Amiga ROM Kernel Reference Manual

DOS

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Contents

Chapter 1

Introduction

1.1 Purpose

The purpose of this manual is to provide a comprehensive documentation of the AmigaDOS subsystem of the Amiga Operation System. This subsystem is represented by the *dos.library*, and it provides services around files, file systems and stream-based input and output. While the Amiga ROM Kernel Reference Manuals [7] document major parts of the AmigaOs, they do not include a volume on AmigaDOS itself. This is due to the history of AmigaDOS which is nothing but a port of the TRIPOS to the Amiga, and thus its documentation became available as the AmigaDOS manual[1] separately. This book itself is, similar to AmigaDOS, based on the TRIPOS manual which has been augmented and updated to reflect the changes that were necessary to fit TRIPOS into AmigaOs. Unfortunately, the book is hard to obtain, and also leaves a lot to deserve.

Good third party documentation is available in the form of the Guru Book[10], though this source is out of print and even harder to obtain. It covers also other aspects of AmigaOs that go beyond AmigaDOS such that its focus is a bit different than this work.

This work attempts to fill this gap by providing a comprehensive and complete documentation of the AmigaDOS library and its subsystems in the style of the ROM Kernel Reference Manuals.

1.2 Language and Type Setting Conventions

The words *shall* and *shall not* indicate normative requirements software shall or shall not follow or in order to satisfy the interface requirements of AmigaOs. The words *should* and *should not* indicate best practise and recommendations that are advisable, but not strictly necessary to satisfy a particular interface. The word *may* provides a hint to a possible implementation strategy.

The word *must* indicates a logical consequence from existing requirements or conditions that follows necessarily without introducing a new restriction, such as in "if a is 2, $a + a$ *must* be 4".

> *Worth to remember!* Important aspects of the text are indicated with a bold vertical bar like this.

Terms are indicated in *italics*, e.g. the *dos.library* implements interface of *AmigaDOS*. Data structures and components of source code are printed `in courier` in fixed-width font, reassembling the output of a terminal, e.g.

```
typedef unsigned char UBYTE; /* an 8-bit unsigned integer */
typedef long LONG;           /* a 32-bit integer          */
```

Chapter 2

Elementary Data Types

2.1 The dos.library

AmigaDOS as part of the *Amiga Operating System* or short *AmigaOs* is represented by the ROM-based *dos.library*. This library is typically opened by the startup code of most compilers anyhow, and its base pointer is placed into `DOSBase` by this startup code:

```
struct DosLibrary *DOSBase;
```

Hence, in general, there is no need to open this library manually.

The structure *struct DosLibrary* is defined in `dos/dosextens.h`, but its layout and its members are usually not required and should rather not be accessed directly. Instead, the library provides accessor functions to read many objects contained within it.

If you do not link with compiler startup code, the base pointer of the *dos.library* can be obtained similar to that of any other library:

```
#include <proto/exec.h>
#include <proto/dos.h>
#include <exec/libraries.h>
#include <dos/dos.h>

...
if ((DOSBase = (struct DosLibrary *)(OpenLibrary(DOSNAME,47))) {
  ...
  CloseLibrary((struct Library *)DOSBase);
}
```

Unlike many other operating system, the *dos.library* does not manage disks or files itself, neither does it provide access to hardware interface components. It rather implements a *virtual file system* which forwards requests to its subsystems, called *handlers* or *file systems*, see 2.8.

2.2 Booleans

AmigaDOS uses a somewhat different convention for booleans, i.e. truth values defined in the file `dos/dos.h`:

Table 1: DOS Truth Values

Define	Value
DOSFALSE	0
DOSTRUE	-1

Note that the C language instead uses the value 1 for `TRUE`. Code that checks for zero or non-zero return codes will function normally, however code shall not compare to `TRUE` in boolean tests.

2.3 Pointers and BPTRs

AmigaDOS is a descendent of the *TRIPOS system* and as such originally implemented in the BCPL language. As of Kickstart 2.0, AmigaDOS was re-implemented in C and assembler, but this implementation had to preserve the existing interface based on BCPL conventions.

BCPL is a typeless language that structures the memory of its host system as an array of 32-bit elements enumerated contiguously from zero up. Rather than pointers, BCPL communicates the position of its data structures in the form of indices of the first 32-bit element of such structures. As each 32-bit group is assigned its own index, one can obtain this index by dividing the byte-address of an element by 4, or equivalently, by right-shifting the address by two bits. This has the consequence that (most) data structures passed into and out of the dos.library shall be aligned to 32-bit boundaries. Similarly, in order to obtain the byte-address of a BPCL structure, the index is multiplied by 4, or left-shifted by 2 bits.

> *Not on the Stack!* Since BPCL structures must have an address that is divisible by 4, you should not keep such structures on the stack as the average compiler will not ensure long word alignment for automatic objects. In the absence of a dedicated constructor function such as *AllocDosObject()*, a safe strategy is use the exec.library memory allocation functions such as *AllocMem()* or *AllocVec()* to obtain memory for holding them.

These indices are called *BCPL pointers* or short *BPTR*s, even though they are not pointers in the sense of the C language, but rather integer numbers as indices to an array of `LONG` (i.e. 32-bit) integers. In order to communicate this fact more clearly, the `dos/dos.h` include file defines the following data type:

```
typedef long  BPTR;                   /* Long word pointer */
```

Conversion from BCPL pointers to conventional C pointers and back are formed by the following macros, also defined in `dos/dos.h`:

```
/* Convert BPTR to typical C pointer */
#define BADDR(x)        ((APTR)((ULONG)(x) << 2))
/* Convert address into a BPTR */
#define MKBADDR(x)      (((LONG)(x)) >> 2)
```

Luckely, in most cases callers of the *dos.library* do not need to convert from and to BPTRs but can rather use such “pointers” as *opaque values* or *handles* representing some AmigaDOS objects.

It is certainly a burden to always allocate temporary BCPL objects from the heap, and doing so may also fragment the AmigaOs memory unnecessarily. However, allocation of automatic objects from the stack does not ensure long-word alignment in general. To work around this burden, one can use a trick and instead request from the compiler a somewhat longer object of automatic lifetime and align the requested object manually within the memory obtained this way. The following macro performs this trick:

```
#define D_S(type,name) char a_##name[sizeof(type)+3]; \
                       type *name = (type *)((ULONG)(a_##name+3) & ~3UL)
```

It is used as follows:

```
D_S (struct FileInfoBlock, fib);
```

At this point, fib is pointer to a properly aligned `struct FileInfoBlock`, e.g. this is equivalent to

```
struct FileInfoBlock _tmp;
struct FileInfoBlock *fib = &tmp;
```

except that the created pointer is properly aligned and can safely be passed into the *dos.library*.

Similar to the C language, a pointer to a non-existing element is expressed by the special pointer value 0. While this is called the `NULL` pointer in C, it is better to reserve another name for it in BPCL as its pointers are rather indices. The following convention is suggested to express an invalid *BPTR*:

```
#define ZERO 0L
```

Clearly, with the above convention, the BCPL `ZERO` pointer converts to the C `NULL` pointer and back, even though the two are conceptionally something different: The first being the index to the first element of the host memory array, the later the pointer to the first address.

