. Thus, in most cases, adding a command to the editor will involve no more than adding an S-expression of the following form to the branches of the CCNE statement:

\[(= \langle\text{command}\rangle \text{ COMMAND}) (\langle\text{command}\rangle \langle\text{possible argument list}\rangle))\].

2.1 Explanation of How Process Executes Edit Commands

(It will be helpful for the reader to refer to the user manual explanation of edit commands [Part 4] as well as the code and documentation for the edit functions used.)

1 USER DEFINED EDIT COMMANDS

The function is simply executed. Note that user_defined commands may not have arguments.
(2) HELP

The HELP function requires a single atomic argument which is either the atom 'ALL or the name of an edit command. The appropriate explanatory message is then displayed on the screen.

(3) TYPE

The Pretty-Printer function SP is called to output the value of *EDIT!* in a meaningful format. The current edit pointer will be the CAR of this list. Note that the editor does not display to the screen unless there is a user request or an error.

(4) EDIT

This command causes EDIT_NEW_SEXPR to be called to initiate editing of another list; the atom and property are specified by the user. The old edit list and edit markers will be saved. In this way, the user may edit as many lists as she wishes while in edit mode.

(5) DEFCMD (Define Command)

The user may define her own commands using combinations of existing edit commands. To do so, she simply enters the name of the command and a sequence of commands. The user-defined edit function will then be available during any edit session while the interpreter is still executing. Note that these commands may not take arguments.
(6) RPT (Repeat)

RPT allows the user to repeat a sequence of edit commands a given number of times. PROCESS actually generates a new function name, calls DEFCMD to define a function consisting of the sequence of edit commands to be repeated, and uses RPT_USER to execute the sequence the given number of times.

(7) CH_CMD_DELIM and CH_LIST_DELIM

These two commands allow the user to change the delimiters for argument lists. Initially, the character '/' is the *LIST_DELIMITER*, and the atom ENDCMD is the *CMD_DELIMITER*. The character '/' is used to separate argument lists for CH, CH!, CHATOM, CHATOM!, CHSTR, and F(ind). The atom ENDCMD is used with DEFCMD and RPT.

(8) REM

This command allows the user to remove a given number of S-expressions from the level of her current position to a buffer which she names. Subsequent REM commands to the same buffer will add those S-expressions onto the end of the buffer. The buffer is really just a list of S-expressions.

(9) BEPL

This command allows the user to take a given number of S-expressions from the buffer she specifies beginning at the position in the specified buffer. This list of S-expressions is then inserted after the current edit position. The buffer may be reused.
(10) DISPLAY

The function DISPLAY pretty prints the names of buffers which the user has created.

(11) CONTENTS

This command causes the display the contents of the buffer which the user specifies.

(12) UN and UN<n> and UN*

These commands ungroup the current edit pointer as many times as specified or until the current edit pointer is an atom. UN uses the simple edit function UNGROUP to remove one level of nesting. UN* uses REPEAT and the auxiliary function UN* to ungroup until the current edit pointer is an atom. (The auxiliary function is used so that no error message is returned if the editor tries to ungroup an atom.) If a number of UNGROUPS are requested PROCESS uses REPEAT and the UNGROUP function to do the specified number of ungrouping. If the current edit pointer becomes an atom before the given number of ungroups is done, an error message will be printed.

(13) DEL and DEL<n> and DEL*

These functions delete the current edit pointer as many times as specified or until at the end of the current edit level. DEL simply executes the edit function DELETE↑ to delete the current edit pointer. DEL* and DEL<n> use the auxiliary function DELETE_N to do the given number of deletions.
(14) IA and IB

These commands are simply executed with the insertion as the argument list read by the function ARG_LIST.

(15) CH and CH↑

These commands both cause process to call CHANGE_N to make a given number of changes to the edit list. Three arguments are needed: (1) the old part which is to be changed, (2) what it is to be changed to (or CAR *EDIT↑↑* if command is CH↑), and (3) how many changes are to be made. PROCESS uses the function ARG_LIST to get the first two arguments and the LISP function READ to get the number of changes.

(16) CHATCM and CHATCM↑

These commands cause PROCESS to use CHANGE_ATOM to edit the characters in an atom. The first three arguments required are all atoms. It is possible to get these arguments with simple use of LISP's READ function; however, the function ARG_LIST is used for consistency with CH and CH↑ which require the *LIST_DELIMITER*. ARG_LIST should return a list of the single atom argument. Then the CAR of that list is sent as the parameter to CHANGE_ATOM. READ then reads the final argument which is the number of changes to be made.
(17) CHSTR

PROCESS uses CHANGE_STRING to change a string of characters within atoms to another given string of characters. Again, the CAR of the argument list is passed; and a call to READ reads the number of changes to be made.

(18) F(ind)

The command F cause PROCESS to use FIND to locate the list returned by the function ARG_LIST.

(19) S and TOP

PROCESS calls the corresponding functions which perform these commands: BACK_TO_START and TOP, respectively.
Part 3: Details of LEDIT Design

There is only one global variable in the LEDIT program. This variable is *USER_COMMANDS*, which stores the names of user-defined edit commands. *USER_COMMANDS* is global so that the user will have access to user-defined commands during the entire session with the interpreter, not just during one session in the editor.

The following part of this report is a detailed description of each major function in the LEDIT program. It will also be helpful to refer to the LISP code of LEDIT (APPENDIX I). When a semantic category is absent from the description of a particular function, then the obvious inference is intended; for example, if PARAMETERS is omitted, then the function has no parameters.
LEDIT

local variables:  *EXPRESSION*  (1)
                 *EDIT*        (2)
                 *LEVEL*       (3)
                 *EDIT_POSITIONS* (4)
                 *ORIGINAL_EXPRESSIONS*  (5)
                 *STORED_EXPRESSIONS*  (6)
                 *ATOM_NAMES*  (7)
                 *PROP.Names* (8)
                 *RPT_Cmd*     (9)
                 *BUFFERS*     (10)
                 *LIST_DELIMITER*  (11)
                 *CMD_DELIMITER* (11)

(See section 3.1 for further explanation of these variables.)

Parameters:  ATCM.NAME
             PROPEJTY_NAME

Functions called:  EDIT_NEW SEXP
                   ERROR.MESSAGE

Description

If no ATCM_NAME then
   ERROR_MESSAGE 'Too few arguments
   RETURN to LISP Mode

Initialize Edit Structures
Loop
   Call EDIT_NEW SEXP
Until no edit expr on stack ; initial
   ; condition
   ; restored
3.1 Major Variables Used by LEDIT

(1) *EXPRESSION*

This variable is the entire expression being edited; it has the value of either the whole property list of the given atom or the property name and property value of the given atom and property. The value of *EXPRESSION* is initialized by the edit command.

(2) *EDIT^*

This is the edit pointer; its value is an S-expression contained in *EXPRESSION*. For example, suppose *EXPRESSION* is (A B C) and the user wishes to fix B. She can conceptually move the edit pointer to that place in the list (A B C). The actual value of *EDIT^* will be the S-expression (B C). So, in this paper 'edit pointer' and 'current edit' position actually refer to the CAR of the variable *EDIT^*.

(3) *LEVEL*

This variable represents the level which contains the edit pointer. For example,

*EXPRESSION*   (A (B C D) E)
*EDIT^*        (C D)
*LEVEL*        (B C D)
Thus, it is used to save the positions to the left of the edit pointer.

(4) *EDIT_POSITIONS*

This variable represents a stack which is used to save edit levels and pointer positions above the current level when the editor is moving down in the expression. When the editor moves down a level, the current value of *EDIT* and *LEVEL* are pushed onto the stack of *EDIT_POSITIONS*. When the editor moves up, it resets those variables to the values which are on the front of *EDITPOSITIONS* (i.e., the CAR and CADR of *EDIT_POSITIONS*). Then those values are popped off the stack; i.e., *EDIT_POSITIONS* is set to the CDDR of *EDIT_POSITIONS*.

(5) *ORIGINAL_EXPRESSIONS*

The editor works only on a copy of the property list to be edited. *ORIGINAL_EXPRESSIONS* saves the original property list. This will be changed to the edited version if the user specifies the FILE option when she leaves the editor. Otherwise, the edited version will be discarded; and the original property list will be unchanged.
(6)  *STORED_EXPRESSIONS*

This variable is used to save information about the expression being previously edited when the EDIT command is called recursively inside the editor. The value is saved on the *STORED_EXPRESSIONS* stack and popped as the user finishes editing the expression.

(7)  *ATOM_NAMES*

This stack contains the atom names whose property lists were being previously edited when recursive edit calls were made. The atom name for the list being currently edited will be on top of the stack.

(8)  *PROP_NAMES*

This stack contains the property names whose values were being previously edited when recursive edit calls were made. The property name for the list being currently edited will be on top of the stack. Names are popped after end of editing.

(9)  *RPT_CMD*

This variable is used to save the internally generated name of a command which is composed of the list of edit commands entered by the user when the RPT command is used.
(10) *BUFFERS*

This variable is a list of buffers named by the user and used to move blocks of S-expressions. (See REMOVE, REPLACE commands.)

(11) *LIST_DELIMITER*, *CMD_DELIMITER*

These variables are delimiters for lists of arguments and commands. (See CH, CH↑, CHATOM, CHATOM↑, CHSTR, F, DEFCMD, RPT commands.)

Originally, they are set to '/ ' and ' ENDCMD', respectively. They may be changed by the user.
EDIT_NEW_SEXPR

Calling functions: LEDIT

Local variables:

COMMAND: edit command entered by user

Parameters: ATOM_NAME
            PROPERTY_NAME

Functions called: PROPERTY_LIST_TO_EDIT
                   ERROR_MESSAGE
                   INITIALIZE_EDIT_MARKERS
                   END
                   RESTORE_EDIT_MARKERS
                   PROCESS

Description

Store edit expr (or 'Done)

Get new p-list to edit

If p-list NOT FOUND then
   Call ERROR_MESSAGE
   Restore edit expr
   Pop stored_expr list
else initialize edit expr

Loop

   Read edit command
   If command = 'END then
      Discard or save edit expr
      Restore previous edit expr
      RETURN

   Call PROCESS (COMMAND)

End loop
Calling Functions: EDIT_NEW_SEXPR

Parameters: ATOM_NAME
            PROPERTY_NAME

Functions called: FIND_PROPERTY

Description

If null prop_name then
  (atom_name entire p-list)
else call FINDPROPERTY
FIND_PROPERTY

Calling Functions: PROPERTY_LIST_TO_EDIT

Parameters: PROPERTY_LIST
PROPERTY

Functions called: FIND_PROPERTY !!!RECURSIVE!!!

Description

If at end of p-list then nil
else if prop-name = second elt of p-list
then p-list
else move over two elts on p-list
Call FIND_PROPERTY (new p-list, prop-name)

This function returns the part of the property list along with a leading marker to the place on the property list. The marker is the element to the left of the property to be edited; or it is the atom itself if the entire list is to be edited (i.e., PROPERTY is nil).

FOR EXAMPLE: The property list of ATCM1 is

(P1 (A B) P P2 (C D) P3 (E F))

If PROPERTY Y = P2 then

(((A B) P2 (C D) P3 (E F)))

will be returned.

If PROPERTY = NIL then

(A (P1 (A B) P2 (C D) P3 (E F)))

will be returned.
INITIALIZE_EDIT_MARKERS

Calling functions: EDIT_NEW_SEXPR

Functions called: COPY (edit expression)

Description

Store original expression

If property-name = NIL then
   edit expr <-- COPY (CDR atom-name)
else edit expr <-- COPY (prop-name prop-value)

Push 'TOP marker onto *EDIT_POSITIONS*

*LEVEL*, *EDIT* <-- edit expr

Push atom-name onto *ATOM_NAMES* stack

Push prop_name onto *PROP_NAMES* stack
COPY

Calling functions:  INITIALIZE_EDIT_MARKERS
                    ARGUMENTS
                    REMOVE
                    CHANGE_N

Parameters:  L(IST)

Functions called:  COPY !!!RECURSIVE!!

