The Oberon Guide

System Release 1.2

Jürg Gutknecht

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Abstract

This guide provides a concise and detailed description of the Oberon system on three different levels: the user's level, the level of programmers of tools, and the level of implementors of new viewer classes. In particular, the guide features a complete documentation of standard commands, a commented series of important interface definitions, and a tutorial collection of Oberon programs exemplifying the typical Oberon programming style.

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Introduction

History

Oberon is simultaneously the name of a project and of its outcome. The project was started by Niklaus Wirth and the author late in 1985 with the goal of developing a modern and portable operating system for personal workstations. Its results are an implementation of the system for the Ceres computer and a programming language (see section Literature).

The development of the *language* Oberon needs perhaps a short justification. It became quite inevitable because the type-system of available languages turned out to be too restrictive to express the desired data model in a natural and safe way. We refer to report for a definition of the new language, and to the third and fourth chapter of this text for some examples of its application.

Design Principles

For the present, we focus on the system Oberon, beginning with a brief overview of its design principles. The underlying dynamic model is extremely simple. There exists a single process acting as a common carrier of multiple tasks. This process repetitively interprets *commands*, which are the official entities of execution in Oberon. Commands are atomic actions operating on the global state of the system. Unlike customary interactive programs, they rigorously avoid direct dialogs with the system user.

The following typical examples indicate the bandwidth covered by the concept of command: Placing the caret, inserting a character into a text, selecting a piece of text, deleting a selected piece of text, applying a new font to a piece of text, searching a pattern in a text, compiling a software module, opening a viewer, backing up a sequence of files to diskette, and displaying a directory. We emphasize that the execution of a command always results in non-volatile information. For example, in the last example, this means that the displayed directory is a text that might immediately undergo further processing. Typically, commands report the outcome of their execution in the form of an entry in the *system-log*. Therefore, the log provides a complete protocol of the current session.

Commands are initiated by input actions. Apart from a few universal operations, every input action is connected with a displayed *viewer*, to which its further handling is delegated. A viewer in Oberon is a rectangular area on the screen that can display any kind of data. Most viewers feature a thin frame and a title-bar containing a menu. Any mouse-oriented input is handled by the viewer the mouse points to. Data from the keyboard is immediately passed over to the current so-called *focus-viewer*. We notice that command interpretation is a highly decentralized activity in Oberon and, as such, is a substantial contribution to what we consider as Oberon's most important quality, namely unlimited extensibility.

Implementing a new viewer type is a very powerful but also quite far-reaching method to extend the Oberon system. It is only appropriate in conjunction with the installation of a new class of displayable objects (for example graphics or tables). The fourth chapter will provide more insight into this topic.

A more moderate way to increase the system's functionality consists in adding new commands operating on objects of an already existing class (for example a language compiler operating on text). We shall see in the third chapter that Oberon's open and coherent modular architecture provides effective support for that. Practically all system ingredients and resources are directly accessible and usable via modular interfaces on as high a level of abstraction as possible.

We should deduce from the foregoing that there is no symbolic wall in Oberon separating actual users from developers. Users are encouraged to customize the system and tailor it to their individual needs by designing and implementing private commands and facilities. Little is "hardwired" in the system. However, there are several general conventions and existing tools. They are presented in the next chapter.

Acknowledgement

I gratefully acknowledge Niklaus Wirth's initiative and willingness for travelling through the adventures of designing and building a new workstation, a new language, and a new operating system, escpecially under the given severe restrictions of personal resources. Without his competence and extraordinary commitment this mammoth-project could not have been successfully completed. I am also very grateful for the possibility to include an extract of Niklaus Wirth's Draw

guide in the first chapter. My thanks further go to the Oberon user's community, in particular to Martin Reiser, Hans-Peter Mössenböck, and Beverly Sanders for their constructive critisism and valuable suggestions for improvements.

User's Guide

Commands and Tools

Among the classes of possible objects to be handled by a computer system the class of texts plays a key role. Not only are input and output data frequently represented as text, but also objects and commands are often identified by their name. *Text* is, therefore, a predefined class of objects in Oberon.

This manifests itself immediately after system startup, when, besides of the *log-viewe*r*,* a so-called *tool viewer* is automatically opened on the screen. It contains a list of command names, some of them followed by parameters. Command names in Oberon are of the form M.P, where M designates a module (package) and P a procedure (operation) that is provided by the module. A user activates a command simply by pointing to its name with the mouse and clicking the middle mouse key. For example, activating the command *Edit.Open* will result in a new viewer showing some default text.

More often than not, the execution of a command is parameterized. For example, the opening of another tool needs the specification of its name, as in *System.Open Edit.Tool* or in *System.Open Net.Tool*. Although typical, this is not by far the most general case of a parameter specification. Some commands accept an entire list of names following the command name and execute repeatedly for each member of the list. In principle, a text obeying an arbitrary syntax (understood by the command) could be passed over equally well. Commands may even expect as parameters objects of any kind currently existing in the system such as viewers, text selections, caret, and a global star-shaped pointer. Some commands even allow different ways of paramewter specification. For example, if *System.Open* or *Edit.Open* is called with a "^"-symbol instead of a file name following the command name, then the file name is taken from the most recent selection. In general, a "^"-symbol following a command name always refers to the current selection.

It is noteworthy that tools are ordinary texts distinguishing themselves from more usual texts only by their structure and contents. In particular, tools are amenable to editing operations. Looking at this differently, we recognize that commands like *Edit.Open Explanations.Text* may well slip into a prose text and be activated directly in situ. Obviously, no limits are set to fantasy exploiting this universal scheme of command interpretation.

One rather moderate application of the universal scheme discussed above is the construction of interconnected texts. As a matter of fact, the set of standard tools is structured as a tree with the *System.Tool* as ancestor and the tools listed in the *System.Tool* as its descendants. We recall that the hierarchical tool system may easily be customized on the fly by adjusting command lists (including parameters) to personal requirements, reconfiguring the tool hierarchy, installing new tools, or even providing on-line documentation.

We now discuss *editing operations*. Recall first that most commands are interpreted individually by viewers. There are, however, a few more universal operations, which are handled directly by the central system. For example, when you type *escape*, all marks on the display are removed, including caret and text selections. Or, when you type *ctrl shift del* the system immediately terminates the execution of the current command and opens a trap-viewer displaying the state of the interrupted process. Notice that we have just identified you as the reader of this guide with a user of the system. In order to simplify phrasing, we shall henceforth occasionally do so tacitly.

Next we turn to viewers and display-specific operations. You can put your primary display screen into any one of three different modes by hitting one of the function keys *PF1*, *PF2*, and *PF3*. *PF1* specifies white script on a black background, *PF2* turns the display off, and *PF3* specifies black script on a white background. Oberon uses a tiling viewer system. The display is divided into vertical *tracks*, and each track is further subdivided into viewers. In reality, the structure of viewers is three-dimensional. A new track may in fact overlay one or, more generally, an integral number of existing tracks. The original configuration will be reestablished when the overlaying track is later removed.

Although the global screen layout can be changed, we relate our current explanations to the standard layout showing two tracks, a larger *user track* on the left and a narrower *system track* on the right. In principle, viewers are allocated automatically by the respective commands using a little heuristics. For example, tool viewers are opened in the system track, and document viewers in the user track. However, you can override any automatic allocation by first placing the *pointer* at the location where you desire the top of the new viewer to be placed. The pointer is a star-shaped marker, and it is placed by moving the mouse to the desired location and then hitting the *SETUP* key. In order to change the size of an existing viewer, simply point to its title-bar, press the left mouse key, and move the mouse up or down accordingly. You can also conveniently move a viewer to any different place on the display screen by starting exactly as just explained, then interclicking the

middle mouse-key, dragging the mouse to the new location, and releasing all keys there.

Interclicking means clicking (pressing and releasing) a secondary mouse button at an arbitrary time while a primary mouse key is being held down. In general, interclicking is an efficient and versatile tool to multiply the expressiveness of the mouse. In Oberon, interclicking is applied according to a systematic underlying pattern. You will find out more about this pattern in the following chapters. Perhaps the easiest and most important rule says that the current command is nullified, if all remaining mouse-keys have been interclicked (not necessarily simultaneously) during the action.

By convention, most viewers (so-called *menu-viewers*) show a header consisting of a title and a list of selected commands *(menu)*. These commands automatically refer to their own viewer. In the case of ordinary text viewers, commands are included from the System tool-package and the Edit tool-package. *System.Close* removes the viewer, *Edit.Copy* opens a new viewer displaying the same instance of text, *Edit.Grow* lets the viewer grow to the size of a full track or of the whole display, *Edit.Locate* locates a text position, and *Edit.Store* stores the text on file. We shall explain these commands in greater detail in the following sections on tools.

First, we fix some terminology and general conventions. We shall call *marked* an object or a location if it is visibly or invisibly marked by the earlier introduced star-shaped pointer. Visibility of the pointer is irrelevant in most cases. As an exception we mention the explicit allocation of a viewer, which requests the pointer to be visible. Note that an explicitly allocated viewer is automatically marked. Also note that the pointer is initially invisible and placed in the lower left corner of the display.

By convention, the title of a viewer is normally either the name of the displayed object or the name of the command that opened this viewer. Further, if a list of names is passed to a command as a parameter, it must be terminated by a symbol other than a name, for example by the character "~". By another convention, the upper right corner of the display is reserved for the *log viewer* reporting on the progress and result in the execution of a command. Finally, there are several *default extensions* of file names. Among them are *Text*, *Graph* and *Pict* for file copies of texts, graphics, and bitmap pictures respectively, and *Scn.Fnt* for screen font files.

In the following sections we shall use the terms parameter and parameter list in the restricted sense of "item following the command name" and "list of items following the command name" respectively.

The Edit Tool Package

We have stated earlier that extensibility was a key objective in the design of Oberon. It was therefore enticing to realize also system-oriented commands as extensions of the system-core on a highest possible level in the modular hierarchy, thereby achieving maximal flexibility. Such a strategy is particularly appropriate for *text editing*. It manifests itself in the existence of an edit *tool package* providing an extensible set of powerful editing commands. Nevertheless, several *built-in commands* are interpreted directly by *text frames*. They include positionning the text within its viewer, placing the caret, inserting a typed character, selecting a part of text, deleting a selected part of text, copying a selected part of text, copying attributes and, most importantly, executing an arbitrary command which is specified by its name. We should point out that all of these built-in commands are applicable in particular to menu-bars (which, in fact, are ordinary text frames featuring an inverted background color).

Mouse Commands

Text positionning. In order to reposition a text within a viewer, move the mouse into the viewer's *scrolling-zone*. This is a vertical bar along the left borderline of about 0.5 cm width. You can scroll forward by pressing the left mouse key, moving the mouse, and releasing the key when the text line that you want to become the top line is underlined. Notice that every text viewer shows a small crossbeam indicating the current position of the displayed section within the entire text. You can position a text directly by clicking the middle mouse key at the location where you want the crossbeam to be. If you wish the beginning of the text to be displayed, you can alternatively simply click the right mouse key anywhere within the scroll-bar.

Placing the caret. If you want to place the caret, move the mouse to the desired text, press the left mouse button and, while keeping it down, move the caret to the desired position. Any subsequently typed characters are then inserted at this position.

Selecting text. You can select any contiguous stretch of text by moving the mouse to the desired

beginning, pressing the right mouse button and, while holding it down, dragging the selection to the end. If you click twice at the beginning, the selection is automatically extended to the origin of that text line. If a piece of text is too large to be selectable within a single viewer, use *Edit.Copy* to open an adjacent second viewer. Then select the beginning of the stretch of text in the upper viewer and its end in the lower viewer separately. Note that a separate selection may be active for each displayed text section, including headers of viewers. If several selections exist simultaneously on the display, commands normally refer to the most recent one or to the most recent ones.

There are the following interesting interclick-variants of caret placing and text selection that combine these marking operations effectively with text editing. Remember the general rule saying that any mouse-controlled operation that is currently under execution can be nullified by interclicking all remaining mouse-keys.

Copying text. If you interclick the middle mouse button while you are placing the caret, the most recent selection is automatically copied to the caret's position as soon as you release the left button. This feature is particularly convenient for copying a specific template to several different places. Alternatively, if the caret is already set and you click the middle mouse key while you are selecting a piece of text, the selected text is copied to the caret's position when you release the select-button. This option is most conveniently used in order to copy a given string to various places. In order to neutralize (undo) any "interclick", simply click the remaining third button while still holding down the primary key.

Copying attributes. If you interclick the right mouse button while you are placing the caret, the character attributes (font, color, vertical offset) of the character by the caret is automatically applied to the most recent selection as soon as you release the left button.