2.4 C Strings and BSTRs

While the C language defines *strings* as 0-terminated arrays of `char`, and AmigaOs in particular to 0-terminated arrays of `UBYTE`s, that is, unsigned characters, the BPCL language uses a different convention, namely that of a `UBYTE` array whose first element contains the size of the string to follow. They are not necessarily 0-terminated either. If BCPL strings are passed into BCPL functions, or are part of BCPL data structures, then typically in the form of a *BPTR* to the 32-bit element containing the size of the string its 8 most significant bits. The include file `dos/dos.h` provides its own data type for such strings:

```
typedef long  BSTR;   /* Long word pointer to BCPL string  */
```

Luckely, functions of the *dos.library* take C strings as arguments and perform the conversion from C strings to their BCPL representation as *BSTR*s internally, such that one rarely gets in contact with this type of strings. They appear as part of some AmigaDOS structures to be discussed, and as part of the interface between the *dos.library* and its handlers, e.g. file systems. However, even though users of the *dos.library* rarely come in contact with *BSTR*s themselves, the *BCPL* convention has an important consequence, namely that (most) strings handled by the *dos.library* cannot be longer than 255 characters as this is the limit imposed by the BCPL convention.

> *Length-Limited Strings* Remember that most strings that are passed into the *dos.library* are internally converted to *BSTR*s and thus cannot exceed a length of 255 characters.

Unfortunately, even as of the latest version of *AmigaDos*, the *dos.library* is ill-prepared to take longer strings, and will likely fail or mis-interpret the string passed in. If longer strings are required, e.g. as part of a *path*, it is (unfortunately) in the responsibility of the caller to take this path apart into components and iterate through the components manually, see also section **??**.

2.5 Files

Files are streams of bytes together with a file pointer that identifies the next position to be read, or the next byte position to be filled. Files are explained in more detail in section 4.

2.6 Locks

Locks are access rights to a particular object on a file system. A locked object cannot be altered by any other process. Section 12.4 provides more details on locks.

2.7 Processes

AmigaDOS is a multi-tasking system operating on top of the *exec* kernel [7]. As such, it can operate multiple tasks at once, where the tasks are assigned to the CPU in a round-robin fashion. A *Process* is an extension of an AmigaOs *Task* that includes additional state information relevant to AmigaDOS, such as a *current directory Current Directory* it operates in, a *default file system*, a *console* it is connected to, and default input, output and error streams. Processes are explained in more detail in section 10.

2.8 Handlers and File Systems

Handlers are special processes that manage files on a volume, or that input or output data to a physical device. AmigaDOS itself delegates all operations on files to such handlers. Handlers are introduced in section **??**.

File systems are special handlers that organize the contents of data carriers such as hard disks, floppies or CD-Roms in the form of files and directories, and provides access to such objects through the *dos.library*. File systems interpret paths (see 4.3) in order to locate objects such as files and directories on such data carriers.

Chapter 3

Date and Time

Due to its history, AmigaOs uses two incompatible representations of date and time. The `timer.device` represents a date as the number of seconds and microseconds since January 1st 1978. As AmigaDOS is based on TRIPOS as an independently developed operating system, the *dos.library* uses a different representation as `DateStamp` structure defined in `dos/dos.h`:

```
struct DateStamp {
   LONG  ds_Days;
   LONG  ds_Minute;
   LONG  ds_Tick;
};
```

The elements of this structure are as follows:

`ds_Days` counts the number of days since January 1st 1978.

`ds_Minute` counts the number of minutes past midnight, i.e. the start of the day.

`ds_Tick` counts the ticks since the start of the minute. The number of ticks per second is defined as `TICKS_PER_SECOND` in `dos/dos.h`.

> *Ticking 50 Times a Second* A system "tick" is always $1/50^{th}$ of a second, regardless whether the system is an NTSC or PAL system. AmigaDOS detects the clock basis during setup and will scale times appropriately such that the definition of the "tick" is independent of the clocking of the system or the monitor refresh frequency.

3.1 Elementary Time and Date Functions

The functions in this section obtain the current system time, compare two times, or delay the system for a given time. They represent times — and dates if appropriate — in the `DateStamp` structure as a triple of days, minutes and ticks.

3.1.1 Obtaining the Time and Date

The `DateStamp()` function obtains the current date and time from AmigaDOS:

```
ds = DateStamp( ds );
D0              D1

struct DateStamp *DateStamp(struct DateStamp *)
```

This function retrieves the current system time and fills it into a `DateStamp` structure pointed to by `ds`. It also returns a pointer to the structure passed in. This function cannot fail.

Unlike many other *dos.library* functions, there is no requirement to align `ds` to a long-word boundary.

3.1.2 Comparing two Times and Dates

The `CompareDates()` function compares two dates as given by `DateStamp` function and returns an indicator which of the dates are earlier.

```
result = CompareDates(date1,date2)
D0                    D1     D2

LONG CompareDates(struct DateStamp *,struct DateStamp *)
```

This function takes two pointers to `DateStamp` structures as `date1` and `date2` and returns a negative number if `date1` is later than `date2`, a positive number if `date2` is later than `date1`, or 0 if the two dates are identical.

3.1.3 Delaying Program Execution

The `Delay()` function delays the execution of the calling process by a specific amount of ticks.

```
Delay( ticks )
       D1

void Delay(ULONG)
```

This function suspends execution of the calling process by `ticks` AmigaDOS ticks. The delay is system-friendly and does not burn CPU cycles; instead, the process is suspended from the CPU the indicated amount of time, makking it available for other processes. Thus, this function is the preferred way of delaying program execution. A tick is $1/50^{th}$ of a second.

AmigaDOS variants below version 36 could not handle delays of 0 appropriately.

3.2 Conversion Into and From Strings

Functions in this section convert date and time in the (binary) AmigaDOS representation to human-readable strings, and in the reveverse direction. Both the input and output of these functions are kept in the `DateTime` structure that is defined in `dos/datetime.h` and reads as follows:

```
struct DateTime {
        struct DateStamp dat_Stamp;
        UBYTE   dat_Format;
        UBYTE   dat_Flags;
        UBYTE   *dat_StrDay;
        UBYTE   *dat_StrDate;
        UBYTE   *dat_StrTime;
};
```

`dat_Stamp` contains the input or output date represented as a `DateStamp` structure.

`dat_Format` defines the format of the date string to create, and the order in which days, months and years appear within the string. The following formats are available, all defined in `dos/datetime.h`:

Table 2: Date formatting options

Format Definition	Description
FORMAT_DOS	The AmigaDOS default format
FORMAT_INT	International (ISO) format
FORMAT_USA	USA date format
FORMAT_CDN	Canadian and European format

FORMAT_DOS represents the date as day of the month in two digits, followed by the month as three-letter abbreviation, followed by a two-digit year counting from the start of the century. An example of this formatting is 30-Sep-23.

FORMAT_INT starts with a two-digit year, followed by the month represented as two digits starting from 01 for January, followed by two digits for the day of the month. An example of this string is 23-09-30.

FORMAT_USA places the month first, encoded as two numerical digits, followed by two digits of the day of the month, followed by two digits of the year. An example of this formatting is 09-30-23.