Description

If list is an atom (including nil) then
RETURN List
else (COPY (CAR list)) (COPY (CDR list))
Calling functions:  EDIT_NEW_SEXPR

Local variables:

END_COMMAND:  user inputs disposition of edit expr

Functions called:  QUIT

FILE

Description

Loop

Prompt 'QUIT OR FILE?
Read End Command

Until legal end command read

Call QUIT or FILE
QUIT

Calling functions: END

Description

Output 'Aborted
No change is made to original expression

FILE

Calling functions: END

Functions called: DELETE_PROPERTY

Description

If a single property was edited then
Call DELETE_PROPERTY to remove the prop-name and value from the p-list
Put the edited version of the prop-name and the value on the p-list
else put the edited version of the p-list in place of the old one
Prompt 'DO YOU WISH TO PUT INTO A FILE?
'TYPE YES OR NO
If yes then
Prompt 'ENTER THE FILENAME:
Put the new p-list into the given LISP file
DELETE_PROPERTY

Calling functions: FILE

Parameters: ATCM
            PROPERTY

Description

Replace CDR of top of *ORIGINAL_EXPRESSIONS*
  (the original edit expression)
with CDDDD5 of the original edit expression

The effect is to attach the marker on the p-list with the
rest of the list past the property and its value.

FOR EXAMPLE:

If original expression was

((VAL2 A) PROP3 (VAL3 B) PRCP4 (VAL4 C))

DELETE_PROPERTY would produce

((VAL2 A) PROP4 (VAL4 C))

DELETE_PROPERTY uses the function REPLACD which does 'list
surgery' on the list, i.e., it actually changes the links
on the property list structure (as below).

[Diagram showing the change in the list structure after applying DELETE_PROPERTY]
RESTORE_EDIT_MARKERS

Calling functions: EDIT_NEW_SEXPR

Functions called: RESTORE_*EDIT_POSITIONS*

Description

Pop stack of original expressions
Pop stack of atom-names
Pop stack of prop-names
Call RESTORE_*EDIT_POSITIONS*
Restore previous edit expr
Pop stored expressions
If previous edit-position 'TOP then
   Level and edit^ <-- edit expr
else
   edit^ <-- top of edit-position stack
level <-- next on edit-position stack
RESTORE_EDIT_POSITIONS*

Calling functions:  RESTORE_EDIT_MARKERS
Functions called:  RESTORE_EDIT_POSITIONS*
                 !!!RECURSIVE!!!

Description

If back at top-marker for edit-positions then
  Pop top-marker
else Pop level and edit↓ off edit-positions
  Call RESTORE_EDIT_POSITIONS*
**PROCESS**

**Calling functions:**  EDIT_NEW SEXP

**Parameters:**  COMMAND

**Functions called:**  HELP  SP  EDIT_NEW SEXP  !!!RECURSIVE!!!  DEFINE_USER_COMMAND  RPT_USER  REMOVE  REPLACE  DISPLAY  CONTENTS  UNGROUP  UN*  FIRST_N  MAKE_NUMBER  GROUP  NUMBER_OF_REPETITIONS  DELETE†  DELETE_N  INSERT_AFTER†  INSERT_BEFORE†  REPEAT  RIGHT  LEFT  UP  DOWN  CHANGE_N  CHANGE_ATOM  CHANGE_STRING  FIND  BACK_TO_START  TOP  ARG_LIST  ERROR_MESSAGE
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(See also 'explanation of how process executes commands'—Section 2.1)

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Command is CONTENTS : Read buffer-name
Call DISPLAY_BUFFER_CONTENTS

Command is UN : Call UNGROUP

Command is UN*: : Call REPEAT (UN* *--global)

First 2 elts of : Call MAKE_NUMBER to
explosion command convert rest of
are U N
explosion command to
number
Call REPEAT (UNGROUP n)

G is first elt : Call NUMBER_OF_REPETITIONS
of explosion command to get arg from
Call GROUP (n)

Command is DELETE : Call DELETE

Command is DEL* : Call DELETE_N (*--globally)

First 3 elts of : Call MAKE_NUMBER to
explosion command get arg from
are D E I
explosion command
Call DELETE_N (n)

Command is IA : Call INSERT_AFTER

Command is IB : Call INSERT_BEFORE

Command is R v L v U v D : Call NUMBER_OF_REPETITIONS
to get arg from
explosion command
Call REPEAT
(R v L v U v D
n)

Command is CH : Call ARG_LIST for old
Call ARG_LIST for change
Read number of changes
Call CHANGE_N (old change n)

Command is CH↑ : Call ARG_LIST for change
Read number of changes
Call CHANGE_N
(car edit↑ change n)

Command is CHATOM : Call ARG_LIST for atom
Call ARG_LIST for old
Call ARG_LIST for change
Read number of changes
Call CHANGE_ATOM
(atom old change n)
Command is CHATOM:  
Call ARG_LIST for old 
Call ARG_LIST for change 
Read number of changes 
Call CHANGE_ATOM 
  ((car edit) old change n)

Command is CHSTR:  
Call ARG_LIST for old 
Call ARG_LIST for change 
Read number of changes 
Call CHANGE_STRING 
  (old change n)

Command is F:  
Call ARG_LIST for key 
Call FIND (key)

Command is S:  
Call BACK_TO_START

Command is TOP:  
Call TOP

Otherwise:  
ERROR_MESSAGE 
'ILLEGAL COMMAND
ARG_LIST

Calling functions: PROCESS
Local variables: I
Parameters: ARG

Description

L <-- nil
Loop
   If ARG = *LIST_DELIMITER* then
      If (null I) then RETURN (nil)
      else RETURN L
   else L <-- I app (ARG)
      Read ARG
      Go Loop

It is possible to have null argument for CHATOM and CHSTR. Since PROCESS calls these functions with CAR (ARG_LIST), it is necessary for ARG_LIST to always return a list (otherwise PROCESS will try to take the CAR of an atom). In this case (NIL) is returned. Otherwise the list of arguments entered by the user is returned.
REPEAT

Calling functions: PROCESS
                CHANGE_N

Local variables: COUNT
                DO_COMMAND

Parameters: COMMAND
            N

Functions called: LEGAL_NUMBER_ARG
                ERROR_MESSAGE

Description

If n not legal argument or =0 then
    RETURN nil

Count <-- 1

Do first command on list

If command not completed then
    ERROR_MESSAGE '0 COMPLETED
    RETURN

Loop

    If (#--global and command
        not completed) then
        RETURN
    Increment Count
    Do next command on list

Go Loop
NUMBER_OF_REPETITIONS

Calling functions: PROCESS

Functions called: MAKE_NUMBER

Description

Calls MAKE_NUMBER to make integer of digit characters in command
MKNUM

Calling functions: NUMBER_OF_REPETITIONS EXPLODE1

Parameters: N

Description

Makes number atom from character digit

MKDIG

Calling functions: EXPLODEDIG

Parameters: N

Description

Makes char atom of number
MAKE_NUMBER

Calling functions:  PROCESS
NUMBER_OF_REPETITIONS

Parameters:  STR

Local variables:
  COUNT:  locp counter
  SUM:  number to be returned

Functions called:  MKNUM

Description

If string of digits is null then
  RETURN 1 (default value)

If first elt of string not a digit then
  RETURN first elt

Count <-- string length - 1

Call MKNUM (first digit)
Sum <-- first digit * count ** 10

Loop

  Pop string of digits
  If first elt of string not a digit then
    RETURN first elt
  Decrement count
  Sum <-- Sum + (MKNUM (first digit)) * count ** 10

Until Count = 0

RETURN Sum
**DEFINE_COMMAND**

**Calling functions:** PROCESS

**Local variables:**

- DEFINITION: user definition
- CMD: edit command
- DESCRIPTION: list of edit commands

**Parameters:** NAME of user defined edit function

**Functions called:** ARGUMENTS
- MOVE_OVER

**Description**

Put name on list of user commands
Call USER_DEF for description
DEFINITION <-- (DEFUN name () )

Loop

Case

- First elt of CMD <--
  description (first elt is IA IB CH CHA arglists)
  CHATCH CHATCHA
  CHSTR F
  (i.e., edit function needing arg list)

- First elt of : ERROR_MESSAGE
  description first elt
  is HELP 'NCT ALLOWED
  EDIT DEF_CMD
  RPT

DEFINITION <-- DEFINITION app (CMD)
(MOVE_OVER)
Until null DESCRIPTION
Calling functions: DEFINE_COMMAND

Local Variables: ARG
                LIS

Description

Read argument
List <-- (ARG)
Loop
  Read arg
  If arg is *CMD_DELIMITER* then
     RETURN Lis
  Lis <-- (Lis Arg)
  Go Loop
ARGUMENTS

Calling functions: DEFINE_COMMAND

Functions called: GET_ARGS

Description

This function puts the list of a command its arguments from the DEFINE_COMMAND description and puts it in the form (COPY <args>) so that it can be put into the definition of the user_command.
GET_ARGS

Calling functions: ARGUMENTS

Local variables: ARG: ARGUMENT FROM DESCRIPTION
                 L1S: (ARG1 ... ARGN)

Description

Pop command off description
Arg \leftarrow \text{first elt of description}
Pop description
List \leftarrow (\text{Arg1})
Loop
  Arg \leftarrow \text{first elt of description}
  If Arg = *LIST_DELIMITER* then
    RETURN List
  Pop description
  List \leftarrow (\text{Arg1} \ldots \text{Argi} \text{Arg})
Go loop
RPT_USER

Calling functions:  PROCESS

Local variables:  COUNT
                  DO_COMMAND

Parameters:  COMMAND  N

Description

If \( n = * \) then
   ERROR_MESSAGE '* not allowed
   RETURN
else if \( n \) not number then
   ERROR_MESSAGE 'Illegal arg
   RETURN
else if \( n = 0 \) then
   ERROR_MESSAGE '0 Completed
   RETURN
Count <-- 1
Do command
If command not completed (DO_COMMAND = nil)
   then
   ERROR_MESSAGE '0 Completed
   RETURN
Loop
   If \( n = * \) and command not completed then
      RETURN
   else if \( n = \) count then RETURN
   else if command not completed then
      ERROR_MESSAGE (count -1) 'completed
      RETURN
Increment count
Do Command
Go loop

(Additional note on next page)
RPT_CMD is the function used for the edit command RPT. Global performance is not allowed because of the danger of infinite loops (e.g., RPT G UN ENDCMD *). RPT stops if a repetition is not completed or if the specified number of repetitions is done.