Deleting text. If you click the left mouse-button while selecting a text, the selected text is eventually deleted. Here also, the interclick can be undone by an additional interclick of the middle mouse-key.

Notice that the above described editing operations are applicable to a header of a viewer only restrictedly. A header cannot be changed. Nor can the caret be placed in a header. Further notice that the copy variant and the delete variant of the select command apply also in the case of large selections involving split viewers.

Activating a command. Activating a named command from within a text viewer is generic and therefore the most general built-in operation. In order to do it simply point to the command's name and click the middle mouse key. Sometimes (e.g. in a test phase) it is important that the newest version of the module providing the desired command is loaded before the command is actually executed. In order to force this, simply interclick the left key while you are pressing the middle mouse key and pointing to the command's name.

If command execution fails, the system falls into a *trap*. There is no interactive debugger currently available under Oberon. However, a trap handler is automatically called whenever a trap has occurred. It displays the state of the interrupted process, including the stack of procedure activations. It also relates the location of trap to a position in the source program text. In order to find the failing statement simply display the source program and mark its viewer. Then select the position number in the trap viewer and invoke Edit.Locate.

The following table summarizes the basic meanings of the three mouse-keys: The left key is the *point-key*. It is used to focus a certain location, i.e. to place the caret. The middle key is the *execute-key*. Pressing and releasing it causes the appropriate command interpreter to be called. The right key is the *select-key*. It is used to select objects within a viewer.

Summary of mouse commands

primary button	left	middle	right
secondary button			
none	set caret	execute	select
left	-	free and execute	delete
middle	copy selection	-	copy this selection
right	copy attributes	-	-

Text viewers display text in a standard line-oriented way. In particular, they do not support any non-trivial formatting, such as automatic line-breaking or right-justifying paragraphs, for example. Font variation, color specification, and vertical offset, are however possible. We recommend the following fonts to be used in connection with text viewers: *Syntax10.Scn.Fnt* (default font),

Syntax10i.Scn.Fnt (italics variant), *Syntax10b.Scn.Fnt* (bold face variant), and *Courier8.Scn.Fnt* (non-proportional font).

According to Oberon's basic scheme, additional functionality is provided by the text edit tool package. It contains the following commands.

Edit Commands

Edit.Open
opens a viewer in the user track displaying the specified text. The text is alternatively specified by a parameter on the command line or, if a "^"-symbol follows the command name, by the most recent selection of a name. If none exists, a default name is taken. In order to override automatic allocation, place the pointer anywhere on the screen.

Edit.Show M.X
opens a viewer in the user track displaying the specified object *X* of module *M*. If the implementation of *M* is available, the implementation of *X* is shown, otherwise *X*'s definition is displayed.

Edit.Store
writes the text in the marked viewer to the file with the name defined by the parameter, or, if called from the menu line of a text viewer, writes the displayed text to the file with the name of the viewer.

Edit.Recall
inserts the most recently deleted piece of text at the position of the caret.

Edit.CopyFont
transfers the font from the marked location to the most recent text selection.

Edit.ChangeFont
applies the font specified by the parameter to the most recent text selection.

Edit.ChangeColor
applies the color specified by the parameter to the most recent text selection.

Edit.ChangeOffset
applies the vertical offset specified by the parameter to the most recent text selection.

Edit.Search
searches a pattern in the marked text. The pattern is defined by the most recent text selection. If none exists, the previous pattern is used. Searching is started at the position of the caret. If none exists in the marked text, searching starts at the beginning. The initial value of the pattern is the space character.

Edit.Locate
positions the text in the marked viewer according to the position-number indicated by the most recent text selection. Leading non-numerical items in the text selection are ignored.

Edit.Print ServerName ["%"] { (TextFileName | "") ["/" NofCopies] }*
sends all texts specified by the parameter list to the print server whose name is taken from the first entry in the parameter list. Names in the parameter list refer to text files, the symbol * to the text in the marked viewer. The symbol % specifies the vanilla-print option. If active, the texts are printed in a single monospaced small Font (Gacha10l). This option is typically used for printing source program listings. NofCopies optionally specifies the desired number of copies. It must be a single-digit number. This command assumes that the correct user identification has previously been installed (by calling *System.SetUser*).

The System Tool Package

This package features system related commands. Among them are procedures to display tools in the form of viewers, to close viewers and tracks, to define and display all kinds of system oriented parameters, and to provide basic utilities for the manipulation of named files. In addition, the system

tool package contains a trap handler that is implicitly called after a trap has occured. It displays the current state of the system stack.

System.Open
opens a viewer in the system track displaying the specified tool. The tool is alternatively specified by a parameter on the command line or, in the case of a "^" following the command name, by the most recent selection of a name. If none exists, a default name is taken..

System.OpenLog
opens a viewer in the system track displaying the system-wide log. Notice that the log is updated regardless of its visibility. Therefore, the log always shows the complete history of the current session.

System.Copy
opens a copy of the original viewer displaying the same instance of contents.

System.Grow
lets the viewer grow to the size of a whole track or, if applied to a viewer already filling a track, to the size of the whole display. Note that the original constellation will be reestablished when the grown viewer is later removed.

System.Close
removes the marked viewer from the display, or, if called from the menu line of a text viewer, removes the own viewer.

System.CloseTrack
closes the marked track, i.e. removes all viewers in this track.

System.Recall
reopens the most-recently (perhaps erronously) closed viewer..

System.Time
displays the current date and time. If date and time parameters *dd.mm.yy hh.mm.ss* (day, month, year and hour, minute, second) immediately follow the command name, *System.Time* first sets date and time accordingly.

System.Watch
displays the amount of currently used disk space and memory resources.

System.Collect
initiates a subsequent garbage collection.

System.Free
unloads every module specified by the parameter list. If a module name is immediately followed by *, imported modules are also unloaded.

System.ShowModules
displays a map of all currently loaded modules.

System.ShowCommands ModName
displays a list of all commands exported by this module.

System.State ModName
displays the global data of the specified module.

System.SetUser
accepts the user's identification in the form *UserName "/" Password* without echoing it on the display. *UserName* is up to eight characters long (initials in most cases). The password is an arbitrary string.

System.Directory
displays the selection of all disk files whose name match the template specified by the parameter. The parameter is a string and may contain the symbol "*" as a wildcard. If option "d" is specified ("/d"

immediately following the parameter) additional information about file sizes and dates is displayed. In the case of a "^" following the command name the parameter is taken from the current selection.

System.CopyFiles
processes a parameter list of pairs A => B. Copies each file A to B. In the case of a "^" following the command name the parameter is taken from the current selection.

System.RenameFiles
processes a parameter list of pairs A => B. Renames each file A to B. In the case of a "^" following the command name the parameter is taken from the current selection.

System.DeleteFiles
deletes each file specified by the parameter list. In the case of a "^" following the command name the parameter (a single file name) is taken from the current selection.

System.SetFont
applies the font specified by the parameter to subsequently typed characters.

System.SetColor
applies the color specified by the parameter to subsequently typed characters.

System.SetOffset
applies the vertical offset specified by the parameter to subsequently typed characters.

The Compiler Tool Package

This package contains the Oberon compiler. The result of compilations is shown in the log viewer. Possible errors are listed in the log viewer together with their position in the source text. In order to locate the error within the source text, use *Edit.Locate* in the log viewer's title menu. The compiler tool exports a single command:

Compiler.Compile
compiles all texts specified by the parameter list. Names in the parameter list refer to text files, the symbol * to the text in the marked viewer. In the case of a "^" following the command name the parameter list is taken from the current selection. The following options are available: "/x" (index check off), "/v" (check integer overflow), "t" (type guards off), "/s" (allow change of symbol file), and "/d" (provide debugging information).

The Miscellaneous Tool Package

This package provides utilities to convert files and determine statistical data.

Miscellaneous.ConvertBlanks
converts all text files specified by the parameter list by replacing pairs of leading spaces by tab characters. "^" following the command name refers to the current selection (a single file name).

Miscellaneous.ConvertTabs
converts all text files specified by the parameter list by replacing leading tab characters by pairs of spaces. "^" following the command name refers to the current selection (a single file name).

Miscellaneous.CountLines
counts the lines of all text files specified by the parameter list. "^" following the command name refers to the current selection (a single file name).

Miscellaneous.GetObjSize
extracts code size and data size from all object files specified by the parameter list. "^" following the command name refers to the current selection (a single file name).

The Backup Tool Package

This package handles the transfer between main disk and diskette. The diskette must be in drive 1.

Backup.Directory
displays the directory of the currently loaded diskette.

Backup.DeleteFiles
deletes all files specified by the parameter list from the currently loaded diskette.

Backup.ReadAll
reads all files from the currently loaded diskette.

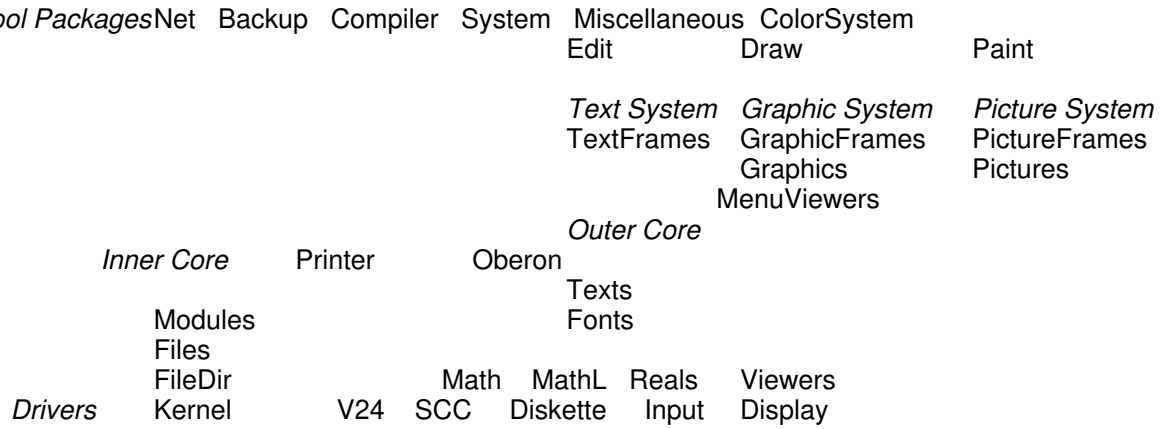
Backup.ReadFiles
reads all files specified by the parameter list from the currently loaded diskette.

Backup.WriteFiles
writes all files specified by the parameter list to the currently loaded diskette.

Guide for Programmers of Commands

In Oberon's modular hierarchy we recognize the following structural entities: The *inner core*, the *outer core*, the *text system*, the *graphic system*, the *picture system*, and a collection of *tools*.

Oberon's module hierarchy



The responsability of the *inner core* comprises memory management, file management, and program loading. The *outer core* additionally provides device drivers for network ports, keyboard, mouse, and display screens. Other parts of the outer core are viewer manager, elementary text management, and support for (remote) printing. Module *Oberon* represents the main interface between the outer core and its clients. It includes sections that are devoted to the current system configuration, to default strategies for track allocation and viewer placement, and to the support of command execution.

Module *Display* stands at the bottom of the display system hierarchy. The display area is considered as a plane with x and y coordinates. It includes both a black-and-white area and a color area. *Raster operation*s are used to generate and copy rectangular areas on the display plane. Sections of the plane can be made visible by *display control* procedures. The visible parts of the display plane are structured as tracks and viewers, and they are managed by the viewer manager *Viewers*. Module *Oberon* defines a standard layout featuring one user track and one system track per display screen. Finally, module *MenuViewers* is a high-level viewer manager for standard viewers consisting of a title bar and a rectangular main area surrounded by a thin frame. Both title bar and main area are so-called *frames*. While the title bar is almost always a *text frame* (see next paragraph), the type of the main frame depends on the kind of viewer.

The *text system*, the *graphic system*, and the *picture system* are identical in structure. Each consists of a triple of linearly dependent modules. In the case of texts they are called *Texts*, *TextFrames*, and *Edit*. *Texts* defines the object type *Text* and exports intrinsic operations on texts. *TextFrame*s defines the object type *TextFrames.Frame* and handles representations of texts within sub-frames of viewers. *Edit* provides additional (non-built-in) text-editing operations.

Modules at the top (like *Edit*) are *tool packages*. Typically, a tool package merely exports a collection of *commands* in the form of parameterless procedures. Tool modules make intensive use of facilities provided by lower level modules, in particular by the viewer system, the text system, and the central system module *Oberon*. It is essential that usual commands strictly operate on texts or graphics instead of accessing keyboard or screen directly.