FORMAT_CDN follows the European convention and places the day of the month first, followed by the month represented as two numerical digits, followed by the year as two digits.

dat_Flags defines additional flags that control the conversion process. They are also defined in dos/datetime.h:

Table 3: Date conversion flags

Flag	Description
DTF_SUBST	Substitute dates by relative description if possible
DTF_FUTURE	Reference direction for relative dates is to the future

The include file dos/datetime.h define in addition also bit numbers for the above flags that start with DTB instead of DTF. The meaning of these flags are as follows:

DTF_SUBST allows, if set, the conversion to substitute dates nearby today's date by descriptions relative to today. This flag is only honored when converting a time and date in AmigaDOS representation to human-readable strings. In particular, the following substitutions are made:

If the date provided is identical to the system date, the output date is set to "Today".

If the date is one day later than the current system date, the output date is set to "Tomorrow".

If the date is one day before te current system date, the output date is set to "Yesterday".

If the date in the past week, the function substitutes it by the name of the day of the week, e.g. "Saturday".

DTF_FUTURE is only only honored when converting a string to the AmigaDOS representation, that is into DateStamp structure. It indicates whether weekdays such as "Monday" are interpreted as dates in the past, i.e. "last Monday", or as dates in the future, i.e. "next Monday". If the flag is cleared, weekdays are interpreted as being in the past, same as the DateToStr() function would generate them. If the flag is set, weekdays are assumed as references into the future.

dat_StrDay: This buffer is only used by converting DateStamps to strings, and — if present — is then filled by the week of the day, e.g. "Saturday".

dat_StrDate: This element points to a buffer that is either filled with the human-readable date, or is input to the conversion then containing a human-readable date. The buffer is formatted, or expected to be formatted according to dat_Format and dat_Flags.

dat_StrTime: This element points to a buffer that is either filled with a human-readable time, or is the input time to be converted. AmigaDOS expects here a 24h clock, hours, minutes and seconds in this order, separated by colon, e.g. 21:47:16.

The functions in this section are patched by the *locale.library* once it is loaded, and then replaced the English strings by the corresponding localized output. The localized versions may also accept (or provide) different formats, such as four-digit years.

3.2.1 Converting a Time and Date to a String

The `DateToStr()` function converts a date and time into a human readable string. The date and time, as well as formatting instructions are given by a `DateTime` structure.

```
success = DateToStr( datetime )
D0                   D1

BOOL DateToStr(struct DateTime *)
```

This function takes the date and time in the AmigaDOS binary representation contained in `dat_Stamp` of the passed in `DateTime` structure introduced in section 3.2 and converts it into human readable strings. The elements of this structure shall be populated as follows:

`dat_Stamp` shall be initialized to the date and time to be converted.

`dat_Format` defines the format of the date string to create. It shall be a value from table 2.

`dat_Flags` defines additional flags that control the conversion process. This function only honors the `DTF_SUBST` flag which indicates that `DateToStr()` is supposed to represent the date relative to the current system date if possible. That is, if possible, the date is represented as "today", "tomorrow", "yesterday" or a weekday. Week days always correspond to past days, e.g. "Friday" corresponds to the past Friday, not a day in the future.

`dat_StrDay`: If this pointer is non-`NULL`, it shall point to a string buffer at least `LEN_DATSTRING` bytes large into which the day of the week is filled, e.g. "Saturday".

`dat_StrDate`: If this pointer is non-`NULL`, it shall also point to a string buffer at least `LEN_DATSTRING` bytes large. This buffer will then be filled by a description for the date according to the format in `dat_Format` and `dat_Flags`.

`dat_StrTime`: This buffer, if the pointer is non-`NULL`, is filled by the time of the day, using a 24h clock. The format is always hours, minutes, seconds, separated by colon.

This function is patched by the *locale.library* once it is loaded, and then replaced the English output by the corresponding localized output.

The function returns 0 on error; the only source of error here is if `dat_Stamp` is invalid, e.g. the number of minutes is larger than 60×24 or the number of ticks is larger than 50×60. This makes this function probably unsuitable to handle leap seconds correctly. This function does not touch `IoErr()`, even in case of failure.

3.2.2 Convert a String to a Date and Time

The `StrToDate()` function converts a date from a human-readable string to its binary AmigaDOS representation.

```
success = StrToDate( datetime )
D0                   D1

BOOL StrToDate( struct DateTime * )
```

This function takes a `DateTime` structure as defined in section 3.2 and converts the date and time strings in this structure to a `DateStamp` structure in `dat_Stamp`. In particular, the elements of the `DateTime` shall be initialized as follows:

`dat_DateTime` may remain uninitialized and is rather filled by this function with the converted date. In other words, this element is used to provide the result of this function.

`dat_Format` shall be initialized by the format that is used by the input date. Table 2 lists the available input formats. In particular, the ROM code within the *dos.library* only accepts two-digit years and interprets the anything between 78 and 99 as 1978 to 1999, and years between 00 and 45 as 2000 to 2045. It refuses all other numbers. However, `StrToDate()` is patched by the *locale.library* whose replacement implementation also accepts four-digit years.

`dat_Flags` shall be initialized by a combination of the flags from table 3. As `StrToDate()` always accepts relative dates such as "yesterday", the `DTF_SUBST` flag is ignored and only `DTF_FUTURE` is honored. This flag indicates whether weekdays are considered a date in the past or in the future.

`dat_StrDay` is ignored by this function. If a relative date given by a day of a week is to be converted, this weekday goes directly into `dat_StrDate`.

`dat_StrDate`, if it is non-`NULL`, points to a string describing the date, in the format according to `dat_Format`. If this string is not given, the output date is taken from the system date, i.e. is today's date.

`dat_StrTime`, if it is non-`NULL`, points to a human-readable string describing the time of the day. This time shall be formatted as a 24h clock, in the order hours, minutes and seconds, each separated by colon. If this pointer is `NULL`, the current system time is used.

This function returns non-zero on success, and 0 on error. It does not set `IoErr()` in case of error. Possible errors include ill-formatted input strings the function cannot interpret.

Also note that this function is patched by the *locale.library* once loaded. It adds conventions of the current locale how dates and times are supposed to be formatted. Interpretation of date and time will then follow the conventions of this library.

Chapter 4

Files

4.1 What are Files?

Files are streams of sequences of bytes that can be read from and written to, along with a file pointer that points to the next byte to be read, or the next byte to be written or overwritten. Files may have an *End-of-File position*, beyond which the file pointer can not advance when reading bytes from it.

4.2 Interactive vs. non-Interactive Files

AmigaDOS knows two types of files: *Interactive* and *non-interactive* files.

Non-interactive files are stored on some persistent data carrier; unless modified by a process, the contents of such non-interactive files does not change. They also have a defined *file size*. The file size is the number of bytes between the start of the file and the end-of-file position, or short *EOF position*. This file size does not change unless some process writes to the file, which may or may not be the same process that reads from the file.

Examples for non-interactive files are data on a disk, such as a floppy or a harddisk. Such files have a name, possibly a path within a hierarchical file system, and possibly multiple protection flags that define which type of actions can be applied to a file; such flags define whether the file can be read from, written to, and so on.

Interactive files depend on the interaction of the computer system with the outside world, and their contents can change due to such interaction. Interactive files may not define a clear end-of-file position, and an attempt to read from them or write to them may block an indefinite amount of time until triggered by an external event.