**Calling functions:** PROCESS

**Parameters:**
- BUFFER_NAME: buffer to place
- S-expressions in
- N: number of S-expressions

**Functions called:** GET_SEXPRS_FOR_BUFFER

**Description**

If n not legal number then
   RETURN nil
else if n = * (global) then
   n <-- number of S-expr in edit
else if n = 0 then
   ERROR_MESSAGE 0 "Illegal Arg"
   RETURN
else if new buffer put name on buffer list
Call GET_SEXPRS_FOR_BUFFER
Add s-exprs to end of buffer
GET_SEXPRS_FOR_BUFFER

Calling functions: REMOVE

Local variables: COUNT: counter for loop
L: list of S-expressions

Parameters: N: number of S-expressions

Functions called: ERROR_MESSAGE

Description

Count <-- 1
L <-- (First elt of edit\^\^ list)

Loop

Increment count

If there is no S-expr to delete and
n < count then
ERROR_MESSAGE (count - 1) 's-exprs removed
RETURN

L <-- (L first elt of edit\^\^ list)

Go loop
REPLACE

**Calling functions:** PROCESS

**Parameters:**
- BUFFER_NAME: where to get s-exprs from
- N: number of s-expressions
- START: number of s-expr to begin with

**Local variables:**
- BUFFER: store contents of buffer

**Functions called:**
- MARK_START
- INSERT_AFTER
- COPY
- ERROR_MESSAGE

**Description**

Store buffer contents in buffer

```
If empty buffer then
    ERROR_MESSAGE 'Empty Buffer
    RETURN
else if n not legal number then RETURN nil
else if START not legal or <= 0 then
    ERROR_MESSAGE START 'illegal arg
    RETURN
else if N = *(global) then
    n <- length of buffer - START + 1
else if n = 0 then
    ERROR_MESSAGE
    RETURN 0 'Illegal arg
else if START > length buffer then
    ERROR_MESSAGE START 'Beyond end of buffer
    RETURN

Call INSERT_AFTER to put COPY of
    FIRST_N n (MARK_START START buffer)
    after the first elt on edit list
```
**MARK_START**

**Calling functions:** REPLACE

**Parameters:**
- N: number of place to mark start
- L: list to mark start on

**Functions called:** MARK_START !!!RECURSIVE!!!

**Description**

If n = 1 then return l  
else if at end of l then return l  
else Call MARK_START (n - 1) (cdr l)
DISPLAY_BUFFER_NAMES

Calling functions: PROCESS

Description

Print names of buffers

DISPLAY_BUFFER_CONTENTS

Calling functions: PROCESS

Parameters: BUFFER_NAME

Description

Pretty print contents of given buffer
DELETE_N

Calling functions: PROCESS

Parameters: N: number of S-exprs to delete

Local variables: COUNT: counter for loop

Functions called: LEGAL_NUMBER_ARGS
ERROR_MESSAGE
DELETEA

Delete_n

If count nct legal arg then RETURN nil
else if n = *(global) then n <-- length edit list
else if n = 0 then
    ERROR_MESSAGE 0 'zero arg
    RETURN

count <-- 1

Loop

If n < count then RETURN
else if there is no S-expr to delete then
    ERROR_MESSAGE count 'Deletions

Increment count

Go Loop
DELETE↑

Calling functions:  PROCESS
                 DELETE_N
                 CHANGE_N

Functions called:  R L U D
                    AT_END_OF_EDIT_LIST
                    AT_BOTTOM_LEVEL
                    ERROR_MESSAGE

Description

If it is possible to go left (L) then
  go left
  connect current edit↑ to second elt past edit↓
If at_end_of_edit_level then
  ERROR_MESSAGE 'End of level
else move pointer to right
else if it is possible to go up (U) then
  go up
  connect current edit↑ to CDAR of edit↑
if at_bottom_level then
  ERROR_MESSAGE 'end of level
else move pointer down to next level
otherwise 'at start of edit s-expr'
  edit↑ ←-- pop edit↑
  expr ←-- edit↑
  level ←-- edit↑

DELETE↑ does list surgery as shown below:

(A B C) → (A C)

(A B C) → (B C)
GROUP

Calling functions: PROCESS

Parameters: N: number of s-exprs to group

Functions called: LEGAL_NUMBER_ARG
AT_BEGINNING
(= EDIT↑ S-EXPR)
ALL_BUT_FIRST

Description

If n not legal then nil
else if n = *(global) then
  n <-- length edit↑
  If at_beginning then
    ERROR_MESSAGE 'FIRST S-EXPR OF LIST
  else if n = 0 then
    ERROR_MESSAGE 'zero arg
  else if length edit↑ < n then
    ERROR_MESSAGE 'n > length of edit↑
  otherwise
    edit↑ <-- (first_n of edit↑ list)

Group does list surgery (as shown below)

(ABC)→(A (a) c)  (A B C)→(A)bc  (A B)→(c)

Diagram:
LEGAL_NUMBER_ARG

Calling functions: REMOVE
                REPLACE
                REMOVE
                DELETE_N
                GROUP
                CHANGE_N

Parameters: N: number to be checked

Functions called: ERROR_MESSAGE

Description

If n is number and n < 0
or n = * then
ERROR_MESSAGE 'illegal arg
UNGROUP

Calling functions: PROCESS
Functions called: ERROR_MESSAGE
               AT_BEGINNING

Description

If current edit↑ is atom then
   ERROR_MESSAGE 'cannot ungroup atom
else if at_beginning then
   Call CHANGE↑ with current edit↑
   current edit↑ ← CAR of current edit↑
otherwise
   Nconc current edit↑ and rest of edit↑ list
If it is possible to go left then
   REPLACD edit↑ with CADR edit↑ list
   go right
else if it is possible to go up then
   REPLACA edit↑ with CAAR edit↑ list
   go down

UNGROUP does list surgery (as below):

(A B C) → (A B C)                             ((A B C) → (A B C)
     ________  _______________________________
    /            \
   /              \
  /                \
 (A)             (A)

     ________  _______________________________
    /            \
   /              \
  /                \
 (B)             (B)

     ________  _______________________________
    /            \
   /              \
  /                \
 (C)             (C)

     ________  _______________________________
    /            \
   /              \
  /                \
 (NIL)           (NIL)

Calling functions: PROCESS

Functions called: AT-BEGINNING
                CHANGE↑

Description

If current edit↑ is atom then RETURN nil
else if at_beginning then
    current edit↑ ←- car current edit↑
otherwise NCONC current edit↑ and rest of edit↑ list
    If it is possible to go left then
        go left
        REPLACD current edit↑ with CAAR edit↑ list
    go right
    go up
    REPLACA current edit↑ with CAAR edit↑ list
    go down
**CHANGE**

**Calling functions:** change_str

**Parameters:** changes

**Functions called:** error_message

**Description**

If current edit is atom then return nil
else if at beginning then
    current edit <-- car current edit
otherwise connect edit with rest of edit list
    If it is possible to go left then
        go left
        replace current edit with cadr edit list
    else if it is possible to go right then
        go right
        replace current edit with caar edit list
    else if it is possible to go up then
        go up
        replace current edit with caar edit list
    else
down

\[ (A \ B \ C) \rightarrow (A \ X \ Y \ C) \]
**INSERT_AFTER**

**Calling functions:**
- PROCESS
- REPL
- INSERT_BEFORE

**Parameters:**
- INSERTION

**Functions called:**
- ERROR_MESSAGE

**Description**

if no insertion then
  Error_message 'no insertions else connect
  insertion with rest of edit list
  edit list ← insertion

**INSERT_AFTER** does list surgery as follows:

(A B) → (A X Y B)
INSERT_BEFORE

Calling functions: PROCESS

Parameters: INSERTION

Functions called: INSERT_AFTER
ERROR_MESSAGE

Description

If no insertion then
ERROR_MESSAGE 'no insertion
else if it is possible to go left then
   go left
   Call INSERT_AFTER
else if it is possible to go up then
   go up
   connect insertion with rest of edit
   edit << insertion
   go down
otherwise
   connect insertion with edit list
   edit << insertion
   expr << edit
   level << edit

INSERT_BEFORE does list surgery as follows:

(A B) → (X Y A B)
Calling functions:  PROCESS
             INSERT_BEFORE↑
             CHANGE_N
             NEXT
             FIND
             LOCATE_NEXT

Description

R(right)

If AT_END_OF_EDIT_LEVEL
  (i.e., nullcdreditlist) then
  nil
Otherwise edit↑list <--
  R_MOVE (i.e.,cdreditlist)
**AT_START_OF_EDIT_LEVEL**

**Calling functions:**
- PROCESS
- INSERT_BEFORE

**Functions called:**
- L_MOVE

**Description**

```lisp
    (if AT_START_OF_EDIT_LEVEL
        (i.e., edit↑ = level) then
        (nil
           otherwise edit↑ list ← L_MOVE)
```
L_MOVE

Calling functions: L

Functions called: ALL_BUT_FIRST

Description

Call ALL_BUT_FIRST
(length level - length edit\uparrow list - 1)
level

FOR EXAMPLE:

If level is (A B C D E) and
edit\uparrow is (C D E) then
L_MOVE is all but the first (5 - 3 - 1) = 1 of
level:

(B C D E)
ALL_BUT_FIRST

Calling functions:  L_MOVE

Parameters:
   N:  number to take off front
   L:  list

Functions called:  ALL_BUT_FIRST  !!!RECURSIVE!!!

Description

   If end of L then nil
   else if N = 0 then L
   otherwise call ALL_BUT_FIRST (N - 1) (rest of L)
Calling functions: PROCESS
INSERT_BEFORE↑
CHANGE_N
NEXT
FIND
LOCATE_NEXT

Description

U

If AT_TOP_LEVEL
  (i.e., 'TOP is on top of
   edit positions stack) then

  nil

else RESET↑
  (i.e., edit↑ <-- top of
   edit positions stack)
  Pop edit positions
  RESET_LEVEL
  (i.e., level <-- top of
   edit positions stack)
  Pop edit positions
D
AT_BOTTOM_LEVEL
NEW↑
NEW_LEVEL

Calling functions:  PROCESS
INSERT_BEFORE↑

Functions called:

Description

D

If AT_BOTTOM_LEVEL
  (i.e., edit↑ is atom) then nil
else push level onto edit positions stack
push edit↑ onto edit positions stack
Call NEW_LEVEL
  (i.e., level ←-- car edit↑)
Call NEW↑
  (i.e., edit↑ ←-- car edit↑)
TOP

Calling functions: BACK_TO_START

Functions called: U TOP !!!RECURSIVE!!!

Description

If it is possible to go up then
   Go up
   Call TOP
   Go up until 'TOP is on top of stack
Calling functions: PROCESS

Functions called:
  TOP   L

Description

Call TOP to get to top level
Loop
  go left (L)
  Until not possible to go left
CALLING FUNCTIONS: PROCESS
CHANGE_ATOM
CHANGE_STR

LOCAL VARIABLES:
COUNT: loop counter
COPY_CHANGES: store copy of changes

PARAMETERS:
KEY: what is to be changed
CHANGES
N: number of changes to be made

FUNCTIONS CALLED:
COPY
LEGAL_NUMBER_ARGS
ERROR_MESSAGE

DESCRIPTION

If null changes then
ERROR_MESSAGE 'null changes
RETURN
If null key then
ERROR_MESSAGE 'null key
RETURN
If n not legal arg then
RETURN nil else if n = * then
n <-- length edit list else if n = 0 then
ERROR_MESSAGE '0 changes
RETURN

count <-- 1

Loop
COPY changes

If either n < count or
key is not on rest of list then
ERROR_MESSAGE (count - 1) 'changes
RETURN
Call R(right) to
go right (length key - 1) times
Connect copy of changes with rest of edit
list

Call I(eft) to
gc let (length key - 1) times

Put changes in behind current edit

Increment counter

Go loop
CHANGE_ATOM

Calling functions: CHANGED_ATOM

Local variables:
NEW_ATOM: atom produced after substring changed
CHK: stores atom made into number

Parameters:
ATM: atom to be changed
OLD: substring to be changed
NEW: substring old to be changed to

Functions called: ERROR_MESSAGE
MAKE_NUMBER
CHANGE_N

Description

If old and new and atm are not atoms then
ERROR_MESSAGE 'argument no atom
RETURN
else if atm or old is null then
ERROR_MESSAGE 'null atom/subatom
RETURN

Call CHANGED_ATOM
NEW_ATOM <-- changed atcm

Call MAKE_NUMBER with new_atom
Store number in CHK

If CHK is a number then new_atm <-- CHK
else if new_atom is same as old atom then
ERROR_MESSAGE old 'not found
RETURN

Call CHANGE_N to change atm to new_atm n times
Next

Calling functions: FIND
                    LOCATE_NEXT
                    CHANGE_N

Functions called:  R  U

Description

Loop

    If it is not possible to go up then
    RETURN nil
    else go up
    If it is possible to go right then
    go right
    RETURN t
    otherwise go loop
FIRST_N

Calling functions: LOCATE_NEXT
                  FIND
                  CHLIST

Parameters: N   L

Functions called: FIRST_N  !!!RECURSIVE!!!
CHANGED_ATOM

Calling functions: CHANGE_ATOM

Parameters:
ATM: atom to be changed
OLD: substring to be changed
NEW: substring old is to be changed to

Functions called: CHLIST
EXPOSE

Description

EXPOSE old new atm
(EXPOSE old explode atom and
makes char digits numbers)

EXDEL atm (leaves char digits)

Call CHLIST to put new in place
of old in exploded atm

Implode this list

Digits within atoms require special care.