We understand this chapter as a tutorial on implementing tool packages. First, we give a commented overview of the definitions of the most important lower-level modules. Then, we shall exemplify their usage by some typical excerpts from existing tools.

The Display System

```
DEFINITION Display; (*display driver*)
  CONST black = 0; white = 15;
    replace = 0; paint = 1; invert = 2; (*operation modes*)
   TYPE
```

```
   Frame = POINTER TO FrameDesc;
   FrameMsg = RECORD END; (*base type of messages to frames*)
   Pattern = LONGINT; (*pointer to pattern descriptor*)
   (*PatternDesc = RECORD
      w, h: SHORTINT;
     raster: ARRAY (w + 7) DIV 8 * h OF BYTE
     END*)
   Font = POINTER TO Bytes;
   Bytes = RECORD END;
   Handler = PROCEDURE (Frame, VAR FrameMsg);
   FrameDesc = RECORD (*base type of frames*)
      dsc, next: Frame;
       X, Y, W, H: INTEGER;
      handle: Handler
    END;
   VAR
    Unit: LONGINT; (*RasterUnit = Unit/36000 mm*)
     Left,           (*left margin of black-and-white maps*)
     ColLeft,       (*left margin of color maps*)
     Bottom,      (*Bottom of primary map*)
     UBottom,   (*Bottom of secondary map*)
     Width,       (*map width*)
     Height:       (*map height*)
        INTEGER;
   arrow, star, cross, downArrow, hook: Pattern;

   PROCEDURE Map (X: INTEGER): LONGINT; (*address of map at X*)
   PROCEDURE SetMode (X: INTEGER; s: SET);  (*set mode of map at X*)
     (*black & white display: 0: display disable, 1: display secondary map, 2: inverse video*)
 (*color display*)
   PROCEDURE SetColor (col, red, green, blue: INTEGER); (*col < 0: overlay color*)
   PROCEDURE GetColor (col: INTEGER; VAR red, green, blue: INTEGER);
   PROCEDURE SetCursor(mode: SET);  (*color cursor; 0: crosshair, 1: arrow*)
   PROCEDURE InitCC;  (*initialize color crosshair to full screen*)
   PROCEDURE InitCP;  (*initialize color pattern to arrow shape*)
   PROCEDURE DefCC (X, Y, W, H: INTEGER);  (*define window for color crosshair*)
    PROCEDURE DefCP (VAR raster: ARRAY OF BYTE); (*define 64 x 64 raster for color pattern
marker*)
   PROCEDURE DrawCX (X, Y: INTEGER);  (*draw color cursor at X, Y*)
   PROCEDURE FadeCX (X, Y: INTEGER);  (*fade color cursor at X, Y*)
 (*fonts*)
   PROCEDURE GetChar(f: Font; ch: CHAR; VAR dx, x, y, w, h: INTEGER; VAR p: Pattern);
     (*get box x, y, w, h, width dx, and raster data p of character ch in font f*)
 (*raster operations*)
   PROCEDURE CopyBlock (SX, SY, W, H, DX, DY, mode: INTEGER);
     (*copy source block SX, SY, W, H to destination DX, DY using operation mode.
     A block is given by its lower left corner X, Y and its dimension W, H*)
   PROCEDURE CopyPattern (col: INTEGER; pat: Pattern; X, Y, mode: INTEGER);
     (*copy pattern p in color col to X, Y using operation mode
     col = 0: black; col = 15: white*)
   PROCEDURE ReplPattern (col: INTEGER; pat: Pattern; X, Y, W, H, mode: INTEGER);
     (*replicate pattern p in color col into block X, Y, W, H using operation mode,
     proceeding from left to right and from bottom to top, starting at lower left corner*)
   PROCEDURE ReplConst (col: INTEGER; X, Y, W, H, mode: INTEGER);
     (*place "ones" in color col into block X, Y, W, H using operation mode*)
END Display.
```

Remarks:

1. The Ceres computer features a monochrome display whose position (lower left corner) is specified by the variables *Left* and *Bottom*, and whose width and height are given by the variables *Width* and *Height*. In fact, the drawing area is bigger; its y-coordinate ranges from -1248 to 799. Two sections

can be made visible by the display control procedures, the first being characterized by {y| -1024 <= y < -224}, and the other by {y| 0 <= y < 800}.

2. If a color display is installed, the module's raster procedures can be used to generate and copy areas on the color screen. The position of the color area (lower left corner) is specified by the variables *ColLeft* and *Bottom*; its width and height are the same as for the monochrome display.

3. The postulated preconditions upon procedure parameters are not checked by the module; this is left to the calling modules which are held responsible for robustness.

```
DEFINITION Viewers; (*viewer manager*)
  IMPORT Display;
  CONST
    restore = 0; modify = 1; suspend = 2;
      (*message ids referring to the following message type*)
  TYPE
      Message = RECORD (*message sent to viewers on viewer events*)
          (Display.FrameMsg)
          id: INTEGER;
          X, Y, W, H: INTEGER;
          state: INTEGER
        END;
    Viewer = POINTER TO ViewerDesc;
    ViewerDesc = RECORD (*viewer descriptor extends Display.FrameDesc*)
        (Display.FrameDesc)
         state: INTEGER
      END;
    (*state > 1: displayed
       state = 1: filler
       state = 0: closed
      state < 0: suspended*)
  VAR curW, minH: INTEGER; (*current width of logical display, minimum viewer height*)
  PROCEDURE InitTrack (W, H: INTEGER; Filler: Viewer);
    (*append to current logical display and init track of width W and height H and install Filler*)
  PROCEDURE OpenTrack (X, W: INTEGER; Filler: Viewer);
    (*open new track overlaying span of [X, X + W[*)
  PROCEDURE CloseTrack (X: INTEGER);
    (*close track at X and restore overlaid tracks*)
  PROCEDURE Locate (X, H: INTEGER; VAR fil, bot, alt, max: Display.Frame);
    (*in the track at X locate the following viewers:
      filler fil,
     bottom viewer bot,
     an alternative viewer alt of height >= H,
     viewer max of maximum height*)
  PROCEDURE Open (V: Viewer; X, Y: INTEGER);
    (*open new viewer V with top at Y in track at X*)
  PROCEDURE Change (V: Viewer; Y: INTEGER);
    (*expand or shrink viewer V to new top Y*)
  PROCEDURE Close (V: Viewer);
    (*remove viewer V from the display*)
  PROCEDURE Recall (VAR V: Viewer);
    (*recall most recently closed viewer*)
  PROCEDURE This (X, Y: INTEGER): Viewer;
    (*return viewer at X, Y*)
  PROCEDURE Next (V: Viewer): Viewer;
    (*return next upper neighbour of V*)
  PROCEDURE Broadcast (VAR M: Display.FrameMsg);
    (*send message M to all visible viewers*)
END Viewers.
```

```
DEFINITION MenuViewers;

  IMPORT Display, Viewers;

  CONST extend = 0; reduce = 1; (*message ids*)

  TYPE
    Viewer = POINTER TO ViewerDesc;

  ViewerDesc = RECORD (Viewers.ViewerDesc)
      menuH: INTEGER (*height of menu frame*)
    END;

   ModifyMsg = RECORD (Display.FrameMsg)
      id: INTEGER; (*extend or reduce*)
      dY, Y, H: INTEGER (*translation vector dY; new Y and H*)
    END;

  VAR Ancestor: Viewer; (*current menu viewer*)

  PROCEDURE Handle (V: Display.Frame; VAR M: Display.FrameMsg);
      (*standard handler for menu viewers*)

  PROCEDURE New (Menu, Main: Display.Frame; menuH, X, Y: INTEGER): Viewer;
        (*create and open at X, Y new menu viewer containing frames Menu and Main*)

END MenuViewers.
```

Remark:

Messages to menu viewers not affexting size and position are passed on to their subframes. The ancestor viewer is made available to the subframe handlers via the variable Ancestor. MenuViewers also creates new messages of type ModifyMsg requesting subframes to change size or vertical position (or both). dY represents a vertical translation vector, and Y and H specify the new position and height respectively.

The Text System

```
DEFINITION Fonts; (*font loader*)
  IMPORT Display;
  TYPE
      Name = ARRAY 32 OF CHAR;
      Font = POINTER TO FontDesc;
      FontDesc = RECORD
         name: Name; (*file name*)
         height, minX, maxX, minY, maxY: INTEGER; (*characteristic data*)
         raster: Display.Font (*raster data*)
      END;

     (*height = minimum distance between text lines,
      minX, maxX, minY, maxY are minima and maxima of X and Y,
      if all character boxes of the font are placed at the origin 0, 0*)
  VAR Default: Font; (*the default font*)
      PROCEDURE This (name: ARRAY OF CHAR): Font;
      (*font with name given*)
END Fonts.
```

```
DEFINITION Texts; (*text manager*)
  IMPORT Files, Fonts;
  CONST
    (*symbol classes, see def. of type Scanner*)
    Inval = 0;          (*invalid symbol*)
    Name = 1;           (*name s (length len)*)
    String = 2;         (*literal string s (length len)*)
    Int = 3;            (*integer i (decimal or hexadecimal)*)
    Real = 4;           (*real number x*)
    LongReal = 5;  (*long real number y*)
    Char = 6;           (*special character c*)
    replace = 0; insert = 1; delete = 2; (*op-codes*)
  TYPE
    Text = POINTER TO TextDesc;
    Notifier = PROCEDURE (T: Text; op: INTEGER; beg, end: LONGINT);
    TextDesc = RECORD
      len: LONGINT; (*text length*)
      notify: Notifier (*of editing operations*)
    END;
    Elem = POINTER TO ElemDesc;
    ElemMsg = RECORD END;
    Handler = PROCEDURE (e: Elem; VAR msg: ElemMsg);
    ElemDesc = RECORD
        W, H: LONGINT;
        handle: Handler
    END;
    Reader = RECORD
      (Files.Rider)
      eot: BOOLEAN;
      fnt: Fonts.Font; (*font of current character*)
      col: SHORTINT; (*color of current character*)
      voff: SHORTINT; (*vertical offset*)
      elem: Elem
    END;
    Scanner = RECORD
      (Reader)
      nextCh: CHAR;
      line: INTEGER;
      class: INTEGER;
      i: LONGINT;
      x: REAL;
      y: LONGREAL;
      c: CHAR;
      len: SHORTINT;
      s: ARRAY 32 OF CHAR
    END;
     (*used to convert a text into a stream of symbols.
     Symbol classes are defined under CONST*)
    Buffer = POINTER TO BufDesc;
    BufDesc = RECORD
      len: LONGINT (*buffer length*)
    END;
    (*used to write a stream of textual data in a buffer*)
    (*used to store a stretch of a text*)
    Writer = RECORD
      (Files.Rider)
      buf: Buffer; (*associated buffer*)
      fnt: Fonts.Font; (*current font*)
      col: SHORTINT; (*color of current character*)
      voff: SHORTINT (*vertical offset*)
```

```
    END;

    FileMsg = RECORD (ElemMsg)
       id: INTEGER;
       pos: LONGINT;
       r: Files.Rider
    END;
    CopyMsg = RECORD (ElemMsg)
       e: Elem
    END;
    IdentifyMsg = RECORD (ElemMsg)
       mod, proc: ARRAY 32 OF CHAR
    END;

VAR
    new: Elem;

  PROCEDURE Load (T: Text; f: Files.File; pos: LONGINT; VAR len: LONGINT);
    (*load text block from file f at position pos to text T*)
  PROCEDURE Open (T: Text; name: ARRAY OF CHAR);
    (*open text T from disk file specified by name; open new text if name = ""*)
  PROCEDURE OpenBuf (B: Buffer);
    (*open new text buffer B*)
  PROCEDURE OpenReader (VAR R: Reader; T: Text; pos: LONGINT);
    (*open text reader R and set it up at position pos in text T*)
  PROCEDURE Read (VAR R: Reader; VAR ch: CHAR);
    (*read next character in ch*)
  PROCEDURE Pos (VAR R: Reader): LONGINT;
    (*return reader's position within its text*)
  PROCEDURE Store (T: Text; f: Files.File; pos: LONGINT; VAR len: LONGINT);
    (*store text T on disk file f at position pos*)
  PROCEDURE Save (T: Text; beg, end: LONGINT; B: Buffer);
    (*append stretch [beg, end[ of text T to buffer B*)
  PROCEDURE Copy (SB, DB: Buffer);
    (*append copy of source buffer SB to destination buffer DB*)
   PROCEDURE ChangeLooks (T: Text; beg, end: LONGINT; sel: SET; fnt: Fonts.Font; col, voff:
SHORTINT);
      (*change character attributes within stretch [beg, end[ of text T. sel selects attributes to be
changed.
     0, 1, 2 IN sel = fnt, col, voff selected*)
  PROCEDURE Insert (T: Text; pos: LONGINT; B: Buffer);
    (*insert buffer B in text T at position pos*)
  PROCEDURE Append (T: Text; B: Buffer);
    (*append buffer B to text T*)
  PROCEDURE Delete (T: Text; beg, end: LONGINT);
    (*delete stretch [beg, end[ of text T*)
  PROCEDURE Recall (VAR B: Buffer);
    (*recall previously deleted text*)
  PROCEDURE OpenScanner (VAR S: Scanner; T: Text; pos: LONGINT);
    (*open text scanner S and set it up at position pos in text T*)
  PROCEDURE Scan (VAR S: Scanner);
    (*read next symbol*)
  PROCEDURE OpenWriter (VAR W: Writer);
    (*open new writer W*)
  PROCEDURE SetFont (VAR W: Writer; fnt: Fonts.Font);
    (*set writer W to font fnt*)
  PROCEDURE SetColor (VAR W: Writer; col: SHORTINT);
    (*set writer W to color col*)
  PROCEDURE SetOffset (VAR W: Writer; voff: SHORTINT);
    (*set writer W to vertical offset voff*)
  PROCEDURE Write (VAR W: Writer; ch: CHAR);
    (*write character ch to W's buffer*)
```

```
  PROCEDURE WriteLn (VAR W: Writer);
    (*write end-of-line to W's buffer*)
  PROCEDURE WriteInt (VAR W: Writer; x, n: LONGINT);
    (*write integer x to W's buffer. Right adjust to n positions*)
  PROCEDURE WriteHex (VAR W: Writer; x: LONGINT);
    (*write integer x to W's buffer in hexadecimal form.
  PROCEDURE WriteString (VAR W: Writer; s: ARRAY OF CHAR);
    (*write string s to W's buffer*)
  PROCEDURE WriteReal (VAR W: Writer; x: REAL; n: INTEGER);
    (*write real number x to W's buffer. Use n positions*)
  PROCEDURE WriteRealFix (VAR W: Writer; x: REAL; n, k: INTEGER);
    (*write real number x to W's buffer in fixed-point form,
      using k positions for decimal fractions and n positions in total*)
  PROCEDURE WriteRealHex (VAR W: Writer; x: REAL);
    (*write real number x to W's buffer in hexadecimal form*)
  PROCEDURE WriteLongReal (VAR W: Writer; x: LONGREAL; n: INTEGER);
    (*write long real number x to W's buffer. Use n positions*)
  PROCEDURE WriteLongRealHex (VAR W: Writer; x: LONGREAL);
    (*write long real number x to W's buffer in hexadecimal form*)

  PROCEDURE CopyElem (SE, DE: Elem);
    (*copy all fields defined in the base type Elem*)
  PROCEDURE ElemBase (E: Elem): Text;
    (*text containing element*)
  PROCEDURE ReadElem (VAR R: Reader);
    (*read the next element at or after the current reader position*)
  PROCEDURE ReadPrevElem (VAR R: Reader);
    (*read the element before the reader position*)
  PROCEDURE WriteElem (VAR W: Writer; e: Elem);
    (*write element into writer buffer*)
END Texts.
```