Examples for interactive files are the console, where reading from it depends on the user entering data in a console window and output corresponds to printing to the console; or the serial port, where read requests are satisfied by serial data arriving at the serial port and written bytes are transmitted out of the port. The parallel port is another example of an interactive file. Requests to read from it result in an error condition, while writing prints data on a printer connected to the port. Writing may block indefinitely if the printer runs out of paper or is turned off.

4.3 Paths and File Names

Files are identified by *paths*, which are strings from which AmigaDOS locates a process through which access to the file is managed. Such a process is called the *Handler* of the file, or, in case of files of on a data carrier, also the *File System*. AmigaDOS itself does not operate on files directly, but delegates such work to its handler.

A *path* is broken up into two parts: An optional device or volume name terminated by a colon (":"), followed by string that identifies the file within the handler identified by the first part.

The first part, if present, is interpreted by AmigaDOS itself. It relates to the name of a handler (or file system) of the given name, or a known disk volume, or a logical volume of the name within the AmigaDOS *device list*. These concepts are presented in further detail in section 8.

The second, or only part is interpreted by the handler identified by the first part.

4.3.1 Devices, Volumes and Assigns

The first part of a path, up to the colon, identifies the device, the volume or the assign a file is located in.

4.3.1.1 Devices

A *device name* identifies the handler or file system directly. Handlers are typically responsible for particular hardware units within the system, for example for the first floppy drive, or the second partition of a harddisk. For example, `df0` is the name of the handler responsible for the first floppy drive, regardless of which disk is inserted into it.

Table 4 lists all devices AmigaDOS mounts itself even without a boot volume available. They can be assumed present any time.

Table 4: System defined devices

Device Name	Description
`DF0`	First floppy drive
`PRT`	Printer
`PAR`	Parallel port
`SER`	Serial port
`CON`	Line-interactive console
`RAW`	Character based console
`PIPE`	Pipeline between processes
`RAM`	RAM-based file handler

If more than one floppy drives are connected to the system, they are named `DF1` through `DF3`. If a hard disk is present, then the device name(s) of the harddisk partitions depend on the contents of Rigid Disk Block, see **??**. These names can be selected upon installation of the harddisks, e.g. through *HDToolBox*. The general convention is to name them `DH0` and following.

The following device names have a special meaning and do not belong to a particular device:

Table 5: System defined devices

Name	Description
`*`	the console of the current process
`CONSOLE`	the console of the current process
`NIL`	the data sink

The `NIL` device is a special device without a handler that is maintained by AmigaDOS itself. Any data written into it vanishes completely, and any attempt to read data from it results in an end-of-file condition.

The `*`, if used as complete path name without a trailing colon, is the current console of the process, if such a console exists. Any data output to the file named `*` will be printed on the console. Any attempt to read from `*` will wait on the user to input data on the console, and will return such data.

> *Not a wildcard!* Unlike other operating systems, the asterisk `*` is *not* a wildcard under AmigaDOS. It rather identifies the current console of a process, or is used as escape character in AmigaDOS shell scripts .

The `CONSOLE` device is the default console of the process. Unlike `*`, but like any other device name, it shall be followed by a colon, and an optional job name. Such job names form *logical consoles* that are used by the shell for job control purposes.

> *Prefer the stars* The difference between `*` and `CONSOLE` is subtle, and the former should be preferred as it identifies the process as part of a particular shell job. An attempt to output to `CONSOLE:` may block the current process as it does not identify it properly as part of its job, but rather denotes the job started when creating the shell. Thus, in case of doubt, use the `*` without any colon if you mean the console.

Additional devices can be loaded into the system by the *Mount* command, see section 12.

4.3.1.2 Volumes

A *volume name* identifies a particular data carrier within a physical drive. For example, it may identify a particular floppy disk, regardless of the drive it is inserted it. For example, the volume name "Workbench3.2" relates always to the same floppy, regardless of whether it is inserted in the first `df0` or second `df1` drive.

4.3.1.3 Assigns

An *assign* or *logical volume* identifies a subset of a files within a file system under a unique name. Such assigns are created by the system or by the user helping to identify portions of the file system containing files that are of particular relevance for the system. For example, the assign `C` contains all commands of the boot shell, and the assign LIBS contains dynamically loadable system libraries. Such assigns can be changed or redirected, and by that the system can be instructed to take system resources from other parts of a file system, or entirely different file systems.

Assigns can be of three types: *Regular assigns*, *non-binding assigns* and *late assigns*. *Regular assigns* bind to a particular directory on a particular volume. If the *assign* is accessed, and the original volume the bound directory is not available, the system will ask to insert this particular volume, and no other volume will be accepted.

Regular assigns can also bind to multiple directories at once, in which case a particular file or directory within such a *multi-assign* is searched in all directories bound to the assign. A particular use case for this is the `FONTS` assign, containing all system-available fonts. Adding another directory to `FONTS` makes additional fonts available to the system without loosing the original ones.

Regular assigns have the drawback that the volume remains known to the system, and the corresponding volume icon will not vanish from the workbench. They also require the volume to be present at the time the assign is created.

Non-binding assigns avoid these problems by only storing the symbolic path the assign goes to; whenever the assign is accessed, any volume of the particular name containing the particular path will work. However, if this also implies that the target of the assign is not necessarily consistent, i.e. if the assign is accessed later on, another volume with different content will be accepted by the system.

Late assigns are a compromise between *regular assigns* and *non-binding assigns*. AmigaDOS initially only stores a target path for the assign, but when the assign is accessed the first time, the assign is converted to a *regular assign* and thus then binds to the particular directory of the particular volume that was inserted at the time of the first access.

Table 6 lists the assigns made by AmigaDOS automatically during bootstrap; except for the `SYS` assign, they all go to a directory of the same name on the boot volume. They are all *regular assigns*, except for `ENVARC`, which is *late assign*.

Table 6: System defined assigns

Assign Name	Description
`C`	Boot shell commands
`L`	AmigaDOS handlers and file systems
`S`	AmigaDOS Scripts
`LIBS`	AmigaOs libraries
`DEVS`	AmigaOs hardware drivers
`FONTS`	AmigaOs fonts
`ENVARC`	AmigaOs preferences (late)
`SYS`	The boot volume

In addition to the above table, the following assigns are handled by AmigaDOS internally and are not part of the *device list*, (see section 8):

Table 7: System defined assigns

Assign Name	Description
`PROGDIR`	Location of the executable

Thus, `PROGDIR` is the directory the currently executed binary was loaded from. Note that `PROGDIR` does not exist in case an executable file was not loaded from disk, probably because it was either taken from ROM or was made resident. More on resident executables is found in section **??**.

Additional assigns can become necessary for a fully operational system, though these assigns are created through the *Startup-sequence*, a particular AmigaDOS script residing in the S assign which is executed by the boot shell. Table 8 lists some of them.

Table 8: Assigns made during bootstrap

Assign Name	Description
`ENV`	Storage for active preferences and global variables
`T`	Storage for temporary files
`CLIPS`	Storage for clipboard contents
`KEYMAPS`	Keymap layouts
`PRINTERS`	Printer drivers
`REXX`	ARexx scripts
`LOCALE`	Catalogs and localization

Additional assigns can always be made with the *Assign* command, see section 12.

4.3.2 Relative and Absolute Paths

As introduced in section 4.3, a path consists either of an device, volume or assign name followed by a colon followed by a second part, or the second part alone. If a device, volume or assign name is present, such a path is said to be an *absolute path* because it identifies a location within a logical or physical volume.