FOR EXAMPLE:

If X1 is EXPOSE'd to (X 1) the '1' is not the
same as the number 1. EXPOSE changes the '1'
to the number 1. However, IMPLD will not work
properly on the number 1; so it is necessary to
IMPLD using the '1'. Thus both the usual
EXPOSE and EXPOSE are necessary.
EXPLODE1

Calling functions: CHANGED_ATOM

Local variables:
L: exploded atm with char digits
NEW_ATOM: exploded atm with char digits converted to numbers

Parameters:
ATM: atom to be exploded

Functions called: MKNUM
EXPL_NUM

Description

If atm is a number then
Call EXPL_NUM to explode atm
RETURN
else if null atm then RETURN
L <-- EXPLODE atm
new_atom <-- (first elt on L)
Loop
Pop L
If at end of L then RETURN new_atom
new-atcm <-- (new_atom
(first elt of L changed by
MKNUM to number if a digit))
Go Loop

This function works exactly like the standard EXPLODE except that it converts char digits to their number value.
Calling functions: EXPLODE1

Parameters:
   N: number to be exploded

Functions called: EXPL_NUM !!!RECURSIVE!!

Description

If n = 0 then nil
else ((EXPL_NUM n/10) (mod n 10))
CHLIST

Calling functions: CHANGED_ATOM

Parameters:

OLD: list
NEW: list
L1: exploded with number for digits
L2: exploded with char digits

Functions called: CHLIST !!!RECURSIVE!!!
EXPLODEDIG
FIRST_N

Description

If at end of L1 then nil
else if old = (first_n (length old) L1)
(that is, old matches first part
of L1) then
Call EXPLODEDIG to change numbers in new
to char digits
Append new to rest of L2 with old removed
otherwise CONS first-elt-L2 with
CHLIST old new rest of L1 and L2
Calling functions: CHLIST

Parameters: L: exploded atom with numbers

Functions called: MKDIG
                  EXPLODEDIG  !!!RECURSIVE!!!

Description

If at end of L then nil
otherwise
append first-elt-cf-L
(with number changed to char digit if necessary)
with EXPLODEDIG rest of L
USER GUIDE TO LEDIT

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Sample Edit Session
HOW TO USE EDIT
A REAL-TIME LISP EDITOR

This manual describes the use of a real-time editor for LISP. The use of this tool will enable you to edit property lists and function definitions without leaving the LISP interpreter. You may also store edited lists in your LISP files, if you wish. This editor provides you with most of the features of a conventional text editor, as well as some commands particularly useful to the LISP programmer.

The following terms are used throughout this document:

1. edit list: the subexpression of the property list you are editing. It contains the edit pointer as it first element.

2. edit pointer or edit↑: the element you wish to edit or examine. It is the first element of the current edit list. In this manual we often use an arrow to indicate the edit pointer.

3. edit level: It is possible to move up and down in levels of nesting in the edit list. The current edit level is the expression which contains the current edit list as a 'tail.'

FOR EXAMPLE:

If the current edit level is (A (B C) D). The current edit list might be (A (B C) D) or ((B C) D) or (D). The current edit↑ could be A or (B C) or D.

You may type as many commands on a line as you wish. The commands will be executed in sequence when you type carriage return. The interpreter reads all commands and delimiters as atoms, so be sure to leave blanks between them.
ENTERING AND LEAVING LEDIT

To enter the editor from the LISP interpreter type

(LEDIT <atom-name> <function-name or NIL>)

The first argument is the name of the atom whose property list you wish to edit. The second argument is the name of the property you wish to edit. If you type NIL for the second argument, the list you will receive to edit will be the entire property list of the atom.

FOR EXAMPLE:
The atom A1 has the following property list:

(P1 (X Y) P2 (Q R) P3 (S T))

==> (EDIT A1 P2)
    results in the edit list

(P2 (Q R))

==> (EDIT A1 NIL)
    results in the edit list

(P1 (X Y) P2 (Q R) P3 (S T))

To exit from the editor type the command END.
The response will be 'QUIT or FILE?'.
If you wish to discard the edited version, type QUIT.
If you wish the original property list to be replaced by the edited version, type FILE.
EDIT <atom-name> <property-name or NIL>

It is possible to edit another property list while you are already in the editor. Simply use the EDIT command (without parentheses or quotes). When you type END, you will be returned to the edit list you were previously editing. You may EDIT as many lists as you wish while you are in the editor.

FOR EXAMPLE:

The property list of atcm A is as follows:

\[
\text{(PROP1 (X Y) PROP2 (Z W) EXPR (LAMBDA (X) (CAR (CADDR X))))}
\]

\[===> \text{EDIT A PROP2 results in the edit list (PROP2 (Z W))}
\]

\[===> \text{EDIT A NIL results in the edit list (PROP1 (X Y) PROP2 (Z W) EXPR (LAMBDA (X) (CAR (CADDR X))))}
\]
QUIT

QUIT

This command simply causes the editor to discard the edited version of the list you have been editing; no changes will be made to the original property list.

The result will be ABORTED.
FILE

This command replaces the original property list with the edited version of the list.

The terminal will prompt with 'DO YOU WISH TO STORE IN A FILE? TYPE YES OR NO

If you type YES, the prompt will be 'TYPE FILE NAME.

The new property list will be stored in the LISP file which you specify.
This command causes you to end editing of that property list. The editor will prompt you with 'QUIT OR FILE?'.

QUIT discards the edited property list; the original property list remains unchanged.

FILE replaces the original property list with the new edited version.
HELP

HELP <edit-command or ALL>

HELP ALL displays a list of all edit commands.

HELP <edit-command> displays an explanation of the syntax and function of the command.
\texttt{T(ype)}

\texttt{T(ype)} causes the current edit pointer list to be display in 'pretty LISP' format. The edit pointer will be the car of that list.

\textbf{FOR EXAMPLE:}

If the result of \texttt{T} is \{(X Y) Z\}, then the edit pointer is \{(X Y)\}. 


R (right) or \texttt{R<n>} or \texttt{R*}

\texttt{R (right)} causes the current edit pointer to be moved to the right the given number of 5-expressions. If no number is specified, the default is one. \texttt{R*} causes the editor to go right until at the end of that edit level.

\textbf{FOR EXAMPLE:}

The current edit list is \((A B (C D) E F)\).

\texttt{====> R} results in the edit list \((E (C D) E F)\).

\texttt{====> R2} results in the edit list \((E F)\).

\texttt{====> R*} results in the edit list \((F)\).

If there are fewer 5-expressions to the right of the edit pointer than you have specified, the editor will simply move the pointer as far right as it can. A message will be printed to tell you how many moves were completed.

\textbf{FOR EXAMPLE:}

The current edit list is \((A (E C) D E)\).

\texttt{====> R4} results in the edit list \((E)\)

3 REPETITIONS
L(eft) causes the current edit pointer to be moved left the given number of S-expressions. If no number is specified, the default is one. L* causes the editor to go to the left until it is at the beginning of the current edit level.

**FOR EXAMPLE:**

The current edit level is \((M \ (N) \ \ X \ \ A \ \ B \ \ (C \ D) \ \ E \ \ F)\).  
The current edit list is \(((C \ D) \ \ E \ \ F)\).

\[
\Rightarrow \text{L results in the edit list} \quad (E \ (C \ D) \ \ E \ D). \\
\Rightarrow \text{L2 results in the edit list} \quad (X \ A \ B \ (C \ D) \ \ E \ F). \\
\Rightarrow \text{L* results in the edit list} \quad (M \ (N) \ \ X \ \ A \ \ E \ \ (C \ D) \ \ E \ F). \\
\]

If the edit pointer reaches the beginning of the current edit level before it has completed the number of moves specified, it will go as far left as it can. An error message will be displayed to tell you how many moves were completed.

**FOR EXAMPLE:**

The current edit level is \((A \ B \ C \ (D \ E) \ \ F)\)  
The current edit list is \(((D \ E) \ \ F)\)  

\[
\Rightarrow \text{L5 results in the edit list} \quad (A \ B \ C \ (D \ E) \ \ F) \\
3 \text{ REPETITIONS} \\
\]
U(p) or U<n> or U*

U(p) causes the current edit pointer to be moved up the given number of levels. If no number is specified, the default is one. U* causes the editor to move up until it is at the top level.

For example:

The current edit expression is \((X \ Y \ (A \ (B \ (C \ ((D)))) \ E)))\).

The current edit list is \((D)\).

\[\text{==> U results in the edit list} \quad (((D)).)\]

\[\text{==> U2 results in the edit list} \quad ((C \ ((D))) \ E))\).

\[\text{==> U* results in the edit list} \quad ((A \ (E \ (C \ ((D)))) \ E))\).

If there are fewer levels above the edit pointer than you have specified, the editor will simply move as far up as it can. A message will be printed to tell you how many moves were completed.

For example:

The current edit expression is \((X \ Y \ (A \ (B \ (C \ ((D)))) \ E)))\).

The current edit list is \((C \ ((D))) \ E))\).

\[\text{==> U5 results in the edit list} \quad ((A \ (E \ (C \ ((D)))) \ E))\]

\[2 \text{ REPETITIONS.} \]
D (own) causes the current edit pointer to be moved down the given number of levels. If no number is specified the default is one. D* causes the editor to move down until it has reached the bottom level.

**FOR EXAMPLE:**

- The current edit expression is: 
  \[(X \ Y \ (A \ (B \ (C \ ((D)) \ E)))\]

- The current edit list: 
  \[(Y \ (A \ (B \ (C \ ((D)) \ E)))\]

  ===> D results in the edit list: 
  \[(B \ (C \ ((D)) \ E))\]

- The current edit list is: 
  \[((D))\]

  ===> D2 results in the edit list: 
  \[(D)\]

- The current edit list is: 
  \[((D))\]

  ===> D* results in the edit list: 
  \[(D)\]

If there are fewer levels below the edit pointer than you have specified, the editor will simply move as far down as it can. A message will be printed to tell you how many moves were completed.

**FOR EXAMPLE:**

- The current edit list is: 
  \[((B \ C \ (D)) \ E)\]

  ===> D5 results in the edit list: 
  \[(B \ C \ (D))\]

  1 REPEITION
S(tart) moves the edit pointer back to the beginning of the edit expression. Its value will be the entire edit expression in its edited version.

FOR EXAMPLE:

The edit expression is \((A (E C (D) E))\).

The edit list is \((D)\).

\[ \implies S \]

results in \((A (E C (D) E))\).
TCP moves the current edit pointer to the top level. It is equivalent to U*.
\[ F(\text{ind}) \]

\[ \text{F <one or more S-expressions> } / \]

Beginning with the current edit pointer, \( F(\text{ind}) \) will locate the given argument. The current edit pointer will then point to the argument (or the first expression in the argument if it was a list of S-expressions).

If the argument is not located, the error message 'NOT FOUND' will be displayed. The current edit pointer will then be restored to the position in which the search began.

**For example:**

The current edit list is \((A\ B\ C\ D\ E\ (A\ (E))\ C)\ D)\)

\[ \text{==> F A B } / \]
results in the edit list \((A\ B\ C\ D\ E\ (A\ (B))\ C)\ D)\)

\[ \text{==> F D } / \]
results in the edit list \((D\ E\ (A\ (B))\ C)\ D)\)

\[ \text{==> F (A (E)) } / \]
results in the edit list \(((A\ (E))\ C)\)

\[ \text{==> F X } / \]
results in the edit list \(((A\ (E))\ C)\)

\text{NOT FOUND}
G(roup) causes the editor to group the given number of S-expressions beginning with the current edit pointer. If no number is specified, the default is one. G* causes the editor to group S-expressions until it reaches the end of the edit level.