Remark:

Open does not create a text object nor does it install a notifier procedure. Both actions are left to the calling modules. Typically, a calling module first creates a text object (or an extension of it) by using NEW, and then installs a notifier procedure. The main purpose of notifier procedures is requesting the display to re-establish consistency after a change in a text has occurred.

```
DEFINITION TextFrames; (*text display*)
  IMPORT Display, Texts;
  TYPE
    Location = RECORD
      org, pos: LONGINT; (*line origin, position*)
      dx, x, y: INTEGER (*width and position of located character*)
    END;
    Frame = POINTER TO FrameDesc;
    FrameDesc = RECORD
      (Display.FrameDesc)
      text: Texts.Text; (*displayed text*)
      org: LONGINT; (*position in text of first displayed character*)
      col: INTEGER; (*background color*)
      lsp, asr, dsr: INTEGER; (*line spacing, ascender, descender*)
      left, right, top, bot: INTEGER; (*margins*)
      markH: INTEGER; (*margin width, position of mark*)
      time: LONGINT; (*time of latest selection*)
      mark, car, sel: INTEGER; (*state of mark, caret, selection*)
      carloc: Location; (*caret location*)
      selbeg, selend: Location (*locations of begin and end of selection*)
    END;
```

```
(*mark < 0: arrow mark
  mark = 0: no mark
  mark > 0: position mark
  car = 0: caret not set
  car > 0: caret set
  sel = 0: no selection active
  sel > 0: selection active*)

 UpdateMsg* = RECORD
    (Display.FrameMsg)
     id: INTEGER;
    text: Texts.Text;
    beg, end: LONGINT
  END;

 VAR menuH, barW, left, right, top, bot, asr, dsr, lsp: INTEGER; (*standard sizes*)

   PROCEDURE Restore (F: Frame);
     (restore frame F*)
  PROCEDURE Suspend(F: Frame);
     (*suspend frame F*)

  PROCEDURE Extend (F: Frame; newY: INTEGER);
   (*extend frame F to bottom newY*)
 PROCEDURE Reduce (F: Frame; newY: INTEGER);
   (*reduce frame F to bottom newY*)
 PROCEDURE Mark (F: Frame; mark: INTEGER);
   (*mark frame F as specified by mark*)
 PROCEDURE Show (F: Frame; pos: LONGINT);
   (*show text part containing position pos in frame F*)
 PROCEDURE Pos (F: Frame; X, Y: INTEGER): LONGINT;
   (*convert coordinates X, Y to text position*)
 PROCEDURE SetCaret (F: Frame; pos: LONGINT);
   (*set caret in frame F at position pos*)
 PROCEDURE TrackCaret (F: Frame; X, Y: INTEGER; VAR keysum: SET);
   (*track caret in frame F, starting from X, Y, and return mouse-keys pressed*)
 PROCEDURE RemoveCaret (F: Frame);
   (*remove caret from frame F*)
 PROCEDURE SetSelection (F: Frame; beg, end: LONGINT);
   (*select text stretch [beg, end[ in F*)
 PROCEDURE TrackSelection (F: Frame; X, Y: INTEGER; VAR keysum: SET);
   (*track selection in frame F, starting from X, Y, and return mouse-keys pressed*)
 PROCEDURE RemoveSelection (F: Frame);
   (*remove selection from frame F*)
 PROCEDURE TrackLine (F: Frame; X, Y: INTEGER; VAR org: LONGINT; VAR keysum: SET);
   (*track text line in frame F, starting from X, Y, and return line-origin and mouse-keys pressed*)
 PROCEDURE TrackWord (F: Frame; X, Y: INTEGER; VAR pos: LONGINT; VAR keysums: SET);
   (*track text word in frame F, starting from X, Y,
  and return starting position and mouse-keys pressed*)
 PROCEDURE Replace (F: Frame; beg, end: LONGINT);
   (*text stretch [beg, end[ was replaced; update frame F*)
 PROCEDURE Insert (F: Frame; beg, end: LONGINT);
   (*text stretch [beg, end[ was inserted; update frame F*)
 PROCEDURE Delete (F: Frame; beg, end: LONGINT);
   (*text stretch [beg, end[ was deleted; update frame F*)

(*---------------- message handling ----------------*)
 PROCEDURE NotifyDisplay (T: Texts.Text; op: INTEGER; beg, end: LONGINT);
   (*notify display manager of text status change*)
 PROCEDURE Call* (F: Frame; pos: LONGINT; new: BOOLEAN);
  (*call command specified at pos in frame F. new forces loading of newest version*)
 PROCEDURE Write* (F: Frame; ch: CHAR; fnt: Fonts.Font; col, voff: SHORTINT);
```

```
    (*write character ch with given attributes at caret position*)
   PROCEDURE Defocus* (F: Frame); (F: Frame; ch: CHAR; fnt: Fonts.Font; col, voff: SHORTINT);
    (*remove caret*)
   PROCEDURE Neutralize* (F: Frame);
    (*remove marks*)
   PROCEDURE Modify* (F: Frame; id, dY, Y, H: INTEGER);
    (*vertically translate and extend or reduce frame F. id indicates type (extension or reduction),
      dy is a translation vector, and Y, H specify new location and height respectively*)
   PROCEDURE Open* (
      F: Frame; H: Display.Handler; T: Texts.Text; org: LONGINT;
      col, left, right, top, bot, asr, dsr, lsp: INTEGER);
     (*open new text frame F displaying text T starting from position org, with background color col,
      margins left, right, top, bot, and line geometry asr, dsr, lsp = ascender, descender line spacing.
         Install notifier H*)
   PROCEDURE Copy* (F: Frame; VAR F1: Frame);
    (*generate copy F1 of frame F. Initialize to empty frame*)
   PROCEDURE CopyOver* (F: Frame; text: Texts.Text; beg, end: LONGINT);
    (*copy over text stretch [beg, end[ to caret position in frame F*)
   PROCEDURE GetSelection* (F: Frame; VAR text: Texts.Text; VAR beg, end, time: LONGINT);
    (*get current text selection in frame F (if any)*)
   PROCEDURE Update* (F: Frame; VAR M: UpdateMsg);
    (*update display after editing operation*)
   PROCEDURE Edit* (F: Frame; X, Y: INTEGER; Keys: SET);
    (*track mouse and interpret editing commands*)
   PROCEDURE Handle* (F: Display.Frame; VAR M: Display.FrameMsg);
    (*standard handler for text frames*)
   PROCEDURE Text* (name: ARRAY OF CHAR): Texts.Text;
    (*create new displayed text from named file. Empty file name means empty text*)
   PROCEDURE NewMenu* (name, commands: ARRAY OF CHAR): Frame;
    (*create new menu frame containing listed commands*)
   PROCEDURE NewText* (text: Texts.Text; pos: LONGINT): Frame;
    (*create new standard text frame*)
END TextFrames.
```