If no first part is present, or if it is empty, i.e. the colon is the first part of the path, AmigaDOS uses information from the calling process to identify a suitable handler. Details on this are provided in section 10. Such a path is called a *relative path*.

This second part is forwarded to the handler and is not interpreted by the *dos.library*. It is then within the responsibility of the handler to interpret this path and locate a file within the data carrier it manages, or to configure an interface to the outside world according to this path.

In general, the *dos.library* does not impose a particular syntax on how this second part looks like. However, several support functions of AmigaDOS implicitly define conventions file systems should follow to make these support functions workable and it is therefore advisable for file system implementors to follow these conventions.

4.3.3 Maximum Path Length

The *dos.library* does not enforce a limit on the size of file or directory names, except that the total length of a path including all of its components shall not be larger than 255 characters. This is because it is converted to a BSTR within the *dos.library*. How large a component name can be is a matter of the file system itself. The *Fast File System* includes variants that limit file names to 30, 56 or 106 characters.

File systems typically do not report an error if the maximum file name is exceeded; instead, the name is clamped to the maximum size without further notice, which may lead to undesired side effects. For example, a file system may clip or remove a trailing `.info` from a workbench icon file name without ever reporting this, resulting in unexpected side effects. The *icon.library* and *workbench.library* of AmigaOs take care to avoid such file names and double check created objects for correct names.

4.3.4 Flat vs. Hiearchical File Systems

?? A flat file system organizes files as a single list of all files available on a physical data carrier. For large amounts of files, such a representation is clearly burdensome as files may be hard to find and hard to identify.

For this reason, all file systems provided by AmigaOs are *hierarchical* and organize files in nested sets of *directories*, where each directory contains files or additional directories. The topmost directory of a volume forms the *root directory* of this volume.

While AmigaDOS itself does not enforce a particular convention, all file systems included in AmigaDOS follow the convention that a path consists of a sequence of zero or more directory names separated by a forwards slash ("/"), and a final file or directory name.

4.3.4.1 Locating Files or Directories

When attempting to locate a particular file or directory, the *dos.library* first checks whether an absolute path name is present. If so, it starts from the root directory on the device, physical or logical volume identified by the device or volume name and delegates the interpretation of the path to the handler.

Otherwise, it uses the *current directory* of the calling process to locate a handler responsible for the interpretation of the path name. If this current directory is `ZERO` (see section 2.3), it uses the *default file system* of the process, which by itself, defaults to the boot file system.

The second part of the path interpretation is up to the file system identified by the first step and is performed there, outside of the *dos.library*. If the path name includes a colon (":"), then locating a file starts from the root of the inserted volume. This also includes the special case of an absent device or volume name, though a present colon, i.e. ":" represents the root directory of the volume to which the current directory belongs.

The following paragraphs describe a recommended set of operations an AmigaDOS file system should follow. A path consists of a sequence of components separated by forward slashes ("/").

To locate a file, the file system should work iteratively through the path, component by component: A single isolated "/" without a preceding component indicates the parent directory of the current directory. The parent directory of the root directory is the root directory itself.

Otherwise, a component followed by "/" instructs the handler to enter the directory of given by the component, and continue searching there.

Scanning terminates when the file system reaches the last component. The file or directory to find is then the given by the last component reached during the scan.

As scanning through directories starts with the current directory and stops when the end of the path has been reached, the empty string indicates the current directory.

> *No Dots Here* Unlike other operating systems, AmigaDOS does not use "." and ".." to indicate the current directory or the parent directory. Rather, the current directory is represented by the empty string, and the parent directory is represented by an isolated forwards slash without a preceding component.

Thus, for example, ":S" is a file or directory named "S" in the root directory of the current directory of the process, and "//Top/Hi" is a file or directory named "Hi" two directories up from the current directory, in a directory named "Top".

4.3.5 Case Sensitivity

The *dos.library* does not define whether file names are case-sensitive or insensitive, except for the device or volume name which is case-insensitive. Most if not all AmigaDOS file-systems are also case-insensitive, or rather should. Some variants of the *Fast File System* do not handle case-insensitive comparisons correctly on non-ASCII characters, i.e. ISO-Latin code points whose most-significant bit is set, see section **??** for details. These variants should be avoided and the "international" variants should be preferred.

4.4 Opening Files

To read data from or write data to a file, it first needs to be opened by the `Open()` function:

```
file = Open( name, accessMode )
D0           D1    D2

BPTR Open(STRPTR, LONG)
```

The `name` argument is the *path* the file to be opened, which is interpreted according to the rules given in section 4.3. The argument `accessMode` identifies how the file is opened. The function returns a `BPTR` to a *file handle* on success, or `ZERO` on failure. A secondary return code can be retrieved from `IoErr()` described in section **??**. It is 0 on success, or an error code from `dos/dos.h` in case opening the file failed.

The access mode shall be one of the following, defined in `dos/dos.h`:

Table 9: Access Modes for Opening Files

Access Name	Description
MODE_OLDFILE	Shared access to existing files
MODE_READWRITE	Shared access to new or existing files
MODE_NEWFILE	Exclusive access to new files

> *Length Limited* As this function needs to convert the path argument from a C string to a BSTR, path names longer than 255 characters are not supported and results are unpredictable if such names are passed into Open(). If such long path names cannot be avoided, it is the responsibility of the caller to split the path name accordingly and potentially walk through the directories manually if necessary. Note that this strategy may not be suitable for interactive files or handlers that follow conventions for the path name that are different from the conventions described in section 4.3.4.1.

The access mode `MODE_OLDFILE` attempts to find an existing file. If the file does not exist, the function fails. If the file exists, it can be read from or written from, though simultaneous access from multiple processes is possible and does not create an error condition. If multiple processes write to the same file simultaneously, the result is undefined and no particular order of the write operations is imposed.

The access mode MODE_READWRITE first attempts to find an existing file, but if the file does not exist, it will be created under the name given by the last component of the path. The function does not attempt to create directories within the path if they do not access. Once the file is opened, access to the file is shared, even if it has been just created. That is, multiple processes may then access it for reading or writing. If multiple processes write to the file simultenously, the order in which the writes are served is undefined and depends on the scheduling of the processes.

The access mode MODE_NEWFILE creates a new file, potentially erasing an already existing file of the same name if it already exists. The function does not attempt to create directories within the path if they do not exist. Access to the file is exclusive, that is, any attempt to access the file from a second process fails with an error condition.

> *No Wildcards* The Open() function, similar to most *dos.library* functions, does not attempt to resolve wild cards. That is, any character potentially reassembling a wild card, such as "?" or "#" will taken as a literal and will be used as part of the file name. While these characters are valid, they should be avoided as they make such files hard to access from the Shell.

4.5 Closing Files

The Close() function writes all internally buffered data to disk and makes an exclusively opened file accessible to other processes again.

```
success = Close( file )
D0               D1

BOOL Close(BPTR)
```

The file is a BPTR to a *FileHandle* identifying the file. The return code indicates whether the file system could successfully close the file and write back any data. If the result code is DOSFALSE, an error code can be obtained through IoErr() described in section **??**. Otherwise, IoErr() will not be altered.

Unfortunately, not much can be done if closing a file fails and no general advise is possible how to handle this situation.

Attempting to close the ZERO file handle returns success immediately.