FOR EXAMPLE:

The current edit list is (A B (C) (D E) F G)

 ===> G
results in the edit list ((A) B (C) (D E) F G)

=== G3
results in the edit list (((A) B (C)) (D E) F G)

 ===> G*
results in the edit list (((((A) B (C)) (D E) F G))

If there are fewer S-expressions to the right of the edit pointer than you have specified, the editor will display an error message. No change will have taken place.

The editor will not group if you are at the beginning of the edit entire property list.

FOR EXAMPLE:

The edit list is (X Y Z).

 ===> G
results in the edit list (X Y Z).
AT BEGINNING

No change will have taken place.
UN or UN<n> or UN*

UN(group) ungroups the current edit pointer the number of times specified. If no number is specified, the default is one. UN* ungroups the edit pointer until it is an atom.

FOR EXAMPLE:

The current edit list is \((((((A B))) C))\).

\[\text{==> UN}\]
result in the edit list \(((((A B))) C)\).

\[\text{==> UN2}\]
result in the edit list \(((A B)) C)\).

\[\text{==> UN*}\]
result in the edit list \((A B C)\).

If the current edit pointer becomes an atom before ungroup executes the given number of times, a message will be printed to tell you how many ungroups were done.

FOR EXAMPLE:

The current edit list is \(((A B) C)\).

\[\text{==> UN5}\]
result in the edit list \((A B C)\)

2 \text{ repetitions}
DEL or DEL<n> or DEL*

Beginning with the current edit pointer, the given number of S-expressions will be deleted by the editor. If no number is specified, the default is one. DEL* will delete everything past and including the current edit pointer. The current edit pointer will now be NIL.

FOR EXAMPLE:

The current edit level is (A B C (D E) (F (G)) H).
The current edit list is (B C (D E) (F (G)) H).

==> DEL
results in the edit list (C (D E) (F (G)) H).

==> DEL2
results in the edit list ((F (G)) H).

==> DEL*
results in the edit list NIL.

If there are fewer S-expressions on the current level than the number you have specified, the editor will delete the rest of the level. The current edit pointer will be NIL. An error message will be displayed to tell you how many deletions occurred.

FOR EXAMPLE:

The current edit list is (A B (C D)).

==> DEL5
result in the edit pointer NIL
AT BOTTOM LEVEL
3 DELETIONS
CH <old list of one or more S-expressions> / 
<new list of one or more S-expressions> / 
<n or *> 

CH (ange) finds the old list which is to be changed and changes it to the new list. It begins the search at the current edit pointer. The given number of changes will be made. There must be a number specified; there is no default. CH old / new / * will find and change all occurrences of old which are found between and including the current edit pointer and the end of the edit list. The edit pointer will point at the last change. If CH* is the command, the changes will be made throughout the rest of the edit list beginning with and including the current edit pointer. The current edit pointer will be at the end of the edit list.

FOR EXAMPLE:

The current edit list is (A (E C) D (A (B) C D) A) 

===> CH B / (BBB) / 1 results in the edit list (BBB C) D (A (B) C D) A) 

===> CH C D / X (Y) / 1 results in the edit list ((X (Y)) A) 

===> CH Y / M M / * results in the edit list {{<= (X (M N)) A) 

If the editor finds fewer instances of the old list than you specified, it will make the necessary changes until it reaches the end of the edit list. An error message will be displayed to tell you how many changes were made. The edit pointer will be at the end of the edit list.

FOR EXAMPLE:

The current edit list is (A B (C D) E F). 

===> CH D / ((X)) / 3 results in the edit list (F) 

1 CHANGE 

{{<= (((C ((X))) E F) } 10
IA inserts the given insertions directly after the current edit pointer.

FOR EXAMPLE:

The current edit list is \( (A \ (E \ C)) \).

\[ \Rightarrow \text{IA } X \ Y \ (Z) \ / \]
\[ \text{results in the edit list } (A \ X \ Y \ (Z) \ (E \ C)). \]

\[ \Rightarrow \text{IA } (M) \ /
\text{results in the edit list } (A \ (M) \ X \ Y \ (Z) \ (E \ C)). \]
IB (insert) B(efore)

IB <new-list-of-one-or-more-s-expressions> /

IB inserts the given insertion directly before the current edit. The current edit will then be at the beginning of the insertion.

**For example:**

The current edit list is \((A B (C))\)

```
===> IB (M) X /
results in the edit list \(((M) X A B (C))\)
```

```
===> IB (Q R S) /
results in the edit list \(((Q R S) (M) X A B (C))\)
```
CH <new-list-of-one-or-more-S-expressions> / <n> or *

CH is exactly like CH(ANGE) except that the old list to be changed is the current edit.

FOR EXAMPLE:

The current edit list is

\[(A\ (B\ C)\ (A\ (B\ (C)\ A))\]

\[===>\] CH \[M\ N\ /\ 2\]

results in the edit list

\[(M\ N\ (B\ (C))\ A)\]

\[<==\] \[(M\ N\ (B\ C)\ (M\ N\ (B\ (C))\ A)\]
CHATOM <old-atom> / <old-atom-substring> / <new-atom-substring> / <n> or *

CHATOM changes the old-atom-substring contained in the old-atom to the new-atom-substring the given number of times. A number must be specified; there is no default. The editor will find the given number of the specified old-atom. If * is specified, the editor will look for the atom and make changes until it reaches the end of the edit list. It is possible to use nothing for the new-substring. This has the effect of deleting the old-substring.

FOR EXAMPLE:

The current edit list is (ABC1 XYZ2 234 P12QRSABCX)

==> CHATOM ABC1 / C1 / YYY / 1
results in the edit list (ABYYY XYZ2 234 P12QRSABCX)

==> CHATOM 2 / 2 / 234 / 1
results in the edit list (234 234 P12QRSABCX)

==> CHATOM 234 / 23 / AB / 2
results in the edit list (AB4 AB4 P12QRSABCX)

Care must be taken with numbers. A digit followed by a nondigit is not a legal atom. Thus CHATOM 234 / 4 / X / 1 would be illegal since 23X is not a legal atom.

If the editor finds fewer instances of the atom than you specified, it will continue until it reaches the end of the edit list. An error message will be displayed to tell you how many changes were made.
CHANTOM\textbackslash\textbackslash \langle \text{old-substring} \rangle / \langle \text{new-substring} \rangle / \langle n \rangle \text{ or } *

CHANTOM\textbackslash\textbackslash\textbackslash performs exactly the same function that CHATOM does except that the atom to be changed is the current edit\textup{\uparrow} (and any subsequent identical atoms).

\textbf{FOR EXAMPLE:}

The current edit list is \((ABC \ (XYZ \ (ABC \ ABC) \ Q))\)

\(==\)\textbackslash\textbackslash\textbackslash CHATOM\textbackslash\textbackslash\textbackslash BC / XXX / 3\)

results in the edit list \((AXXX)\)

\(\textless\textless\)

\((AXXX \ (XYZ \ (AXXX \ AXXX) \ Q))\)
CHSTR <old-substring> / <new-substring> / <n> or *

CHSTR looks at each atom on the edit list (beginning with and including the current edit) for the given old substring and changes it to the given new substring the number of times specified. A number must be specified; there is no default. If * is specified, the editor will continue to the end of the edit list. It is possible to use a nil new-atom. This has the effect of deleting old string from the atom.

FOR EXAMPLE:

The current edit list is

(ABC (XYZ (CBA YZW) ABQRS CABRS)

==> CHSTR AB / I / 3
results in the edit list (CIRS)

{<=

(IC (XYZ (CBA YZW) IQRS CIRS)

If the editor finds fewer occurrences of the string than you specified, it will continue until it reaches the end of the edit list. An error message will be displayed to tell you how many changes were made. Be careful not to use or create any illegal (i.e., a leading digit followed by a nondigit --like 12X).
RPT <list-of-edit-commands> ENDCMD <n>

RPT allows the user to list a string of edit commands and the editor will repeat the sequence the given number of times. A number must be specified. There is no default: * is illegal with RPT. The editor will stop the repetition if a command does not execute. An error message will be displayed to tell you how many times the sequence was executed.

For example:

The current edit list is (A B C (I E (F) G) H)

The current edit list is (E C (D E (F) G) H)

===> RPT R DEL D P ENDCMD
results in ((D E (F) G)
            (F))

The current edit list is (A B (C A E (A B)))

===> RPT R CH A / AAA / 1 T ENDCMD 2
results in (AAA B (A (B)))
            (AAA (B))

The current edit list is (A (B) (C) ((D)) X (Z) V)

===> RPT T UN ENDCMD 5
results in edit list (X (Z) V)
            3 REPETITIONS

{===> (A B C (D) X (Z) V)
DEFCMD <name-of-user-defined-edit-command>
   <list-of-edit-commands>
ENDCMD

DEFCMD allows the user to define his own edit commands using combinations of the existing commands. The following commands are not allowed in DEFCMD lists: HELP, EDIT, DEFCMD, RPT. The user-defined command may then be called at any time during the edit session. It may also be called during subsequent edit sessions as long as you are still in the LISP interpreter. The command has been DEFUN'ed, so it may be saved to a LISP file just as you might save any other functions. User-defined edit commands are not allowed to have arguments.

FOR EXAMPLE:

DEFCMD USER1 P2 UN* S CH X / Y / 3 S T ENDCMD

When you type USER1 any time you are in edit mode it will perform the command sequence in the definition. User commands may be used within user-command definitions.
CH(ange)_LIST_DELIM(iter)

CH_LIST_DELIM <S-expression>

CH_LIST_DELIM allows you to change the delimiter for the argument lists used with P(ind), CH(ange), CH(ange) CH(ange)ATOM, CH(ange)ATOM, I(insert)A(fter), I(insert)B(efore), and CH(ange)STEP(ing)

For example:

=== CH_LIST_DELIM ***

will allow you to type  CHSTR /// *** /X/ ***

The changed delimiter will remain in effect until you change it or get out of the editor.
CH_CMD_DELIM <S-expression>

CH_CMD_DELIM allows you to change the delimiter for command lists used with RPT and DEFCMD.

FOR EXAMPLE:

```plaintext
==> CH_CMD_DELIM ***
```

will allow you to type

```
DEFCMD R T TCF D3 ***
```

The changed delimiter will remain in effect until you change it or get out of the editor.
REM <buffer-name> <n> or *

REM causes the editor to remove the given number of S-expressions (beginning with and including the current edit pointer) and place them in the given buffer. A number must be specified; there is no default. If * is specified, the rest of the edit level (beginning with and including the current edit pointer) will be removed. If fewer S-expressions remain than you have specified, the editor will remove as many as there are on that edit level; an error message will be displayed to tell you how many S-expressions were removed.

FOR EXAMPLE:

The current edit expression is (A B (C) D (E F))

The current edit list is (B (C) D (E F))

===\ REM BUFFER1 3
results in the edit list (\((E \ F)\))
  \{\<== A (E F)\)

BUFFER1 = (B (C) D)
REPL (ace)

REPL <buffer-name> <starting-number> <n> or *

REPL causes the editor to retrieve the given number of lines from the buffer (or the entire buffer if * is specified) beginning with the starting number given. A starting number and number of S-expressions must be specified; there is no default. The S-expressions will be inserted after the current edit pointer.