The Oberon Core

```
DEFINITION Math; (*math library for reals*)
  CONST pi = 3.14159265; e = 2.71828182;
  PROCEDURE sqrt(x: REAL): REAL;
  PROCEDURE exp(x: REAL): REAL;
  PROCEDURE ln(x: REAL): REAL;
  PROCEDURE sin(x: REAL): REAL;
  PROCEDURE cos(x: REAL): REAL;
  PROCEDURE arctan(x: REAL): REAL;
END Math.
```

```
DEFINITION MathL; (*math library for longreals*)
    CONST pi = 3.141592653589793D0;
      e = 2.718281828459045D0;
  PROCEDURE sqrt(x: LONGREAL): LONGREAL;
  PROCEDURE exp(x: LONGREAL): LONGREAL;
  PROCEDURE ln(x: LONGREAL): LONGREAL;
  PROCEDURE sin(x: LONGREAL): LONGREAL;
  PROCEDURE cos(x: LONGREAL): LONGREAL;
  PROCEDURE arctan(x: LONGREAL): LONGREAL;
END MathL.
```

```
---------------------------------------------------------------------------

DEFINITION Files; (*file manager*)
  TYPE Handle = RECORD END ;
       File   = POINTER TO Handle;
     (*A file is a sequence of bytes, accessed via (a pointer to) a  handle. Files are stored on disk and
       may be referenced through a name entered in the file directory*)
       Rider  = RECORD
                  res: INTEGER;
                  eof: BOOLEAN;
                  file: File
                END ;
    (*Elements  of files are accessed through a rider, which has a position that is advanced when
      reading or writing data. The position is an integer between 0 and the length of the file to which
      the rider is attached. The fields eof and res serve as result parameters of file procedures.*)
  PROCEDURE Old(name: ARRAY OF CHAR): File;
    (*the file with the given name. NIL if the name is not in the directory*)
  PROCEDURE New(name: ARRAY OF CHAR): File;
    (*a new file with given name*)
  PROCEDURE Register(f: File);
    (*Close file f and register it under its name in the directory.
      If the name exists already, the corresponding old file is unregistered*)
  PROCEDURE Close(f: File);
  PROCEDURE Purge(f: File);
  PROCEDURE Length(f: File): LONGINT;  (*the number of bytes in the file*)
  PROCEDURE Set(VAR r: Rider; f: File; pos: LONGINT);
    (*Associate rider r with file f at position pos. r.eof := FALSE*)
  PROCEDURE Read(VAR r: Rider; VAR x: BYTE);
    (*read byte and advance rider by one position. If at end, r.eof := TRUE and x := 0X*)
  PROCEDURE ReadBytes(VAR r: Rider; VAR x: ARRAY OF BYTE; n: INTEGER);
    (*read n bytes and advance rider by n positions.
      If at end, r.eof := TRUE and r.res := no. of bytes requested but not read.*)
  PROCEDURE Write(VAR r: Rider; x: BYTE);
    (*write byte and advance rider by one position*)
  PROCEDURE WriteBytes(VAR r: Rider; VAR x: ARRAY OF BYTE; n: INTEGER);
    (*write n bytes and advance rider by n positions*)
  PROCEDURE Pos(VAR r: Rider): LONGINT;
  PROCEDURE Base(VAR r: Rider): File;
  PROCEDURE Rename(old, new: ARRAY OF CHAR; VAR res: INTEGER);
    (*res = 0: renamed;  res = 1: new name existed already and now denotes the renamed file;
       res = 2: old name not in directory;  res = 3: name is illegal;  res = 4: name is too long *)
  PROCEDURE Delete(name: ARRAY OF CHAR; VAR res: INTEGER);
    (*res = 0: deleted;  res = 2: name not in directory;
       res = 3: name is illegal;  res = 4: name is too long *)
END Files.

---------------------------------------------------------------------------

DEFINITION Diskette; (*diskette manager*)

   TYPE EntryHandler* = PROCEDURE (name: ARRAY OF CHAR; date, time: INTEGER; size:
LONGINT);

  VAR res: INTEGER; (*result of file-oriented operation, error occurred = (res # 0)*)
      err: SHORTINT; sect: LONGINT; busy: BOOLEAN; (*state of device driver*)

  (*device driver*)
  PROCEDURE Reset;
  PROCEDURE GetSector (sec: INTEGER; VAR buf: ARRAY OF BYTE; off: INTEGER);
  PROCEDURE PutSector (sec: INTEGER; VAR buf: ARRAY OF BYTE; off: INTEGER);
  PROCEDURE Format;
```

```
  (*directory handler*)
  PROCEDURE InitDir (format: CHAR); (*format for future extension*)
  PROCEDURE ReadDir;
  PROCEDURE WriteDir;
  PROCEDURE GetData (VAR date, time, nofFiles, nofClusters: INTEGER); (*get volume data*)
  PROCEDURE Enumerate (proc: EntryHandler);

  (*file handler*)
  PROCEDURE ReadAll;
  PROCEDURE ReadFile (name: ARRAY OF CHAR);
  PROCEDURE WriteFile (name: ARRAY OF CHAR);
  PROCEDURE DeleteFile (name: ARRAY OF CHAR);

END Diskette.
```

```
DEFINITION Input; (*keyboard and mouse driver*)
  PROCEDURE Available(): INTEGER;
    (*the number of characters available from the keyboard*)
  PROCEDURE Read (VAR ch: CHAR);
    (*next character from keyboard*)
  PROCEDURE Mouse (VAR keys: SET; VAR x, y: INTEGER);
    (*current coordinates and key setting of mouse.
      0 IN keys = right key pressed
      1 IN keys = middle key pressed
      2 IN keys = left key pressed*)
  PROCEDURE SetMouseLimits (w, h: INTEGER);
    (* define width and height of rectangle in which mouse moves*)
  PROCEDURE Time(): LONGINT;
    (* current system time in units of 1/300 sec*)
END Input.
```

```
DEFINITION SCC; (*SCC driver*)
  (*Serial Communications Controller driver module (Zilog Z8530)
    Data are transmitted in blocks. Each block contains two parts: header and data *)
  TYPE Header =
    RECORD valid: BOOLEAN; dadr, sadr, typ: SHORTINT;
      len: INTEGER; (*of data following header*)
      destLink, srcLink: INTEGER  (*link numbers*)
    END ;
  (*dadr is the receiver's machine number, len is the length (number of bytes) of
    the data part. typ, destLink, and srcLink are not interpreted by SCC*)
  PROCEDURE Start(filter: BOOLEAN);
    (*initialise the SCC*)
  PROCEDURE Send(VAR head, buf: ARRAY OF BYTE);
    (*send buf[0] ... buf[head.len-1] to head.adr*)
  PROCEDURE Available(): INTEGER;
    (*number of bytes available from receiver buffer. Buffer contains stream of
      received bytes, including headers and data parts*)
  PROCEDURE ReceiveHead(VAR head: ARRAY OF BYTE);
    (*read a header from the receiver buffer*)
  PROCEDURE Receive(VAR x: BYTE);
    (*read a byte from the receiver buffer*)
  PROCEDURE Skip(m: INTEGER);
    (*skip m bytes in the receiver buffer*)
  PROCEDURE Stop;  (*turn SCC off*)
END SCC.
```

```
DEFINITION Printer; (*printer interface*)
   VAR res: INTEGER; (*result*)
     PROCEDURE Open(VAR name, user: ARRAY OF CHAR; password: LONGINT);
      (*res = 0: opened, 1: no printer, 2: no link, 3: bad response, 4: no permission*)

      PROCEDURE Circle (x0, y0, r: INTEGER); (*place circle*)
      PROCEDURE ContString (VAR s, fname: ARRAY OF CHAR); (*place continuation string*)
      PROCEDURE Ellipse (x0, y0, a, b: INTEGER); (*place ellipsis*)
      PROCEDURE Line (x0, y0, x1, y1: INTEGER); (*place line of general direction*)
      PROCEDURE Page (nofcopies: INTEGER); (*print current page*)
      PROCEDURE Picture (x, y, w, h, mode: INTEGER; adr: LONGINT); (*place picture*)
      PROCEDURE ReplConst (x, y, w, h: INTEGER); (*place horizontal or vertical line*)
      PROCEDURE ReplPattern (x, y, w, h, col: INTEGER); (*shade area*)
      PROCEDURE Spline (x0, y0, n, open: INTEGER; VAR X, Y: ARRAY OF INTEGER); (*place
spline*)
      PROCEDURE String (x, y: INTEGER; VAR s, fname: ARRAY OF CHAR); (*place string*)
      PROCEDURE UseListFont (VAR name: ARRAY OF CHAR);

      PROCEDURE Close; (*close connection*)

END Printer.

---------------------------------------------------------------------------

DEFINITION Oberon; (*system manager*)
 IMPORT Display, Viewers, Texts;
 CONST
   consume = 0; track = 1; (*ids for input messages*)
   defocus = 0; neutralize = 1; mark = 2; (*ids for control messages*)

 TYPE
   Painter = PROCEDURE (x, y: INTEGER);
   Marker = RECORD Fade, Draw: Painter END;

   Cursor = RECORD
     on: BOOLEAN; m: Marker; X, Y: INTEGER
   END;

  ParList = POINTER TO ParRec;
  ParRec = RECORD
    vwr: Viewers.Viewer; (*caller's viewer*)
    frame: Display.Frame; (*caller's sub-frame*)
    text: Texts.Text; (*parameter list*)
    pos: LONGINT (*starting position of parameter list*)
  END;
   InputMsg = RECORD
    (Display.FrameMsg)
    id: INTEGER; (*message id*)
    modes, keys: SET; (*current modes and mouse keys*)
    X, Y: INTEGER; (*current location of the mouse*)
    ch: CHAR (*current char*)
   END;

   ControlMsg = RECORD
    (Display.FrameMsg)
    id: INTEGER; (*message id*)
    X, Y: INTEGER (*current location of the mous*)
   END;
   SelectionMsg = RECORD
    (Display.FrameMsg)
    time: LONGINT;
    text: Texts.Text;
```

```
    beg, end: LONGINT
  END;
  CopyOverMsg* = RECORD
    (Display.FrameMsg)
    text*: Texts.Text;
    beg*, end*: LONGINT
  END;

  CopyMsg* = RECORD
    (Display.FrameMsg)
    F*: Display.Frame
  END;

 Task = POINTER TO TaskDesc; (*installable task*)
  Handler = PROCEDURE;
  TaskDesc = RECORD
    safe: BOOLEAN; (*safe tasks are not removed after trap*)
    handle: Handler
  END;
VAR
(*configuration*)
  FocusViewer: Viewers.Viewer; (*current focus viewer*)
  Log: Texts.Text; (*system log text*)
  Par: ParList; (*actual parameters for next command*)
  User: ARRAY 8 OF CHAR; Password: LONGINT; (*current user*)

  CurFnt, CurCol:, CurOff SHORTINT; (*current font, color, vertical offset*)
    Arrow, Star: Marker;
    Mouse, Pointer: Cursor;
(*user identification*)
  PROCEDURE SetUser (VAR user, password: ARRAY OF CHAR);
(*clocks*)
  PROCEDURE GetClock (VAR t, d: LONGINT);
  PROCEDURE SetClock (t, d: LONGINT);
  PROCEDURE Time (): LONGINT; (*in units of 1/300 sec*)
(*cursor handling*)
  PROCEDURE OpenCursor (VAR c: Cursor);
  PROCEDURE FadeCursor (VAR c: Cursor);
  PROCEDURE DrawCursor (VAR c: Cursor; VAR m: Marker; X, Y: INTEGER);
 (*display management*)
  PROCEDURE OpenDisplay (UW, SW, H: INTEGER);
      (*initialize new display with user track width UW, system track width SW, and height H*)
  PROCEDURE DisplayWidth (X: INTEGER): INTEGER;
      (*get width of display at X*)
  PROCEDURE DisplayHeight (X: INTEGER): INTEGER;
      (*get height of display at X*)
   PROCEDURE OpenTrack (X, W: INTEGER);
      (*open a new track of width W at X*)
   PROCEDURE UserTrack (X: INTEGER): INTEGER;
      (*get left margin of user track at X*)
   PROCEDURE SystemTrack (X: INTEGER): INTEGER;
      (*get left margin of system track at X*)
   PROCEDURE AllocateUserViewer (DX: INTEGER; VAR X, Y: INTEGER);
      (*allocate new user viewer within display at DX*)
   PROCEDURE AllocateSystemViewer (DX: INTEGER; VAR X, Y: INTEGER);
      (*allocate new system viewer within display at DX*)
  PROCEDURE PassFocus (V: Viewers.Viewer);
      (*pass focus to viewer V*)
    PROCEDURE RemoveMarks (X, Y, W, H: INTEGER);
      (*remove marks within given rectangle*)
  PROCEDURE MarkedViewer (): Viewers.Viewer;
      (*returns viewer marked by star-shaped pointer*)
```

```
  (*command interpretation*)
    PROCEDURE ShowMenu (VAR cmd: INTEGER; X, Y: INTEGER; menu: ARRAY OF CHAR);
      (* menu = {command "|"} command.
         Six commands allowed, 6 > cmd >= -1.
         cmd  = 5:  first command selected
         cmd = 0:  last command selected
         cmd = -1:  no selection *)
       PROCEDURE Call (VAR name: ARRAY OF CHAR; par: ParList; new: BOOLEAN; VAR res:
INTEGER);
       (*call command name and pass parameter list par. Option new requests loading of module.
          Done = (res = 0)*)
     PROCEDURE GetSelection (VAR text: Texts.Text; VAR beg, end, time: LONGINT);
     (*get most recent text selection. Text selection exists = (time >= 0)*)
       PROCEDURE Install (T: Task);
        (*install new task T*)
     PROCEDURE Remove (T: Task);
       (*remove installed task T*)
     PROCEDURE Collect;
       (*demand garbage collector*)
    PROCEDURE SetFont* (fnt: Fonts.Font);
       (*set current font*)
    PROCEDURE SetColor* (col: SHORTINT);
       (*set current color*)
     PROCEDURE SetOffset* (voff: SHORTINT);
       (*set current vertical offset*)

END Oberon.
```

Remark:

Installed tasks are considered to be background activities. They are activated by the central loop when no input events have been detected. For example, the garbage collector is implemented as an installed task. Notice that installed tasks may be invalidated after their host module has been unloaded (or replaced). Unsafe tasks are automatically removed after a system trap in order to avoid an infinite repetition of the same error.

Tutorial Examples

Write time stamp to system log

```
  PROCEDURE TimeStamp;
  BEGIN
    Texts.WriteString(W, "TimeStamp "); Texts.WriteInt(W, Oberon.Time(), 1); Texts.WriteLn(W);
    Texts.Append(Oberon.Log, W.buf)
  END TimeStamp;
```

where

```
  VAR W: Texts.Writer;
```

is globally defined initialized by *Texts.OpenWriter(W)*.