4.6 Types of Files and Handlers

As introduced in 4.2, AmigaDOS distinguishes between non-interactive files managed by file systems and interactive files that interact with the outside world. Typically, *file systems* create non-interactive files; all other *handlers* create interactive or non-interactive files, depending on the nature of the handler.

4.6.1 Obtaining the Type from a File

A file can be either interactive, in which case attempts to read or write data to the file may block indefinitely, or non-interactive where the amount of available data is determined by file itself. The IsInteractive() function returns the nature of an already opened file.

```
status = IsInteractive( file )
 D0                      D1

BOOL IsInteractive(BPTR)
```

The `IsInteractive()` function returns `TRUE` in case the *file handle* passed in is interactive, or `FALSE` in case it corresponds to a non-interactive stream of bytes, potentially on a file system. This function cannot fail and does not alter `IoErr()`.

4.6.2 Obtaining the Type from a Path

A *handler* that manages physical data carriers and allows to access named files on such data carriers is a *file system*. The `IsFileSystem()` function determines the nature of a handler given a path (see 4.3) to a candidate handler.

```
result = IsFileSystem(name)
D0                    D1

BOOL IsFileSystem(STRPTR)
```

The `name` argument is a path that does not need to identify a physically existing object. Instead, it is used to identify a handler that would be responsible to such a hypothetical object regardless whether it exists or not.

It is of advisable to provide a path that identifies the handler uniquely, i.e. a string that is terminated by a colon (":"). Otherwise, the call checks whether the *handler* responsible for the current directory of the calling process is a file system.

The returned result is `DOSTRUE` in case the handler identified by the path is a file system, and as such allows access to multiple files on a physical data carrier and examining directories. Otherwise, it returns `DOSFALSE`.

4.7 Unbuffered Input and Output

The functions described in this section read bytes from or write bytes to already opened files. These functions are *unbuffered*, that is, any request goes directly to the handler. Since a request performs necessarily a task switch from the caller to the handler managing the file, these functions are inefficient on small amounts of data and should be avoided. Instead, files should be read or written in larger chunks, either by buffering data manually, or by using the buffered I/O functions described in section **??**.

4.7.1 Reading Data

The following function reads data from an opened file by directly invoking the handler for performing the read:

```
actualLength = Read( file, buffer, length )
D0                   D1    D2      D3

LONG Read(BPTR, void *, LONG)
```

The `Read()` function reads `length` bytes from an opened file identified by the *file handle* `file` into the buffer pointed to by `buffer`. The buffer is a standard C pointer, not a BPTR.

The return code `actualLength` is the amount of bytes actually read, or -1 for an error condition. A secondary return code can be retrieved from `IoErr()` described in section **??**. It is 0 on success, or an error code from `dos/dos.h` in case reading failed.

The amount of data read may be less data than requested by the `length` argument, either because the *EOF* position has been reached (see section 4.2) for non-interactive files, or because the interactive source is depleted. Note that for interactive files, the function may block indefinitely until data becomes available.

4.7.2 Testing for Availability of Data

An issue of the `Read`function is that it may block indefinitely on an interactive file if the user does not enter any data. The `WaitForChar()` tests for the availability of a character on an interactive file for limited amount of time and returns if no data becomes available.

```
status = WaitForChar( file, timeout )
  D0                    D1    D2

BOOL WaitForChar(BPTR, LONG)
```

This function waits for a maximum of `timeout` microseconds for the availability of input on `file`. If data is already available, or becomes available within this time, the function returns `DOSTRUE`. Otherwise, the function returns `DOSFALSE`.

A secondary return code can be obtained from `IoErr()`. If it is 0, the handler was able check the availability of a byte from the given file. Otherwise, an error code from `dos/dos.h` indicates failure of the function.

This function requires an interactive file to operate, file systems will typically not implement this function as they do not block.

4.7.3 Writing Data

The following call writes an array of bytes unbuffered to a file, interacting directly with the corresponding handler:

```
returnedLength =  Write( file, buffer, length )
 D0                        D1    D2      D3

LONG Write (BPTR, void *, LONG)
```

The Write function writes `length` bytes in the buffer pointed to by `buffer` to the *file handle* given by the `file` argument. On success, it returns the number of bytes written as `returnedLength`, and advances the file pointer of the file by this amount. Note that this amount of bytes may even be 0 in case the file cannot absorb any more bytes. On error, -1 is returned.

A secondary return code can be retrieved from `IoErr()` described in section **??**. It is 0 on success, or an error code from `dos/dos.h` in case writing failed.

For interactive files, this function may block indefinitely until the corresponding handler is able to take additional data.

4.7.4 Adjusting the File Pointer

The `Seek()` adjusts the file pointer of a non-interactive file such that subsequent reading or writing is performed from an alternative position of the file.

```
oldPosition = Seek( file, position, mode )
 D0                  D1    D2        D3

LONG Seek(BPTR, LONG, LONG)
```

This function adjusts the file pointer of `file` relative to the position determined by `mode` by `position` bytes. The value of `mode` shall be one of the following options, defined in `dos/dos.h`:

Table 10: Seek Modes

Mode Name	Description
OFFSET_BEGINNING	Seek relative to the start of the file
OFFSET_CURRENT	Seek relative to the current file position
OFFSET_END	Seek relative to the end of the file

> *Undefined on Interactive Files* The Seek function will typically indicate failure if applied to interactive files. Some handlers may assign this function, however, a particular meaning. See the handler definition for details.

If mode is OFFSET_BEGINNING, then the new file pointer is placed position bytes from the start of the file, i.e. the new file pointer is equal to position.

If mode is OFFSET_CURRENT, then position is added to the file pointer. That is, the file pointer is advanced if position is positive, or rewinded if position is negative.

If mode is OFFSET_END, then the end-of-file position is determined, and position is added to this position. This, in particular, requires that position should be negative.

The Seek() function returns the file pointer before its adjustment, or -1 in case of an error.

A secondary return code can be retrieved from IoErr() described in section **??**. It is 0 on success, or an error code from dos/dos.h in case adjusting the file pointer failed.

> *Not 64bit safe* Unfortunately, it is not quite clear how Seek operates on files that are larger than 2GB, and it is file system dependent how such files could be handled. OFFSET_BEGINNING can probably only reach the first 2GB of a larger file as the file system may interpret negative values as an attempt to reach a file position upfront the start of the file and may return an error. Similarly, OFFSET_END may possibly only reach the last 2GB of the file. Any other position within the file may be reached by splitting the seek into chunks of at most 2GB and perform multiple OFFSET_CURRENT seeks. However, whether such a strategy succeeds is pretty much file system dependent. Note in particular that the return code of the function does not allow to distinguish between a file pointer just below the 4GB barrier and an error condition. A zero result code of IoErr() should be then used to learn whether a result of -1 indicates a file position of 0xffffffff instead. Most AmigaDOS file systems may not be able to handle files larger than 2GB.

Even though Seek() is an unbuffered function, it is aware of a buffer and implicitly flushes the file system internal buffer. That is, it can be safely used by buffered and unbuffered functions.

4.7.5 Setting the Size of a File

The SetFileSize() function truncates or extends the size of an opened file to a given size. Not all handlers support this function.

```
newsize = SetFileSize(fh, offset, mode)
D0                    D1      D2     D3

LONG SetFileSize(BPTR, LONG, LONG)
```

This function extends or truncates the size of the file identified by the *file handle* fh; the target size is determined by the current file pointer, offset and the mode. Interpretation of mode and offset is similar to Seek(), except that the end-of-file position of the file is adjusted, and not the file pointer.