PCR EXAMPLE:

The current edit list is (A B)
The contents of BUFFER1 is (S1 S2 S3 S4 S5 S6)

==> REPL BUFFER1 2 4
results in the edit list (A S2 S3 S4 S5 B)

No S-expressions are removed from the buffer.
DISPLAY

DISPLAY causes the editor to display the names of all buffers that have been created.
CONTENTS <buffer-name>

CONTENTS causes the editor to display the contents of the given buffer.
SAMPLE EDIT SESSION

\begin{verbatim}
 E:EDIT DOUBLE LIST
 .T

 (EXPR (LAMBDA (L) (CONS ((NULL L)) (CDR L)
                  (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
                   (EXPLODE (CAR L))
                   (DOUBLELIST (CDR L)) ) ) ) ) )

 .R D R2 D T

 (CONS ((NULL L)) (CDR L)
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .CHATOM 5 / D / 1 T
    <<< 1 CHANGES >>>

 (COND ((NULL L)) (CDR L)
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .R2 CH* NIL / 1 T
    <<< 1 CHANGES >>>

 (NIL (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .L T

 ((NULL L)) NIL
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .UN T

 ((NULL L)) NIL
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .G2 L T

 (COND ((NULL L) NIL)
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
     (EXPLODE (CAR L))
     (DOUBLELIST (CDR L)) ) ) )

 .CH IMPLOD / IMPLODE / 1 S T
    <<< 1 CHANGES >>>

 /EXPR (LAMBDA (L) (COND ((NULL L) NIL)
    (T (APPEND (IMPLOD (CONS (EXPLODE (CAR L))))
      (EXPLODE (CAR L))
      'DOUBLELIST (CDR L)) ) ) )
\end{verbatim}
(EXPR (LAMBDA (L))
  (COND ((NULL L) NIL)
    (T (APPEND (IMPLODE (APPEND (EXPLODE (CAR L)))
                   (EXPLODE (CAR L)))
      (DOUBLE_LIST (CDR L))))))

(INTERN T)

(IF (APPEND / CH^ CONS / T
      (COND ((NULL L) NIL)
        (T (APPEND (IMPLODE (APPEND (EXPLODE (CAR L)))
                     (EXPLODE (CAR L)))
           (DOUBLE_LIST (CDR L)))
        (DOUBLE_LIST (CDR L))))))

(UN T)

(IF (APPEND (EXPLODE (CAR L)) (EXPLODE (CAR L)) (DOUBLE_LIST (CDR L)))
  (G3 L G2 T)
  (IF (APPEND (EXPLODE (CAR L)) (EXPLODE (CAR L)))
      (DOUBLE_LIST (CDR L)))
  (S T)

(EXPR (LAMBDA (L))
  (COND ((NULL L) NIL)
    (T (CONS (IMPLODE
                 (APPEND
                  (EXPLODE (CAR L))
                  (EXPLODE (CAR L)))
                (DOUBLE_LIST (CDR L)))))))

(END
QUIT OR FILE?
"FILE"
DO YOU WISH TO PLACE IN A FILE?
TYPE "FP" OR "Q"
APPENDIX I

The LEDIT Program Code
(DEFUN = (S1 S2) (EQUAL S1 S2))
(DEFUN GT (X Y) (GREATERP X Y))
(DEFUN LT (ARG1 ARG2) (LESSP ARG1 ARG2))
(DEFUN LE (ARG1 ARG2) (OR (LT ARG1 ARG2) (= ARG1 ARG2)))

(CSETQ LITERALC '3)

(SETC *USER_COMMAND* NIL)

(DEFUN EDIT_PEXPR (ARGS)
  (PROG (ATOM_NAME PROPERTY_NAME
    *EXPRESSION*
    *EDIT*
    *LEVEL*
    *EDIT_POSITIONS*
    *ORIGINAL_EXPRESSIONS*
    *STORED_EXPRESSIONS*
    *ATCH_NAMES*
    *PROP_NAMES*
    *EDIT_CAD*
    *BUFFERS*
    *LIST_DELIMITER* *CAD_DELIMITER*)
    (SETQ *ORIGINAL_EXPRESSIONS* NIL)
    (SETQ *EDIT_POSITIONS* NIL)
    (SETQ *ATCH_NAMES* NIL)
    (SETQ *PROP_NAMES* NIL)
    (SETQ *BUFFERS* NIL)
    (SETQ *EXPRESSION* (= 'DONE=))
    (SETQ *LIST_DELIMITER* '/
    (SETQ *CAD_DELIMITER* 'ENDCAD)
    (COND ( (= (LENGTH ARGS) 0)
      (RETURN (ERROR_MESSAGE NIL 'TOO_FEW_ARGUMENTS)))
    (SETQ ATON_NAME (CAB ARGS))
    (COND ((NULL (CDE ARGS)) (SETQ PROPERTY_NAME NIL)
      (T (SETQ PROPERTY_NAME (CADR ARGS)))
        LOOP
        (EDIT_NEW_SEXP ATON_NAME PROPERTY_NAME)
        (COND ((='EXPRESSION' '='DONE=) (RETURN 'LISP))
          (GO LOOP))))

(DEFUN EDIT_W2W_SEXP (ATOM_NAME PROPERTY_NAME)
  (SETQ *STORED_EXPRESSIONS* (CONS *EXPRESSION* *STORED_EXPRESSIONS*)
  (SETQ *EXPRESSION* (PROPERTY_LIST_TO_EDIT
    ATOM_NAME PROPERTY_NAME))
  (COND ((= (NULL *EXPRESSION*)
    (ERROR_MESSAGE NIL 'NO_PROPERTY_LIST_FOUND)
    (SETQ *EXPRESSION* (CDE *STORED_EXPRESSIONS*))
    (SETQ *STORED_EXPRESSIONS* (CDR *STORED_EXPRESSIONS*)))
    (T (INITIALIZE_EDIT_MARKERS)
      (PROG (COMMAND)
        LOOP))))
(SETQ COMMAND (READ))
(COND (\= COMMAND 'END)
   (END)
   (RETURN (RESTORE_EDIT_MARKERS)))

(PROCESS COMMAND)
(GO LOOP))

(DEFUN PROPERTY_LIST_TO_EDIT (ATOM_NAME PROPERTY_NAME)
 (COND ((null PROPERTY_NAME) ATOM_NAME)
    (T (FIND_PROPERTY ATOM_NAME PROPERTY_NAME)))

(DEFUN FIND_PROPERTY (PROPERTY_LIST PROPERTY)
 (COND ((null (cdr PROPERTY_LIST)) nil)
    (= (CAR PROPERTY_LIST) PROPERTY) PROPERTY_LIST)
    (T (FIND_PROPERTY (CDR PROPERTY_LIST) PROPERTY)))

(DEFUN ERROR_MESSAGE (ARG MESSAGE)
 (PRINC '\$<< \$)
 (COND (ARG (PRINC ARG) (PRINC '\$ \$))
    (PRINC MESSAGE) (PRINC '\$ >>> \$) (TERPRI) )

(DEFUN INITIALIZE_EDIT_MARKERS ()
 (SETQ *ORIGINAL_EXPRESSIONS* (CONS *EXPRESSION* *ORIGINAL_EXPRESSIONS*))
 (COND ((null PROPERTY_NAME)
    (SETQ *EXPRESSION* (COPY (CDB ATOM_NAME)))
    (T (SETQ *EXPRESSION* (COPY APPEND (LIST (CADDR *EXPRESSION*)))
      (LIST (CADDR *EXPRESSION*)))))))

(DEFUN COPY (L)
 (COND ((ATOM L) L)
    (T (CONS (COPY (CAR L)) (COPY (CDR L)))))

(DEFUN END ()
 (PRINC 'QUIT OR FILE?) (TERPRI)
 (SETQ END_COMMAND (READ))
 (COND ((MEMBER END_COMMAND ' (QUIT FILE))
    (RETURN (EVAL (LIST END_COMMAND))))
 (GO LOOP)))

(DEFUN QUIT () (PRINT 'ABORTED))

(DEFUN FILE ()
 (PRINC 'DO YOU WISH TO PLACE IN A FILE?) (TERPRI)
 (PRINC 'TYPE YES OR NO?) (TERPRI)
 (COND (\= (READ) 'YES) (READ) (TERPRI))
 (SP (COND (PROPERTY_NAME

...
(DEFUN DELETE_PROPERTY (ATOM_NAME PROPERTY_NAME)
  (PUTPROP ATOM_NAME
    (CADD CAR *ORIGINAL_EXPRESSIONS*)
    (T (REPLACD ATOM_NAME *EXPRESSION*))))

(DEFUN RESTORE_EDIT_MARKERS ()
  (SETQ *ORIGINAL_EXPRESSIONS* (CDF *ORIGINAL_EXPRESSIONS*))
  (SETQ *ATOM_NAMES* (CDF *ATOM_NAMES*))
  (SETQ *PROP_NAMES* (CDF *PROP_NAMES*))
  (RESTORE_EDIT_POSITIONS*)
  (SETQ *EXPRESSION* (CAR *STORED_EXPRESSIONS*)
  (SETQ *STORED_EXPRESSIONS* (CDF *STORED_EXPRESSIONS*))
  (COND ((= (CATE *EDITPOSITIONS*) 'TOP)
    (SETQ *LEVEL* *EXPRESSION*)
    (SETQ *EDIT* *EXPRESSION*)
    (T (SETQ *LEVEL* (*ATOM_EDITPOSITIONS*)
      (SETQ *EDIT* (*ATOM_EDITPOSITIONS*))))
  (RESTORE_EDIT_POSITIONS*))

(DEFUN RESTORE_EDIT_POSITIONS ()
  (COND ((= (CATE *EDITPOSITIONS*) 'TOP)
    (SETQ *EDITPOSITIONS* (CDF *EDITPOSITIONS*))
    (T (SETQ *EDITPOSITIONS* (CDF *EDITPOSITIONS*)
      (RESTORE_EDIT_POSITIONS*))))

(DEFUN PROCESS COMMAND)
  (COND ((MEMBER COMMAND *USER_COMMAND*) (COMMAND))
    (HELP COMMAND) (HELP (READ))
    (T COMMAND) (SP *EDIT* T)
    (EDIT NEW SEXP (READ) (READ))
    (DEFCD Command)
      (PRINC ' ENTER USER COMMAND NAME: A)
      (DEFCD (READ))
    (RPT COMMAND) (SETQ *RPT_CMD* (GENSYM '3*%1))
      (DEFCD *RPT_CMD*)
      (RPT_USER *RPT_CMD* (READ))
    (CH CMD DEDILM COMMAND)
      (CH CMD_DELIMITER* (READ))
      (PRINC 'B--- COMMAND DELIMITER NOW: A)
      (PRINC *CMD_DELIMITER*) (PRINC 'B ---A) (TERPRI))
    (CH LIST DELILM COMMAND)
      (LIST_DELIMITER* (READ))
      (PRINC 'B--- LIST DELIMITER NOW: A)
(PRINC *LIST_DELIMITER*) (PRINC 'a ---b) (TIRPRI))

(= 'REM COMMAND) (REMOVE (READ) (READ)))

(= 'REPL COMMAND) (REPLACE (READ) (READ) (READ)))

(= 'DISPLAY COMMAND) (DISPLAY_BUFFER_NAMES))

(= 'CONTENTS COMMAND) (DISPLAY_BUFFER_CONTENTS (READ)))

(= 'UN COMMAND) (UNGROUP))

(= (UN* COMMAND)
  (REPEAT 'UN* '*))

(= (FIRST_N 2 (EXPLODE COMMAND)) '((n 2)
  (REPEAT 'UNGROUP (MAKE_NUMBER (CDDA (EXPLODE COMMAND))))))

(= 'G (CAR (EXPLODE COMMAND)))
  (GROUP (NUMBER_OF_REPETITIONS)))

(= 'DEL COMMAND) (DELETE())

(= 'DEL* COMMAND) (DELETE_N '*))

(= (FIRST_N 3 (EXPLODE COMMAND)) '(* E L))
  (DELETE_N (MAKE_NUMBER (CDDR (EXPLODE COMMAND))))

(= 'IA COMMAND) (INSERT_AFTER (ARG_LIST (READ))))

(= 'IB COMMAND) (INSERT_BEFORE (ARG_LIST (READ))))