Remarks:

1. Normally, one (global) writer per module is sufficient.

2. If you desire a specific part of the output text to appear in a new font, for example in italics variant *Syntax10i.Scn.Fnt*, call *Texts.SetFont(W,Fonts.This("Syntax10i.Scn.Fnt"))* before writing this part and *Texts.SetFont(W,Fonts.Default)* before continuing to write ordinary text.

Process selected text

```
PROCEDURE CountWords;
  VAR T: Texts.Text; R: Texts.Reader;
    beg, end, pos, time: LONGINT; words: INTEGER; ch: CHAR;
BEGIN words := 0;
 Oberon.GetSelection(T, beg, end, time); (*get most recent selection*)
  IF time >= 0 THEN (*if it exists*)
    Texts.OpenReader(R, T, beg); pos := beg; (*setup reader and initialize pos*)
    Texts.Read(R, ch); INC(pos); (*read next character*)
    IF (pos # end) & (ch > " ") THEN
      REPEAT Texts.Read(R, ch); INC(pos) UNTIL (pos = end) OR (ch <= " ");
      INC(words)
    END;
    WHILE pos # end DO
       (*(pos # end) & (ch <= " ")*)
       REPEAT Texts.Read(R, ch); INC(pos) UNTIL (pos = end) OR (ch > " ");
       IF pos # end THEN
         REPEAT Texts.Read(R, ch); INC(pos) UNTIL (pos = end) OR (ch <= " ");
         INC(words)
       END
     END
  END;
  Texts.WriteString(W, "WordCount = "); Texts.WriteInt(W, words, 1); Texts.WriteLn(W);
  Texts.Append(Oberon.Log, W.buf) (*append to system log*)
END CountWords;
```

where again

```
  VAR W: Texts.Writer;
```

is globally defined and initialized by *Texts.OpenWriter(W)*.

Open a viewer in system track, generate, and display text data

```
PROCEDURE Directory;
   VAR Menu, Main: TextFrames.Frame; T: Texts.Text; V: Viewers.Viewer; X, Y: INTEGER;
BEGIN
   T := TextFrames.Text(""); (*generate new (and empty) text to be displayed in a frame*)
   Menu := TextFrames.NewMenu("Directory", StandardMenu); (*generate standard menu frame*)
   Main := TextFrames.NewText(T, 0); (*generate standard text frame*)
   Oberon.AllocateSystemViewer(Oberon.Par.vwr.X, X, Y);
   V := MenuViewers.New(Menu, Main, TextFrames.menuH, X, Y); (*open standard menu viewer*)
   TextFrames.Mark(Main, -1); (*setup vertical arrow mark*)
   Diskette.Enumerate(Lister); (*pass over Lister-procedure to enumerator*)
   Texts.Append(T, W.buf); (*append writer to T and display written text*)
   TextFrames.Mark(Main, 1) (*restore position mark*)
END Directory;
```

where

```
CONST StandardMenu = "System.Close System.Copy System.Grow Edit.Search Edit.Store";
 VAR T: Texts.Text; W: Texts.Writer;
```

are globally defined, W is globally initialized by *Texts.OpenWriter(W)*, and Lister is an (upcalled) procedure displaying directory entries:

```
PROCEDURE* Lister (name: ARRAY OF CHAR; date, time: INTEGER; size: LONGINT);
BEGIN
  Texts.WriteString(W, name);
  Texts.Write(W, " "); Texts.WriteInt(W, size, 1);
  Texts.Write(W, " "); Texts.WriteDate(W, time, date);
  Texts.WriteLn(W)
```

```
END Lister;
```

Remarks:

1. The above program generates its whole output text before displaying it. Alternatively, if you move the statement Texts.Append(T, W.buf) into the Lister-procedure, every generated directory entry is displayed immediately.

2. *Oberon.AllocateSystemViewer(Oberon.Par.vwr.X, X, Y)* is a standard proposal for the placing of a new system viewer within the track from which the command was called. Of course, individual algorithms are possible as well. For example, if the new viewer is desired to cover the bottom most viewer, except if the pointer overrides this, the algorithm is

```
PROCEDURE AllocateSystemViewer (DX: INTEGER; VAR X, Y: INTEGER);
  VAR bot: Viewers.Viewer;
BEGIN
  IF Oberon.Pointer.on THEN X := Oberon.Pointer.X; Y := Oberon.Pointer.Y
  ELSE bot := Viewers.This(Oberon.SystemTrack(DX), 0); X := bot.X; Y := bot.H - Viewers.minH
  END
END AllocateSystemViewer;
```

3. *TextFrames.NewText* generates a standard text frame. The following statement sequence produce a text frame with an individual handler and a customized geometry.

```
NEW(F); Open(F, Handle, text, pos, col, left, right, top, bot, asr, dsr, lsp);
```

where F is of type TextFrames.Frame.

Open a viewer in user track and display existing text

```
PROCEDURE OpenText;
  VAR par: Oberon.ParList; Text: TextFrames.Frame; S: Texts.Scanner;
  V: Viewers.Viewer; X, Y: INTEGER;
BEGIN
  par := Oberon.Par; (*access parameters*)
  Text := par.frame(TextFrames.Frame); (*calling frame*)
  TextFrames.Mark(Text, -1); (*arrow mark*)
  Texts.OpenScanner(S, par.text, par.pos); (*open scanner at position of parameter list*)
  Texts.Scan(S); (*get symbol*)
  IF S.class = Texts.Name THEN
    Oberon.AllocateUserViewer(par.vwr.X, X, Y);
    V := MenuViewers.New(
      TextFrames.NewMenu(S.s, StandardMenu);
      TextFrames.NewText(TextFrames.Text(S.s), 0);
      TextFrames.menuH, X, Y);
  END;
  TextFrames.Mark(Text, 1) (*restore position mark*)
END OpenText;
```

Remark:

Oberon.AllocateUserViewer(par.vwr.X, X, Y) is a standard proposal for the placing of a new viewer in the caller's user track. Again, individual algorithms are possible as well.

Grow viewer

```
PROCEDURE Grow;
  VAR V, newV: Viewers.Viewer; M: Oberon.CopyMsg; N: Viewers.ViewerMsg; DH: INTEGER;
BEGIN
  V := Oberon.Par.vwr; (*get originator viewer*)
```

```
    DH := Oberon.DisplayHeight(V.X); (*get height of this track*)
    IF V.H < Oberon.DisplayHeight(V.X) THEN (*if viewer is small*)
      Oberon.OpenTrack(V.X, V.W); (*open overlaying track*)
      V.handle(V, M); newV := M.F(Viewers.Viewer); (*get a copy of the viewer*)
      Viewers.Open(newV, V.X, DH); (*open new big viewer*)
      N.id := Viewers.restore; newV.handle(newV, N) (*ask new viewer to draw itself*)
    END
  END Grow;
```

Remark:

The Grow command is *generic* in the sense that it can handle viewer instances of any (current or future) class. Typically (and unavoidably) generic commands use *message passing* instead of ordinary procedure calls. This *object-oriented style* will be explained in more detail in the next chapter. Also notice that actually a copy of the original viewer is opened in the new track. When this track is being closed later, the original viewer will reappear.

Process viewer text or sequence of texts, depending on context

```
  PROCEDURE ProcessText;
    VAR par: Oberon.ParList; Main: TextFrames.Frame; S: Texts.Scanner; T: Texts.Text;
  BEGIN
    par := Oberon.Par; (*access parameters*)
    IF par.frame = par.vwr.dsc THEN (*command in menu frame*)
      IF par.vwr.dsc.next IS TextFrames.Frame THEN
        Main := par.vwr.dsc.next(TextFrames.Frame); (*main text frame*)
        TextFrames.Mark(Main, -1) (*set arrow mark*)
        Process(Main.text); (*process displayed text*)
        TextFrames.Mark(Main, 1) (*restore position mark*)
      END
    ELSE (*command in main text frame*)
      Main := par.frame(TextFrames.Frame);
      TextFrames.Mark(Main, -1) (*set arrow mark*)
      Texts.OpenScanner(S, par.text, par.pos); (*open scanner at position of parameter list*)
      Texts.Scan(S); (*get first symbol*)
      WHILE S.class = Texts.Name DO
        Texts.Open(T, S.s); (*open text from file*)
        Process(T); (*process this text*)
        Texts.Scan(S) (*get next symbol*)
      END;
      TextFrames.Mark(Main, 1) (*restore position mark*)
    END
  END ProcessText;
```

Delete selected part of text in marked viewer

```
  PROCEDURE Delete;
    VAR Main: TextFrames.Frame; V: Viewers.Viewer;
  BEGIN
    V := Oberon.MarkedViewer(); (*get marked viewer*)
    Main := V.dsc.next(TextFrames.Frame); (*main text frame of marked viewer*)
    IF Main.sel > 0 THEN (*if there exists a selection*)
      Texts.Delete(Main.text, Main.selbeg.pos, Main.selend.pos) (*delete text*)
    END
  END Delete;
```

Copy most recently selected text part to caret's position

```
  PROCEDURE CopyText;
```

```
  VAR Main: TextFrames.Frame; buf: Texts.Buffer; V: Viewers.Viewer; time: LONGINT;
BEGIN
  Oberon.GetSelection(T, beg, end, time); (*get most recent selection*)
  IF time >= 0 THEN (*if it exists*)
    Texts.OpenBuffer(buf);
    Texts.Save(T, beg, end, buf); (*save text in buffer*)
    V := Oberon.FocusViewer; (*get focus viewer*)
    IF (V.dsc # NIL) & (V.dsc.next IS TextFrames.Frame) THEN (*if text viewer*)
      Main := V.dsc.next(TextFrames.Frame); (*main text frame*)
      IF Main.car > 0 THEN (*if caret set*)
        Texts.Insert(Main.text, Main.carloc.pos, buf) (*insert text at caret's position*)
      END
    END
  END
END CopyText;
```

Copy font from visibly marked position to text selection

```
PROCEDURE CopyFont;
  VAR F: TextFrames.Frame; T: Texts.Text; R: Texts.Reader; V: Viewers.Viewer;
    beg, end, time: LONGINT; X, Y: INTEGER; ch: CHAR;
BEGIN
  Oberon.GetSelection(T, beg, end, time); (*get most recent selection*)
  IF (time >= 0) & Oberon.Pointer.on THEN (*if found and pointer visible*)
    X := Oberons.Pointer.X; Y := Oberon.Pointer.Y;
    V := Viewers.This(X, Y); (*marked viewer*)
    IF (V.dsc # NIL) & (V.dsc.next IS TextFrames.Frame) THEN
      F := V.dsc.next(TextFrames.Frame);
      IF (X >= F.X) & (X < F.X + F.W) & (Y >= F.Y) & (Y < F.Y + F.H) THEN
        Texts.OpenReader(R, F.text, TextFrames.Pos(F, X, Y)); (*position reader*)
        Texts.Read(R, ch); (*read marked char*)
        Texts.ChangeLooks(T, beg, end, {0}, R.fnt, 0, 0) (*change font alone*)
      END
    END
  END
END CopyFont;
```

Move caret to next character written in italics

```
PROCEDURE SearchItalics;
  VAR Main: TextFrames.Frame; R: Texts.Reader; italic: Fonts.Font; V: Viewers.Viewer;
    pos: LONGINT; ch: CHAR;
BEGIN
  italic := Fonts.This("Syntax10i.Scn.Fnt");
  V := Oberon.FocusViewer; (*get focus viewer*)
  IF (V.dsc # NIL) & (V.dsc.next IS TextFrames.Frame) THEN (*if text viewer*)
    Main := V.dsc.next(TextFrames.Frame); (*main text frame*)
    IF Main.car > 0 THEN (*if caret set*)
      Texts.OpenReader(R, Main.text, Main.carloc.pos); (*open reader at caret's position*)
      Texts.Read(R, ch);
      WHILE ~R.eot & (R.fnt # italic) DO Texts.Read(R, ch) END; (*read char stream*)
      IF ~R.eot THEN (*not end of text*)
        pos := Texts.Pos(R); (*reader's position*)
        TextFrames.RemoveSelection(Main); (*remove all marks*)
        TextFrames.RemoveCaret(Main);
        Oberon.RemoveMarks(Main.X, Main.Y, Main.W, Main.H);
        TextFrames.Show(Main, Max(0, pos - 200)); (*show text at pos*)
        TextFrames.SetCaret(Main, pos) (*set caret to new position*)
      END
    END
```

```
    END
  END SearchItalics;
```

where *Max* is the maximum-function.