The mode shall be selected from to table 10. In particular, it is interpreted as follows:

If `mode` is `OFFSET_BEGINNING`, then the file size is set to the value of `offset`, irrespectible of the current file pointer.

If `mode` is `OFFSET_CURRENT`, then the new end-of-file position is set `offset` bytes relative to the current file pointer. That is, the file is truncated if `offset` is negative, and extended if `offset` is positive.

If `mode` is `OFFSET_END`, the new file size is given by the current file size plus `offset`. That is, the file is extended by `offset` bytes if positive, or truncated otherwise. The value of the current file pointer is irrelevant and ignored.

If the current file pointer of any *file handle* opened on the same file is, after a potential truncation, beyond the new end-of-file, it is clamped to the end-of-file. They remain unchanged otherwise.

If the file is enlarged, the values within the file beyond the previous end-of-file position are undetermined.

The return value `newsize` is the size of the file after the adjustment, i.e. the position of the end-of-file location.

> *Not 64bit safe* Similar to `Seek()`, `SetFileSize()` cannot be assumed to work properly if the (old or new) file size is larger than 2GB. What exactly happens if an attempt is made to adjust the file by more than 2GB depends on the file system performing the operation. A possible strategy to adjust the file size to a value above 2GB is to first seek to the closest position, potentially using multiple seeks of maximal size, and then perform one or multiple calls to `SetFileSize()` with the `mode` set to `OFFSET_CURRENT`. However, whether this strategy succeeds is file system dependent.

4.8 Buffered Input and Output

AmigaDOS also offers buffered input and output functions that stores data in an intermediate buffer. AmigaDOS then transfers data only in larger chunks between the buffer and the handler, minimizing the task switching overhead and offering better performance if data is to be read or written in smaller units.

> *Performance Improved* While buffered I/O functions of AmigaOs 3.1.4 and below were designed around single-byte functions and thus caused massive overhead in the buffered functions described in this section, the functions in this section were redesigned in AmigaOs 3.2 and now offer significantly better performance. Unfortunately, the default buffer size AmigaDOS uses is quite small and should be significantly increased by `SetVBuf()`. A suggested buffer size is 4096 bytes which corresponds to a disk block of modern hard drives.

4.8.1 Buffered Read From a File

The `FRead()` function reads multiple equally-sized records from a file through a buffer, and returns the number of records retrieved.

```
count = FRead(fh, buf, blocklen, blocks)
 D0           D1  D2   D3        D4

LONG FRead(BPTR, STRPTR, ULONG, ULONG)
```

This function reads `blocks` records each of `blocklen` bytes from the file `fh` into the buffer `buf`. It returns the number of complete records retrieved from the file. If the file runs out of data, the last record may be incomplete.

From AmigaOs 3.2 onwards, `FRead()` first attempts to satisfy the request from the file handle internal buffer, but if the number of remaining bytes is larger than the buffer size, the handler will be invoked directly for "bursting" the data into the target buffer, bypassing the file buffer.

This function does not modify `IoErr()` in case the request can be satisfied completely from the file handle buffer. It neither returns -1 in case of an error. Callers should instead use `SetIoErr(0)` to clear the error state before calling this function, and then use `IoErr()` to learn if any error occurred if the number of records read is smaller than the number of records requested.

4.8.2 Buffered Write to a File

The `FWrite()` function writes multiple equally-sized records to a file through a buffer, and returns the number of records it could write.

```
count = FWrite(fh, buf, blocklen, blocks)
D0             D1  D2   D3        D4

LONG FWrite(BPTR, STRPTR, ULONG, ULONG)
```

This function write `blocks` records each of `blocklen` bytes from the buffer `buf` to the file `fh`. It returns the number of complete records written to the file. On an error, the last record written may be incomplete.

From AmigaOs 3.2 onwards, `FWrite()` first checks whether the file handle internal buffer is partially filled. If so, the file handle internal buffer is filled from `buf`. If any bytes remain to be written, and the number of bytes is larger than the internal buffer size, the handler will be invoked to write the data in a single block, bypassing the buffer. Otherwise, the data will be copied to the internal buffer.

This function does not modify `IoErr()` in case the request can be satisfied completely by using the file handle buffer. It neither returns -1 in case of an error. Callers should instead use `SetIoErr(0)` to clear the error state before calling this function, and then use `IoErr()` to learn if any error occurred if the number of records written is smaller than the number of records passed in.

4.8.3 Buffered Write to the Output Stream

The `WriteChars()` writes an array of bytes buffered to the output stream.

```
count = WriteChars(buf, buflen)
D0                 D1   D2

LONG WriteChars(STRPTR, LONG)
```

This function is equivalent to `FWrite(Output(),buf,1,buflen)`, that is, the bytes in the buffer `buf` of size `buflen` is writing to the output stream, and the number of characters written is returned. Therefore, this function has similar quirks concerning error reporting as `FWrite()`: It does not set `IoErr()` consistently, namely only when the buffer is written to the stream. It neither returns -1 on an error. It is therefore recommended to reset the error upfront with `SetIoErr(0)`.

4.8.4 Adjusting the Buffer

The `SetVBuf()` function allows to adjust the internal buffer size for buffered input/output functions such as `FRead()` or `FWrite()`. It also sets the buffer mode. The default buffer size is 204 characters, which is too low for many applications.

```
error = SetVBuf(fh, buff, type, size)
D0              D1   D2    D3    D4

LONG SetVBuf(BPTR, STRPTR, LONG, LONG)
```

This function sets the internal buffer of the *file handle* `fh` to `size` bytes. Sizes smaller than 204 characters will be rounded up to 204. If `buff` is non-`NULL`, it is a pointer to a user-provided buffer that will be used for buffering. This buffer shall be aligned to a 32-bit boundary. A user provided buffer will not be released when the file is closed.

Otherwise, if `buff` is `NULL` AmigaDOS will allocate the buffer for you, and will also release it when the file is closed.

The `type` argument identifies the type of buffering according to Table 11; the modes there are defined in the include file `dos/stdio.h`.

Table 11: Buffer Modes

Buffer Name	Description
`BUF_LINE`	Buffer up to end of line
`BUF_FULL`	Buffer everything
`BUF_NONE`	No buffering

The buffer mode `BUF_LINE` automatically flushes the buffer when writing a line feed (0x0a), carriage return (0x0c) or ASCII NUL (0x00) character to the buffer, and the target file is interactive. Otherwise, the characters remain in the buffer until it either overflows or is flushed manually, see `Flush()`.

The buffer mode `BUF_FULL` buffers all characters until the buffer either overflows or is flushed.

The buffer mode `BUF_NONE` effectively disables the buffer and writes all characters to the target file immediately.

On reading, `BUF_LINE` and `BUF_FULL` are equivalent and fill the entire buffer from the file; `BUF_NONE` disables buffering.

The function returns non-zero on success, or 0 on error. Error conditions are either out-of-memory, an invalid buffer mode or an invalid file handle. Unfortunately, `IoErr()` is only set on an out-of-memory condition and remains otherwise unchanged.