(SEPER (CAR (EXPLODE COMMAND)) '((E I U D))
  (REPEAT (CAR (EXPLODE COMMAND))
    (NUMBER_OF_REPETITIONS)))

(= 'CH COMMAND)
  (CHANGE_N (ARG_LIST (READ))
    (ARG_LIST (READ)) (READ)))

(= 'CH! COMMAND) (CHANGE_N (LIST (CAR *EDIT*))
  (ARG_LIST (READ)) (READ)))

(= 'CHATOM COMMAND)
  (CHANGE_ATOM (CAR (ARG_LIST (READ))))
    (CAR (ARG_LIST (READ)))
    (CAR (ARG_LIST (READ))) (READ)))

(= 'CHATOM COMMAND)
  (CHANGE_ATOM (CAR *EDIT*))
    (CAR (ARG_LIST (READ)))
    (CAR (ARG_LIST (READ))) (READ)))

(= 'CHSTR COMMAND) (CHANGE_STE (CAR (ARG_LIST (READ)))
  (CAR (ARG_LIST (READ))) (READ)))
(DEFUN ARG_LIST (ARG)
  (PROG (L)
    (SETQ L NIL)
    LOOP
      (COND ((= ARG *LIST_DELIMITER*)
         (COND ((NULL L) (RETURN (LIST NIL)))
         (T (RETURN L)))
      )
    (SETQ L (APPEND L (LIST ARG)))
    (SETQ ARG (READ))
    (GO LOOP)))

(DEFUN REPEAT (COMMAND N)
  (PROG (COUNT DOCMD)
    (COND ((OR (NOT (LEGAL_NUMBER_ARG N))
             (= N 0)) (RETURN NIL)))
    (SETQ COUNT 1)
    (SETQ DOCMD (EVAL (LIST COMMAND)))
    (COND ((NULL DOCMD) (RETURN (ERROR_MESSAGE 0 'COMPLETED)))
          (T (COND ((= N COUNT) (RETURN T))
               (T (COND ((NULL DOCMD)
                         (RETURN (ERROR_MESSAGE (SUB1 COUNT) 'COMPLETED)))
               )
               (SETQ COUNT (ADD1 COUNT))
               (SETQ DOCMD (EVAL (LIST COMMAND)))
               (GO LOOP)))
    )

(DEFUN NUMBER_OF_REPETITIONS ()
  (MAKE_NUMBER (CDR (EXPLODE COMMAND)))
)

(DEFUN RNKBUN (N) (RUMB N) (NKATCH))

(DEFUN NKBUN (N)
  (COND ((= N 1) 1)
        ((= N 2) 2)
        ((= N 3) 3)
        ((= N 4) 4)
        ((= N 5) 5)
        ((= N 6) 6)
        ((= N 7) 7)
        ((= N 8) 8)
        ((= N 9) 9)
        ((= N 0) 0))))

(DEFUN MAKE_NUMBER (STR)
  (PROG (COUNT SUM)
    (COND ((NULL STR) (RETURN 1)))
    (COND ((NOT (DIGP (CAR STR))) (RETURN (CAR STR)))
    )
    (SETQ COUNT (DIFFERENCE (LENGTH STR) 1))
    )

(setq sum (times (remove (car str))
(expt 10 count)))

loop
(cond (= count 0) (return sum)))
(setq str (cdr str))
(cond ((not (digp (car str))) (return (car str))))
(setq count (sub1 count))
(setq sum (plus sum
(times (remove (car str))
(expt 10 count))))

(defun defcmd (name)
(prog (program cmd description)
(setq *user-command* (cons name *user-command*))
(setq description (user-def))
(setq program (list 'defun name '()))
loop
(cond ((null description)
(return (eval program))))
(cond (= (car description) 'xa)
(setq cmd (appende
'(insert after)
(_arguments))))
(= (car description) 'yb)
(setq cmd (appende
'(tyset before)
(_arguments))))
(= (car description) 'ch)
(setq cmd (appende
'(change n)
(_arguments)
(Arguments)
(move over)
(list (car description))
(move over))))
(= (car description) 'ch1)
(setq cmd (appende
'(change n)
(list (car *edit*))
(_arguments)
(move over)
(list (car description))
(move over))))
(= (car description) 'ch2)
(setq cmd (appende
'(change atom)
(list (car *edit*))
(list (list 'car (car (arguments))))
(list (list 'car (car (arguments))))
(move over)
(list (car description))
(move over))))
(= (car description) 'ch3)
(setq cmd (appende
'(change atom)
(list (list 'car (car (arguments))))
(move over)
(list (list 'car (car (arguments))))
(move over))))
(DEFUN USER-DEF () (PRINT ("ENTER NAME DEF:") (PROG (ARG LIS) (SETQ ARG (READ))) (SETQ LIS (CONS ARG NIL)) LOOP (SETQ ARG (READ)) (COND (\(=\) ARG *CMD_DELIMITER*) (RETURN LIS)) (SETQ LIS (APPEND LIS (LIST ARG))) (GO LOOP))

(DEFUN ARGUMENTS () (LIST (LIST 'COPY (LIST 'QUOTE (GET_ARGS))))))

(DEFUN GET_ARGS () (PROG (ARG LIS) (MOVE_OVER) (SETQ ARG (CAR DESCRIPTION)) (MOVE_OVER) (SETQ LIS (CONS ARG NIL)) LOOP (SETQ ARG (CAR DESCRIPTION)) (COND (\(=\) ARG *LIST_DELIMITER*) (RETURN LIS)) (MOVE_OVER) (SETQ LIS (APPEND LIS (LIST ARG))) (GO LOOP)))

(DEFUN MOVE_OVER () (SETQ DESCRIPTION (CDR DESCRIPTION)))

(DEFUN BPT-USER (COMMAND N) (PROG (COUNT DOCMD) (COND (\(=\) N * ) (RETURN (ERROR_MESSAGE N 'NOT_ALLOWED_WITH_BPT))) ((NOT (NUMBER N)) (RETURN (ERROR_MESSAGE N 'ILLEGAL_ARGUMENT))))
(DEFUN REMOVE (BUFFER_NAME N)
  (PROG ()
    (COND ((NOT (LEGAL_NUMBER_ARG N))
        (RETURN NIL))
        (EQ N 'w') (SETQ N (LENGTH *EDIT*))
        (EQ N 0) (RETURN (ERROR_MESSAGE N 'ILLEGAL_ARGUMENT))
        (NOT (MEMBER BUFFER_NAME *BUFFERS*)
        (SETQ *BUFFERS* (CONS BUFFER_NAME *BUFFERS*)))(RETURN (PUTPROP BUFFER_NAME
          COPY (APPEND (GET BUFFER_NAME 'CONTENT)
            (GET_LINES_PCB_BUFFER
              BUFFER_NAME N))
            'CONTENT))))

(DEFUN GET_LINES_PCB_BUFFER (BUFFER N)
  (PROG (CCOUNT L)
    (SETQ COUNT 1)
    (SETQ L (LIST (CAR *EDIT*)))
    LOOP
      (SETQ COUNT (ADD1 CCOUNT))
      (COND (OR (NULL (DELETE)) (LT N COUNT))
        (ERROR_MESSAGE (SUB1 CCOUNT) 'CHANGES)
        (RETURN N))
      (SETQ L (APPEND L (LIST (CAR *EDIT*)))
        (GO LOOP)))

(DEFUN REPLACE (BUFFER_NAME N START)
  (PROG (BUFF))
    (SETQ BUFFER (GET BUFFER_NAME 'CONTENT)
    (COND ((NULL BUFFER)
      (RETURN (ERROR_MESSAGE N 'NULL_BUFFER'))
      (NOT (LEGAL_NUMBER_ARG N)) (RETURN NIL))
      (OR (NOT BUFFER) START) (LE N 0))
      (RETURN (ERROR_MESSAGE N 'ILLEGAL_ARGUMENT))
      (EQ N 'w') (SETQ N (ADD1 (MINUS (LENGTH
        (GET BUFFER_NAME
          'CONTENT)
        START))))
      (EQ N 0) (RETURN (ERROR_MESSAGE N 'ILLEGAL_ARGUMENT))
      ((GT START (LENGTH (GET BUFFER_NAME 'CONTENT)))
        (RETURN (ERROR_MESSAGE N 'BETWEEN_END_OF_BUFFER_CONTENTS))))
      (INSERT_AFTER)
        (COPY (FIRST N N (MARK_START START
          (GET BUFFER_NAME
            'CONTENT)))))
(DEFUN MARK-START (N L)
  (COND ((= N 1) L)
          ((NULL L) L)
          (T (MARK-START (SU1 N) (CDR L))))
  (DEFUN DISPLAY-BUFFER-NAMES () (PRINT "BUFFERS")
  (DEFUN DISPLAY-BUFFER-CONTENTS (BUFFER-NAMES)
    (PRINT (GET BUFFER-NAMES 'CONTENTS))
  (DEFUN DELETE-N (N)
    (FLOOR (COUNT)
      (COND ((NOT (LEGAL-NUMBER-ARG N)) (RETURN NIL)
            (SETQ N (LENGTH *EDIT*)))
            (SETQ COUNT 1)
            LOP)
      (COND ((LT N COUNT) (RETURN T))
             ((NOT (DELETE!)) (RETURN (ERROR-MESSAGE COUNT "DELETIONS")
                             (SETQ COUNT (ADD1 CCOUNT))
                             (GO LOOP)))
      (DEFUN DELETE! () (COND ((L) (REPLACE *EDIT* (CDR *EDIT*)
            (COND ((AT-END-OF-EDIT-LIST) (ERROR-MESSAGE NIL "END-OF-LEVEL")
                    (T (R)))
                    ((R) (REPLACE *EDIT* (CAR *EDIT*)
                          (COND ((AT-BOTTOM-LEVEL) (ERROR-MESSAGE NIL "AT-BOTTOM-LEVEL")
                                  (T (R)))
                                  (T (SETQ *EDIT* (CDR *EDIT*))))
                                  (T (SETQ *EXPRESSION* *EDIT*)))
                                  (SETQ *LEVEL* *EDIT*)))))
      (DEFUN GROUP (N)
        (COND ((NOT (LEGAL-NUMBER-ARG N)) NIL)
            (T (COND ((= N 1) (SETQ N (LENGTH *EDIT*)))
                                 (ERROR-MESSAGE NIL "FIRST-STEP-OF-LIST")
                                 (LT N 0) (ERROR-MESSAGE NIL "ZERO-ARGUMENT")
                                 (N (ERROR-MESSAGE N "GT-LENGTH-OF-LIST")
                                 (RPLACED *EDIT* (FIRST N *EDIT*)))
                                 (RPLACED *EDIT* (ALL-BUT-FIRST N *EDIT*)))))
      (DEFUN AT-BEGINNING () (= *EDIT* *EXPRESSION*)))
      (DEFUN LEGAL-NUMBER-ARG (N)
        (COND ((NUMBERP N) (LT N 0))
              (AND (NOT (NUMBERP N)) (NOT (= N "")))
              (ERROR-MESSAGE N "ILLEGAL-ARGUMENT")
              (T T)))
(DEFUN UNGROUP ()
  (COND ((ATOM (CAR *EDIT*)))
    (ERROR_MESSAGE NIL 'CANNOT_UGROUP_ATOM))
  ((AT_BEGINNING) (CHANGE! (CAR *EDIT*))
    (T (NCONC (CAR *EDIT*) (CDR *EDIT*))
    (COND (((L) (SPLACD *EDIT* (CDR *EDIT*))) (R))
    (U) (REPLAC *EDIT* (CAAR *EDIT*) (D)))))

(DEFUN UN* ()
  (COND ((ATOM (CAR *EDIT*))
    (RETURN NIL))
  ((AT_BEGINNING) (CHANGE! (CAR *EDIT*))
    (T (NCONC (CAR *EDIT*) (CDR *EDIT*))
    (COND (((L) (SPLACD *EDIT* (CDR *EDIT*))) (R))
    (U) (REPLAC *EDIT* (CAAR *EDIT*) (D)))))