Guide for Programmers of new Frame Classes and Viewer Types

Frames as Active Objects

Frames are the basic entities of Oberon's display system. They are more-or-less autonomous rectangular areas on the display screen and may be nested. In particular, the display screen is hierarchically organized like this: Display > tracks > viewers > data frames. Display, tracks, and viewers are entities to be managed by the viewer handler module *Viewers*. Because of Oberon's tiling approach, all of these frames are totally visible or totally invisible, i.e. there is no partial overlapping on this level. There exists a class of standard viewers called *menu-viewers* (and handled by module *MenuViewers*). Every menu-viewer contains exactly two vertically adjacent data frames: A header frame (including title and menu) and a main data frame. The main frame of a menu-viewer can be regarded as a virtual display terminal representing the user interface to a certain application or task. It may itself be nested, i.e. contain further subframes. Because an individual *command interpreter* is associated with every frame, implementing a new class of data frames is a most powerful way of adding functionality to the Oberon system.

We have intentionally used the term *class*. As a matter of fact, frames are implemented in Oberon as *active objects* in the sense of object-oriented programming. Calls of frame-specific handling procedures are made by system routines in the form of message transfers. In particular, the central Oberon loop typically initiates reactions on user-input actions by sending appropriate messages to the respective viewers. We emphasize that employing the object-oriented programming paradigm in connection with the handling of frames is necessary in order to enable the kernel to call command interpreters whose identity is unknown to it.

Any handler that is associated with a certain viewer class, for example menu-viewers, is expected to handle messages from (at least) three different originators: From the viewer manager, from the document manager, and from the central loop. Messages from the viewer manager report on the state change of the viewer. For example, the viewer manager *Viewers* sends a message whenever a hidden viewer becomes visible (and must therefore restore its contents), or when the size of a viewer has changed because its lower neighbour was opened, changed, or closed. Messages from the document manager remind the viewer of updating its contents after an editing operation. Finally, messages from module Oberon notify the viewer of system-wide events, such as input events (for example, "mouse button i pressed at position X, Y") or an inquiry for the most recent text selection (regarded in Oberon as the *standard input*). The interpreter-part handling input events should be regarded as an *editor* that is bound to the viewer class. In the case of viewers displaying text, this is a text editor, in the case of graphics, it is a graphics editor, and in the case of a viewer representing a mailbox it is an editor for electronic mail.

A typical viewer handler (like the one associated with menu-viewers) processes viewer-oriented messages directly and delegates the handling of the more data-specific messages by passing them on to the viewer's subframes. Prime examples of viewer-oriented messages are requests to restore a viewer or change its size. Examples of data-specific messages are selecting an object or invoking a command by pointing to its name. Notice that new and finer-grained requests may evolve from processing of viewer-oriented message.s For example, a request to change the size of a menu-viewer is resolved in requests to change the size of one or both of its subframes. In summarizing, viewer handlers normally act both as mediators and originators of messages to be processed by the handlers of their subframes.

The Canonical Decomposition of an Application

Modularizing by separation of concerns is one of the most effective techniques applied to the design of large software systems. Our concept of a class of frames displaying data of a certain kind provides a perfect opportunity to demonstrate this technique. We can extract the following separate topics from the program implementing an interactive application: the *tool package*, the *command interpreter*, the *display handler*, and the *data manager*. The following tasks are assigned to these parts: Providing a collection of powerful and customized commands operating on the data of the given kind (tool package), reacting on input actions within the associated display frame (command interpreter), displaying the visible objects (display handler), and encapsulating the management of the data without any concern of how they are displayed (data manager). Typically, the data part comprises a set of editing operations. It maintains an internal data structure describing the current state of the data.

It is natural to try to assign a separate module to each of these parts. We soon see that the

command interpreter part and the display manager are preferably combined in one module because both need to operate on the same associated display frame. This leads to the following canonical module configurations in the casess of standard texts, graphics, pictures, and MyData, for example:

Tool Package	Edit	Draw	Paint	MyTool
Comm. Int. & Disp. Handler	TextFrames	GraphicFrames	PictureFrames	MyFrames
Data Manager	Texts	Graphics	Pictures	MyData

Notice that the same data manager can in principle be used by different display handlers and command interpreters. Data managers serve as links between different applications and thus enable an optimal integration. For example, if the graphic system is based on module *Texts* for the management of text captions, then text can freely be exchanged between frames of these classes: Graphic frames and text frames are integrated.

Tutorial Example: Text Viewers

So far, we have not explained yet how objects and messages are realized in the Oberon language. In contrast to typical object-oriented programming systems, the complete set of messages understood by an object need not be specified together with the definition of the object class. Instead, Oberon explores a more flexible dual approach: Messages are typically defined in sender modules. For example, messages of the first of the above mentioned kinds are defined in module *Viewers*, messages of the second kind are defined in the respective editor module (*TextFrames* in the case of text), and messages of the third kind are defined in module *Oberon* which detects input events.

Roughly speaking, the Oberon language supports *subclassing* (by the type extension facility), but *messages* and *message handlers* are not institutionalized in the form of a language construct. We have implemented the above outlined scheme by making use of procedure variables, and by applying Oberon's record extension facility to objects *and* to messages.

We shall now exemplify this model with the help of standard *text-viewers*, i.e. menu-viewers whose subframes (menu and main) are text frames. The following exposition may serve as a tutorial and template for implementors of arbitrary frame classes or viewer types. We recall that the display data structure is a hierarchy of display frames. Restricting our explanations to text-viewers we have the following hierarchy of types:

```
Viewers.Track     MenuViewers.Viewer
      ^                   ^
 Viewers.Viewer    TextFrames.Frame
        ^            ^
        Display.Frame
```

Module *Display* features the base types of frames and frame messages and the type of the message handler. The (empty) base message serves as a root in the (potentially unlimited) hierarchy of messages to be accepted by frames. Module *Viewers* provides the definition of type *Viewer*, which is an extension (variant) of type *Display.Frame*. Menu-viewers are a based on *Viewers.Viewer* an defined in module *MenuViewers*.

In definition of Display:

```
TYPE
  Frame = POINTER TO FrameDesc;
  FrameMsg = RECORD END;
  Handler = PROCEDURE (Frame, VAR FrameMsg);
  FrameDesc = RECORD
    dsc, next: Frame; (*son, brother*)
    X, Y, W, H: INTEGER;
    handle: Handler
  END;
```

In the definition of Viewers:

```
TYPE
 Viewer = POINTER TO ViewerDesc;
```

```
ViewerDesc = RECORD (Display.FrameDesc)
  state: INTEGER
END;
```

In the definition of MenuViewers:

```
TYPE
  Viewer = POINTER TO ViewerDesc;
  ViewerDesc = RECORD (Viewers.ViewerDesc)
    menuH: INTEGER
  END;
```

The following are the declarations of messages that are expected to be handled by every viewer. Note that they are distributed over several modules rather than concentrated in one place (as it would be the case in an "ordinary" object-oriented model).

In definition of Viewers:

```
ViewerMsg = RECORD (Display.FrameMsg)
  id: INTEGER;
  X, Y, W, H: INTEGER; (*new rectangle*)
  state: INTEGER (*new state*)
END;
(*signals change of viewer state
  id = 0: restore viewer
       1: modify size at bottom
       2: suspend viewer*)
```

In definition of TextFrames:

```
UpdateMsg = RECORD (Display.FrameMsg)
  id: INTEGER; (*operation*)
  text: Texts.Text; (*edited text*)
  beg, end: LONGINT (*stretch*)
END;
(*signals change of contents
  id = 0: stretch [beg, end[ replaced
       1: stretch [beg, end[ inserted
       2: stretch [beg, end[ deleted*)
```

In definition of Oberon:

```
InputMsg = RECORD (Display.FrameMsg)
  id: INTEGER; (*operation*)
  modes, keys: SET; (*mouse*)
  X, Y: INTEGER; (*position*)
  ch: CHAR (*character read*)
END;
(*signals input event
  id = 0: track mouse
       1: consume character*)

ControlMsg = RECORD (Display.FrameMsg)
  id: INTEGER; (*operation*)
  X, Y: INTEGER (*current location of the mous*)
END;
 (*signals control action
    id = 0: remove focus
         1: remove all marks
         2: : mark*)
SelectionMsg = RECORD (Display.FrameMsg)
    time: LONGINT;
```

```
      text: Texts.Text;
      beg, end: LONGINT
    END;
    (*signals inquiry for most recent text selection*)

    CopyOverMsg = RECORD (Display.FrameMsg)
      text: Texts.Text;
      beg, end: LONGINT
    END;
    (*receive text stretch [beg, end[*)

    CopyMsg* = RECORD (Display.FrameMsg)
      F: Display.Frame
    END;
    (*request for the creation of a copy of a text frame*)
```

We recall that high-level viewer managers like *MenuViewers* typically pass on most of the received messages to their subframes. In the course of (pre-)processing viewer-oriented requests, high-level viewer managers can also produce new messages. In the case of *MenuViewers* these are

```
    ModifyMsg* = RECORD (Display.FrameMsg)
      id: INTEGER; (*operation*)
      dY, Y, H: INTEGER (*vector dY, new Y and H*)
    END;
    (*vertically move and extend or reduce frame at bottom*)
      id = 0: extend frame
      id = 1: reduce frame*)
```

dY represents a vertical translation vector showing upwards in the extend-case and showing downwards in the reduce-case. By definition, dY is always non-negative. Y and H specify the new position and height respectively.
In summary, essentially the same messages have to be handled by a viewer and its subframes, except that some of the messages are processed or preprocessed by the ancestor viewer already which, in turn, may result in sending new and finer-grained messages to its subframes.

A message is sent to a specific object simply by calling its installed handler. For example, *F.handle(F, M)* has the effect of sending message *M* to frame *F*. In case of text-frames, the installed handler is *Handle*. It is elaborated in module *TextFrames*. We now provide a tutorial sketch of this procedure. Notice that *Handle* makes extensive use of Oberon's type test (and type guard) facility in order to discriminate among the different message kinds.

```
1  PROCEDURE Handle (F: Display.Frame; VAR M: Display.FrameMsg);
2    VAR F1: Frame;
3  BEGIN
4   WITH F: Frame DO
5    IF M IS Oberon.InputMsg THEN
6     WITH M: Oberon.InputMsg DO
7      IF M.id = Oberon.track THEN Edit(F, M.X, M.Y, M.keys)
8      ELSIF M.id = Oberon.consume THEN
9       IF F.car # 0 THEN Write(F, M.ch, M.fnt, M.col, M.voff) END
12     END
13    END
14   ELSIF M IS Oberon.ControlMsg THEN
15    WITH M: Oberon.ControlMsg DO
16     IF M.id = Oberon.defocus THEN Defocus(F)
17     ELSIF M.id = Oberon.neutralize THEN Neutralize(F)
18     END
19    END
20   ELSIF M IS Oberon.SelectionMsg THEN
21    WITH M: Oberon.SelectionMsg DO GetSelection(F, M.text, M.beg, M.end, M.time) END
22   ELSIF M IS Oberon.CopyOverMsg THEN
23    WITH M: Oberon.CopyOverMsg DO CopyOver(F, M.text, M.beg, M.end) END
24   ELSIF M IS Oberon.CopyMsg THEN
```

```
25      WITH M: Oberon.CopyMsg DO Copy(F, F1); M.F := F1 END
26    ELSIF M IS MenuViewers.ModifyMsg THEN
27      WITH M: MenuViewers.ModifyMsg DO Modify(F, M.id, M.dY, M.Y, M.H) END
28    ELSIF M IS UpdateMsg THEN
29      WITH M: UpdateMsg DO
30        IF F.text = M.text THEN Update(F, M) END
31      END
32    END
33  END
34  END Handle;
```

Explanations:

```
1   procedure of type Display.Handler
2   auxiliary variable for frame copy (line 25). Needed because M.F is base type
4   type guard; F must be a text frame
5   type test; is message an Oberon input message?
6   type guard
7   if message demands mouse tracking
8   if message demands consuming then consume a character
9   if caret is active in this text frame
14   type test; is message an Oberon control message?
15   type guard
16   if message demands removing the caret
17   if message demands removing caret and selection
20   type test; is message an Oberon selection inquiry?
21   if so, register own selection if it is newer than candidate
22   type test; is message a copy-over-message?
23   if so, copy text stretch to caret's location in this frame
24   type test; is message a copy-message?
25   if so, produce a copy of this frame (initialized to empty)
26   type test; is message a modify-message?
27   if so, modify size or position of this frame (see below)
28   type test; is message an update message?
30   if so, check if changed text is represented in this frame and then update frame
```

We also provide the following refinement of the procedure *TextFrames.Modify* called in line 27 in *TextFrames.Handle*. It shows well how subframes of menu-viewers should react on a *MenuViewers.ModifyMsg*.

```
 PROCEDURE Modify (F: Frame; id, dY, Y, H: INTEGER);
 BEGIN
   Mark(F, 0); RemoveMarks(F); (*remove position-bar, caret, and selection*)
   IF id = MenuViewers.extend THEN
     IF dY > 0 THEN (*if frame is to be moved*)
         Display.CopyBlock(F.X, F.Y, F.W, F.H, F.X, F.Y + dY, 0); F.Y := F.Y + dY (*move original
block*)
     END;
     Extend(F, Y) (*extend moved frame at its bottom*)
   ELSIF id = MenuViewers.reduce THEN
     Reduce(F, Y + dY); (*reduce original frame at its bottom*)
     IF dY > 0 THEN (*if frame is to be moved*)
       Display.CopyBlock(F.X, F.Y, F.W, F.H, F.X, Y, 0); F.Y := Y (*move reduced block*)
     END
   END;
   IF F.H > 0 THEN Mark(F, 1) END (*restore position-bar*)
 END Modify;
```

Remember that dY is always non-negative, and notice that the reduce-part of the procedure is the exact inverse of the extend-part.