(DEFUN INSERT_AFTER () (INSERTION)
  (COND (((NULL INSERTION) (ERROR_MESSAGE NIL 'NO_INSERTIONS))
    (T (NCONC INSERTION (CDR *EDIT*))
    (REPLAC *EDIT* INSERTION)))

(DEFUN INSERT_BEFORE () (INSERTION)
  (COND (((NULL INSERTION) (ERROR_MESSAGE NIL 'NO_INSERTIONS))
    (T (COND ((L) (INSERT_AFTER INSERTION) (R))
    (U) (NCONC INSERTION (CAR *EDIT*))
    (REPLAC *EDIT* INSERTION)
    (D))
    (T (NCONC INSERTION *EDIT*)
    (SETQ *EDIT* INSERTION)
    (SETQ *EXPRESSION* *EDIT*)))
    (SETQ *LEVEL* *EDIT*))))))

(DEFUN R ()
  (COND ((AT_END_OF_EDIT_LIST) NIL)
    (T (SETQ *EDIT* (R_MOVE))))

(DEFUN R_MOVE () (CAR *EDIT*))

(DEFUN AT_END_OF_EDIT_LIST () (NULL (CDR *EDIT*)))

(DEFUN L ()
  (COND ((AT_START_OF_EDIT_LEVEL) NIL)
    (T (SETQ *EDIT* (L_MOVE)))))

(DEFUN AT_START_OF_EDIT_LEVEL () (= *EDIT* *LEVEL*)

(DEFUN L_MOVE ()
  (ALL_BUT_FIRST
    (SUB1 (DIFFERENCE (LENGTH *LEVEL*) (LENGTH *EDIT*)))
    *LEVEL*))

(DEFUN ALL_BUT_FIRST (N L)
  (COND (((NULL L) NIL)
    (N 0) L)
(DEFUN U ()
  (COND ((AT_TOP_LEVEL) NIL)
         (T (RESET) (RESET_LEVEL)
             (SETQ *EDIT-POSITIONS* (CDR *EDIT-POSITIONS*) T)))))

(DEFUN AT_TOP_LEVEL () (= (CAR *EDIT-POSITIONS*) 'TOP))

(DEFUN RESET () (SETQ *EDIT* (CAR *EDIT-POSITIONS*)))

(DEFUN RESET-LEVEL () (SETQ *LEVEL* (CDR *EDIT-POSITIONS*)))

(DEFUN D ()
  (COND ((AT_BOTTOM_LEVEL) NIL)
         (T (SETQ *EDIT-POSITIONS* (CONS *LEVEL* *EDIT-POSITIONS*))
             (SETQ *EDIT-POSITIONS* (CONS *EDIT* *EDIT-POSITIONS*))
             (NEW_LEVEL) (NEW) T)))))

(DEFUN AT_BOTTOM_LEVEL () (ATOM (CAR *EDIT*)))

(DEFUN NEW_LEVEL () (SETQ *LEVEL* (CAR *EDIT*)))))

(DEFUN NEW () (SETQ *EDIT* (CAR *EDIT*)))))

(DEFUN TOP ()
  (COND ((U) (TOP)))))

(DEFUN BACK_TO_START ()
  (PROG ()
    (TCP)
    LOOP
    (COND (NULL (L)) (RETURN T)))
  (GO LOOP)))

(DEFUN CHANGE-N (KEY CHANGES N)
  (PROG (COUN COUNT COPY-CHANGES)
    (COND ((NULL CHANGES)
      (RETURN (ERROR-MESSAGE NIL 'NULL-CHANGES)))
      (COND ((NULL KEY)
        (RETURN (ERROR-MESSAGE NIL 'NULL-KEY)))
      (COND ((NOT (LEGAL-NUMBER ARG N)) (RETURN NIL))
        (N 'N) (SETQ N (LENGTH *EDIT*))
        (N 0) (RETURN (ERROR-MESSAGE 0 'CHANGES)))
      (SETQ COUNT 1)
      LOOP
      (SETQ COPY-CHANGES (COPY-CHANGES)
        (COND (OR (LT N COUNT) (NOT (LOCATE-ONE KEY))
          (RETURN (ERROR-MESSAGE (SUB1 COUNT) 'CHANGES)))
          (REPEAT 'R) (SUB1 (LENGTH KEY)))
        (REPEAT 'L) (SUB1 (LENGTH KEY)))
        (COND (L) (REPLACE *EDIT* COPY-CHANGES (R))
          (U) (REPLACE *EDIT* COPY-CHANGES (D))
          (T (SETQ *EDIT* COPY-CHANGES)
            (SETQ *EXPRESSION* *EDIT*)
            (SETQ *LEVEL* *EDIT*))))))
(DEFUN COUNT (COUNT) (ADD1 COUNT)) (GO LOOP))

(DEFUN CHANGE (CHANGES)
  (COND ((NULL CHANGES) (ERROR MESSAGE NIL 'NC_CHANGES))
    (T (NCONC CHANGES (CDR *EDIT*))
      (COND ((L) (REPLACE *EDIT* CHANGES (L))
        (COND (T (EDIT1* CHANGES)
          (SETQ *EXPRESSION* *EDIT*)
            (SETQ *LEVEL* *EDIT*))
            (SETQ *LEVEL* *EDIT*))))))

(DEFUN CHANGE_ATOM (ATN OLD NEW N)
  (PROG (NEW_ATOM CHK)
    (COND ((NOT (AND (ATOM ATN) (ATOM OLD) (ATOM NEW)))
      (RETURN (ERROR_MESSAGE NIL 'ARGUMENT_NOT_ATOM)))
      (OR (NULL ATN) (NULL OLD))
        (RETURN (ERROR_MESSAGE NIL 'NULL_ATOM_SUBATOM)))
      (SETQ NEW_ATOM (CHANGE_ATOM ATN OLD NEW N))
      (SETQ CHK (MAKE_NUMBER (EXPLODE NEW_ATOM)))
      (COND ((NUMBERP CHK) (SETQ NEW_ATOM CHK))
        (= NEW_ATOM ATN)
          (RETURN (ERROR_MESSAGE OLD 'NOT_FOUND))))
      (RETURN (CHANGE_ATOM (LIST ATN) (LIST NEW_ATOM N))))

(DEFUN NEXT () (PROG ()
  LOOP
      (COND ((NULL (U)) (RETURN NIL))
        (E) (RETURN T)
          (T (GO LOOP)))))

(DEFUN FIRST_N (N L)
  (COND ((NULL L) NIL)
    (LE N 0) NIL)
     (T (CCNS (CAR L) (FIRST_N (SUE1 N) (CNR L))))))

(DEFUN CHANGED_ATOM (ATN OLD NEW)
  (EXPLODE (CHLIST (EXFICDE1 OLD)
    (EXPLODE1 NEW)
      (EXFICDE1 ATN)
        (EXFICDE1 ATM))))

(DEFUN EXPLODE1 (ATM)
  (PROG (NEW_ATOM)
    (COND ((NUMBERP ATM) (RETURN (EXP1_NUM ATM)))
      (NULL ATM) (RETURN NIL))
        (SETQ L (EXPLODE ATM))
          (SETQ NEW_ATOM (LIST (CAR L)))
            LOOP
              (SETQ L (CDR L))
                (COND ((NULL L) (RETURN NEW_ATOM))
                  (SETQ NEW_ATOM (APPEND NEW_ATOM
                    (LIST (COND ((LISP (CAR L))
                      (EXFNUM (CAR L)))
                        (T (CAR L)))))
                          ))})
(defun expl-num (n)
  (cond ((= n 0) nil)
         (t (append (expl-num (quotient n 10))
                    (list (remainder n 10))))))

(defun chlist (old new l l2)
  (cond ((null l1) nil)
         ((= old (first n (length old) l1))
          (append (explodeig new) (rest old l2)))
         (t (cons (car l2) (chlist old new (cdr l1) (cdr l2))))))

(defun explodeig (l)
  (cond ((null l) nil)
         (t (append (list (cond ((numberp (car l)) (mkdig (car l)))
                           (t (car l))))
                 (explodeig (cdr l))))))

(defun countatoms (s)
  (cond ((null s) 0)
         ((atom s) 1)
         (t (plus (countatoms (car s)) (countatoms (cdr s)))))))

(defun expt (n x)
  (prog (count prod)
         (cond ((= x 0) (return 1))
               (setq count 1)
               (setq prod n)
               loop
               (cond ((= count 1) (return prod))
                     (setq prod (+ (* prod n))
                            (setq count (+ 1 count))
                            (go loop)))))

(defun changez-step (old new n)
  (prog (count new-atm)
         (cond (not (legal-number arg n) (return nil))
               (= n '*') (setq n (countatoms *edit*))
               (= n 0) (return (error-message 0 'changes)))))

(defun rest (substring string)
  (cond ((null substring) string)
         (t (rest (cdr substring) (cdr string)))))

(defun end-of-file () (and (at-end-of-edit-list) (at-top-level))
(DEFUN FIND (KEY)
 (PROG (FOUND SAVE LENGTH_KEY)
   (COND ((NULL KEY) (RETURN (ERROR_MESSAGE NIL 'NULL_KEY))))
   (SETQ SAVE (LIST *EDIT* *LEVEL* *EDIT_POSITIONS*))
   (SETQ LENGTH_KEY (LENGTH KEY))
   (SETQ FOUND NIL)
   LOOP
   (COND (FOUND (RETURN T)))
   (COND ((OR (D) (E) (NEXT)))
     (SETQ FOUND (= (FIRST-N LENGTH_KEY *EDIT* KEY))
     (GO LOOP))
     (T (RESET_SAVE)
     (RETURN (ERROR_MESSAGE KEY 'NOT_FOUND))))))

(DEFUN RESIT_SAVE ()
 (SETQ *EDIT* (CAR SAVE))
 (SETQ *LEVEL* (CADE SAVE))
 (SETQ *EDIT_POSITIONS* (CADED SAVE)))

(DEFUN LOCATE_NEXT (KEY)
 (PROG (FOUND)
   (COND ((NULL KEY) (RETURN NIL)))
   (SETQ FOUND (= (FIRST-N (LENGTH KEY) *EDIT* KEY))
   LOOP
   (COND (FOUND (RETURN T)))
   (COND ((OR (D) (B) (NEXT)))
     (SETQ FOUND (= (FIRST-N (LENGTH KEY) *EDIT* KEY))
     (GO LOOP))
     (T (RETURN NIL))))))
APPENDIX II

References
REFERENCES


THE DESIGN, IMPLEMENTATION, AND USE OF LEDIT: A REAL-TIME EDITOR FOR LISP

by

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B. S., Kansas State University, 1973
Ms Ed., University of Southern California, 1975

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THE DESIGN, IMPLEMENTATION, AND USE OF LEDIT: A REAL-TIME EDITOR FOR LISP

'Programming languages can be divided into two categories. In one category, there is LISP; in the second category, all the other programming languages!'  

Jean Sammet [1]

LEDIT is a collection of LISP functions which enable the programmer to edit LISP programs and data bases without ever exiting from the LISP interpreter.

A comprehensive range of edit commands are included for implementation. LEDIT provides the user with the same capability that a conventional text editor provides. In addition, commands are available which are designed specifically to aid in editing LISP structures.

Since it is simply a relatively small set of LISP functions, LEDIT can be easily implemented on any LISP system; and the editor can be used with any line-oriented terminal.

Even novice and casual LISP programmers will find LEDIT easy to use. When LEDIT is used by the LISP programmer, editing will be more consistent with the LISP edit structures and more convenient for the user.

Part 1 of this report is the presentation of the motivation for the design and implementation of LEDIT. Part 2 is the overview of the LEDIT design. Part 3 is the detailed analysis of the LEDIT implementation. Part 4 is the User's Guide to LEDIT.