Notice by the way that the above handler is used for the handling of both data-frames and standard header-frames. The two variants of text frames differ only by their background color. This

fact testifies for a streamlined system design and is an example of the "today en-vogue" notion of code reusing.

The attentative and experienced reader may have noticed that the module *TextFrames* plays two very different roles. Its first role is that of a (late-bound) *handler* of messages sent to frame instances. The second role is that of a *library* of procedures operating on text frames. Examples are *Edit*, *Write*, *CopyOverShow*, *SetCaret*, and *TrackWord*. To the two roles of *TextFrames* correspond two different ways of treating text frames, namely as *active objects* individually reacting on messages, and as *passive rectangles* to be operated on conventionally by invoking procedures. The second way of treating frames might be of importance in cases where text frames are text boxes belonging to the contents of some more complex document.

Module *TextFrames* offers yet another choice, this time to potential implementors of handlers of subclasses of text frames: Either they implement their own handler by just adding increments, and then refer to *Handle*, or they compose an individual handler from the elements. For example, a designer of *MailFrames* might apply the first strategy. He might just add a few mail-oriented methods catching the mail-oriented messages, and then delegate all further processing to *TextFrames.Handle*. In contrast, an implementor of a new user-interface to text frames might prefer strategy 2.

We conclude this section by explaining briefly the flow of control after, for example, a character has been typed. We assume that the focus viewer is a text viewer and that the caret is set in its main data frame. First, the central loop *Oberon* detects the new character in the keyboard buffer. It then sends an input consume-message to the focus-viewer which, in turn, passes on this message to its main subframe. After that, the handler (command interpreter) of this subframe locates the caret within the underlying text and subsequently calls the *Insert*-procedure of the text data manager *Texts*. On that, *Insert* inserts the character in the text and (up-)calls the associated notifier which, in our case, is residing in *TextFrames*. The notifier then sends a broadcast-message of type *TextFrames.UpdateMsg* to all visible viewers. Every single of these viewers passes on this message to its subframes. If a subframe understands the message and finds itself involved in this update, it restores its contents by accessing the new data, again from the data manager *Texts.*

We now present some typical examples of implementations.

Tutorial Examples 1: Frame oriented operations

Display text line within text frame

```
PROCEDURE DisplayLine (F: Frame; L: Line; VAR R: Texts.Reader; X, Y: INTEGER; len: LONGINT);
  VAR pat: Display.Pattern; NX, dx, x, y, w, h: INTEGER;
BEGIN NX := F.X + F.W;
  WHILE (nextCh # CarriageReturn) & (R.fnt # NIL) DO
    Display.GetChar(R.fnt.raster, nextCh, dx, x, y, w, h, pat);
    IF (X + x + w <= NX) & (h # 0) THEN
      Display.CopyPattern(R.col, pat, X + x, Y + y, 2)
    END;
    X := X + dx; INC(len); Texts.Read(R, nextCh)
  END;
  L.len := len + 1; L.wid := X + eolW - (F.X + F.margW);
  L.eot := R.fnt = NIL; Texts.Read(R, nextCh)
END DisplayLine;
```

where the types *Line* and *Frame* are defined as follows. Notice that *Line* is a private type and *TextFrames.Frame* is the public projection of type *Frame*.

```
Line = POINTER TO LineDesc;
LineDesc = RECORD
  len: LONGINT; (*number of characters in this line*)
  wid: INTEGER; (*width of line box*)
  eot: BOOLEAN; (*end of text flag*)
  next: Line (*next lower neighbour*)
END;
```

```
  Location = RECORD
    org, pos: LONGINT; (*line origin, position*)
    dx, x, y: INTEGER; (*width and position of located character*)
    lin: Line (*associated line*)
  END;
  Frame = POINTER TO FrameDesc;
  FrameDesc = RECORD (Display.FrameDesc)
    text: Texts.Text; (*displayed text*)
    org: LONGINT; (*position in text of first displayed character*)
    col: INTEGER; (*background color*)
    lsp, asr, dsr: INTEGER; (*line spacing, ascender, descender*)
    left, right, top, bot: INTEGER; (*margins*)
    markH: INTEGER; (*margin width, position of mark*)
    time: LONGINT; (*time of latest selection*)
    mark, car, sel: INTEGER; (*state of mark, caret, selection*)
    carloc: Location; (*caret location*)
    selbeg, selend: Location (*locations of begin and end of selection*)
   trailer: Line (*pointer to the associated sequence of line descriptors*)
    END;
```

Track caret

```
  PROCEDURE TrackCaret (F: Frame; X, Y: INTEGER; VAR keysum: SET);
    VAR loc: Location; keys: SET;
  BEGIN
    IF F.trailer.next # F.trailer THEN
      LocateChar(F, X - F.X, Y - F.Y, F.carloc);
      FlipCaret(F);
      keysum := {};
      LOOP
        Input.Mouse(keys, X, Y);
          IF keys = {} THEN EXIT END;
          keysum := keysum + keys;
          Oberon.DrawCursor(Oberon.Mouse, Oberon.Mouse.marker, X, Y);
          LocateChar(F, X - F.X, Y - F.Y, loc);
        IF loc.pos # F.carloc.pos THEN FlipCaret(F); F.carloc := loc; FlipCaret(F) END
      END;
      F.car := 1
    END
  END TrackCaret;
```

where the following auxiliary procedures are used:

```
   PROCEDURE LocateChar (F: Frame; x, y: INTEGER; VAR loc: Location);
    VAR R: Texts.Reader;
      pat: Display.Pattern;
      pos, lim: LONGINT;
      ox, dx, u, v, w, h: INTEGER;
  BEGIN LocateLine(F, y, loc);
    lim := loc.org + loc.lin.len - 1;
    pos := loc.org; ox := F.left;
    Texts.OpenReader(R, F.text, loc.org); Texts.Read(R, nextCh);
    LOOP
      IF pos = lim THEN dx := eolW; EXIT END;
      Display.GetChar(R.fnt.raster, nextCh, dx, u, v, w, h, pat);
      IF ox + dx > x THEN EXIT END;
      INC(pos); ox := ox + dx; Texts.Read(R, nextCh)
    END;
    loc.pos := pos; loc.dx := dx; loc.x := ox
  END LocateChar;
```

```
PROCEDURE LocateLine (F: Frame; y: INTEGER; VAR loc: Location);
  VAR T: Texts.Text; L: Line; org: LONGINT; cury: INTEGER;
 BEGIN T := F.text;
  org := F.org; L := F.trailer.next; cury := F.H - F.top - F.asr;
  WHILE (L.next # F.trailer) & (cury > y + F.dsr) DO
    org := org + L.len; L := L.next; cury := cury - F.lsp
  END;
  loc.org := org; loc.lin := L; loc.y := cury
END LocateLine;

PROCEDURE FlipCaret (F: Frame);
 BEGIN
  IF F.carloc.x < F.W THEN
    IF (F.carloc.y >= 10) & (F.carloc.x + 12 < F.W) THEN
      Display.CopyPattern(white, BigCaret, F.X + F.carloc.x, F.Y + F.carloc.y - 10, 2)
    ELSIF (F.carloc.y >= 4) & (F.carloc.x + 6 < F.W) THEN
      Display.CopyPattern(white, SmallCaret, F.X + F.carloc.x, F.Y + F.carloc.y - 4, 2)
    END
  END
END FlipCaret;
```

Tutorial Examples 2: Text oriented operations

Save text in buffer

```
PROCEDURE Save (T: Text; beg, end: LONGINT; B: Buffer);
  VAR p, q, qb, qe: Piece; org: LONGINT;
BEGIN
  IF end > T.len THEN end := T.len END;
  FindPiece(T, beg, org, p);
  NEW(qb); qb^ := p^;
  qb.len := qb.len - (beg - org);
  qb.off := qb.off + (beg - org);
  qe := qb;
  WHILE end > org + p.len DO
    org := org + p.len; p := p.next;
    NEW(q); q^ := p^; qe.next := q; q.prev := qe; qe := q
  END;
  qe.next := NIL; qe.len := qe.len - (org + p.len - end);
  B.last.next := qb; qb.prev := B.last; B.last := qe;
  B.len := B.len + (end - beg)
END Save;
```

where *FindPiece* is the following auxiliary procedure:

```
PROCEDURE FindPiece (T: Text; pos: LONGINT; VAR org: LONGINT; VAR p: Piece);
   VAR n: INTEGER;
BEGIN
  IF pos < T.org THEN T.org := -1; T.pce := T.trailer END;
  org := T.org; p := T.pce; (*from cache*)
  n := 0;
  WHILE pos >= org + p.len DO org := org + p.len; p := p.next; INC(n) END;
  IF n > 50 THEN T.org := org; T.pce := p END (*to cache*)
END FindPiece;
```

and where the types *Piece*, *Text*, and *Buffer* are defined as follows. Notice that *Piece* is a private type, *Texts.Text* is the public projection of type *Text*, and *Texts.Buffer* is the public part of type *Buffer*.

```
Piece = POINTER TO PieceDesc;
PieceDesc = RECORD
   f: Files.File; (*carrier file*)
   off: LONGINT; (*offset in file*)
   len: LONGINT; (*piece length*)
   fnt: Fonts.Font; (*font*)
   col: SHORTINT; (*color*)
   voff: SHORTINT; (*vertical offset*)
   prev, next: Piece (*links to neighbours*)
END;
Text = POINTER TO TextDesc;
Notifier = PROCEDURE (Text, INTEGER, LONGINT, LONGINT);
TextDesc = RECORD
   len: LONGINT; (*text length*)
   notify: Notifier; (*called after text changes*)
   trailer: Piece; (*sentinel*)
   org: LONGINT; (*cached origin*)
   pce: Piece (*cached piece*)
 END;
Buffer = POINTER TO BufDesc;
BufDesc = RECORD
  len: LONGINT; (*buffer length*)
  header, last: Piece (*buffered piece list*)
END;
```

Insert contents of buffer in text

```
PROCEDURE Insert (T: Text; pos: LONGINT; B: Buffer);
  VAR pl, pr, p, qb, qe: Piece; org: LONGINT;
BEGIN
  FindPiece(T, pos, org, p); SplitPiece(p, pos - org, pr);
  IF T.org >= org THEN (*adjust cache*)
    T.org := org - p.prev.len; T.pce := p.prev
  END;
  pl := pr.prev; qb := B.header.next;
  IF (qb # NIL) & (qb.f = pl.f) & (qb.off = pl.off + pl.len)
    & (qb.fnt = pl.fnt) THEN pl.len := pl.len + qb.len; qb := qb.next
  END;
  IF qb # NIL THEN qe := B.last;
    qb.prev := pl; pl.next := qb; qe.next := pr; pr.prev := qe
  END;
  T.len := T.len + B.len;
  T.notify(T, insert, pos, pos + B.len); (*call postprocessor*)
  B.last := B.header; B.last.next := NIL; B.len := 0
END Insert;
```

where *SplitPiece* is

```
PROCEDURE SplitPiece (p: Piece; off: LONGINT; VAR pr: Piece);
  VAR q: Piece;
BEGIN
  IF off > 0 THEN NEW(q);
    q.col := p.col; q.fnt := p.fnt;
    q.len := p.len - off;
    q.f := p.f; q.off := p.off + off;
    p.len := off;
    q.next := p.next; p.next := q;
    q.prev := p; q.next.prev := q;
    pr := q
  ELSE pr := p
  END
```

```
END SplitPiece;
```

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