4.8.5 Synchronize the File to the Buffer

The `Flush()` function flushes the internal buffer of a *file handle* and synchronizes the file pointer to the buffer position.

```
success = Flush(fh)
D0              D1

LONG Flush(BPTR)
```

Synchronizes the file pointer to the buffer, that is, if bytes were written to the buffer, writes out buffer content to file. If bytes were read from the file and non-read files remained in the buffer, such bytes are dropped and the function attempts to seek back to the position of the last read byte. This can fail for interactive files.

The return code is currently always `DOSTRUE` and thus cannot be used as an indication of error, even if not all bytes could be written, or if seeking failed. If error detection is desired, the caller should first use `SetIoErr(0)` to erase an error condition, then call flush, and then use `IoErr()` to check whether an error occurred.

Flush when switching between reading and writing The `Flush()` function shall be called when switching from writing to a file to reading from the same file, or vice versa. The internal buffer logic is unfortunately not capable to handle this case correctly. Also, `Flush()` shall be called when switching from buffered to unbuffered input/output.

4.8.6 Write a Character Buffered to a File

The `FPutC()` function writes a single character to a file, using the *file handle* internal buffer.

```
char = FPutC(fh, char)
D0             D1   D2

LONG FPutC(BPTR, LONG)
```

This function writes the single character `char` to the *file handle* `fh`. Depending on the buffer mode, the character and the type of file, the character may go to the buffer first, or may cause the buffer to be emptied. See `SetVBuf()` for details on buffer modes and conditions for implicit buffer flushes.

It returns the character written, or `ENDSTREAMCH` on an error. The latter constant is defined in `dos/stdio.h` and equals to -1.

This function does not touch `IoErr()` if the character only goes into the internal buffer.

4.8.7 Write a String Buffered to a File

The `FPuts()` function writes a `NUL`-terminated string to a file, using the *file handle* internal buffer.

```
error = FPuts(fh, str)
D0              D1  D2

LONG FPuts(BPTR, STRPTR)
```

This function writes the NUL-terminated (C-style) string `str` to the *file handle* `fh`. The terminating `NUL` character is not written.

Depending on the buffer mode, the string will first go into the buffer, or may be written out immediately. See `SetVBuf()` for details on buffer modes and conditions for implicit buffer flushes.

This function returns 0 on success, or `ENDSTREAMCH` on an error. The latter constant is defined in `dos/stdio.h` and equals to -1. The error code `IoErr()` is only adjusted when the buffer is flushed.

4.8.8 Write a String Buffered to the Output Stream

The `PutStr()` function writes a `NUL`-terminated string to the output. No newline is appended.

```
error = PutStr(str)
D0               D1

LONG PutStr(STRPTR)
```

This function is equivalent to `FPuts(Output(),str)`, that is, it writes the `NUL`-terminated string pointed to by `str` to the output. It returns 0 on success and -1 on error. The `IoErr()` is only adjusted when the buffer of the `Output()` *FileHandle* is flushed. When this happens depends on the buffer mode installed by `SetVBuf()`.

4.8.9 Read a Character from a File

The `FGetC()` function reads a single character from a file through the internal buffer of the *file handle*.

```
char = FGetC(fh)
D0           D1

LONG FGetC(BPTR)
```

This function attempts to read a single character from the *file handle* `fh` using the buffer of the handle. If characters are present in the buffer, the request is satisfied from the buffer first, then the function attempts to refill the buffer from the file and tries again.

The function returns the character read, or `ENDSTREAMCH` on an end-of-file condition or an error. The latter constant is defined in `dos/stdio.h` and equals to -1.

To distinguish between the error and the end-of-file case, the caller should first reset the error condition with `SetIoErr(0)`, and then check `IoErr()` when the function returns with `ENDSTREAMCH`.

4.8.10 Read a Line from a File

The `FGets()` function reads a newline-terminated string from a file, using the *file handle* internal buffer.

```
buffer = FGets(fh, buf, len)
D0             D1  D2   D3

STRPTR FGets(BPTR, STRPTR, ULONG)
```

This function reads a line from the *file handle* into the buffer pointed to by `buf`, capable of holding `len` characters.

Reading terminates either if `len`-1 characters have been read, filling up the buffer completely; or a line-feed character is found, which is copied into the buffer; or if an end-of-file condition or an error condition is encountered. In either event, the string is `NUL` terminated.

The function returns `NULL` in case not even a single character could be read. Otherwise, the function returns the buffer passed in.

To distinguish between the error and end-of-file condition, the caller should first use `SetIoErr(0)`, and then test `IoErr()` in case the function returns `NULL`.

4.8.11 Revert a Single Byte Read

The `UnGetC()` function reverts a single byte read from a stream and makes this byte available for reading again.

```
value = UnGetC(fh, ch)
D0             D1  D2

LONG UnGetC(BPTR, LONG)
```

The character `ch` is pushed back into the *file handle* `fh` such that the next attempt to read a character from `fh` returns `ch`. If `ch` is -1, the last character read will be pushed back. If the last read operation indicated an error or end-of-file condition, `UnGetC(fh,-1)` pushes an end-of-file condition back.

This function returns non-zero on success or 0 if the character could not be pushed back. At most a single character can be pushed back after each read operation, an attempt to push back more characters can fail.

4.9 File Handle Documentation

So far, the *file handle* has been used as an opaque value bare any meaning. However, the BPTR, once converted to a regular pointer, is a pointer to FileHandle structure:

```
BPTR file = Open("S:Startup-Sequence,MODE_OLDFILE);
struct FileHandle *fh = BADDR(file);
```

In the following sections, this structure and its functions are documented.

4.9.1 The struct FileHandle

When opening a file via Open(), the *file handle* is allocated by the *dos.library* by going through AllocDosObject(), and then forwarded to the file system or handler for second-level initialization. It is documented in dos/dosextens.h as replicated here:

```
struct FileHandle {
   struct Message *fh_Link;
   struct MsgPort *fh_Port;
   struct MsgPort *fh_Type;
   BPTR fh_Buf;
   LONG fh_Pos;
   LONG fh_End;
   LONG fh_Funcs;
#define fh_Func1 fh_Funcs
   LONG fh_Func2;
   LONG fh_Func3;
   LONG fh_Args;
#define fh_Arg1 fh_Args
   LONG fh_Arg2;
};
```

fh_Link is actually not a pointer, but an AmigaDOS internal value that shall not be interpreted or touched, and of which one cannot make productive use.

fh_Port is similarly not a pointer, but a LONG. If it is non-zero, the file is interactive, otherwise it is a file system. IsInteractive() makes use of this member. The file system or handler shall initialize this value when opening a file and shall initialize it according to the nature of the handler.

fh_Type points to the MsgPort of the handler or file system that implements all input and output operations. Section **??** provides additional information on how handlers and file systems work. If this pointer is NULL, no handler is associated to the file handle. This is also the value AmigaDOS will deposit here when opening a file to the NIL: (pseudo-)device. Attempting to Read() from this handle results in an end-of-file situation, and calling Write() on such a handle does nothing, ignoring any data written.

fh_Buf is a BPTR to the file handle internal buffer all buffered I/O function documented in this section use.

fh_Pos is the next read or write position within this buffer.

fh_End is the size of the buffer in bytes.

fh_Func1 is a function pointer that is called whenever the buffer is to be filled through the handler. Users shall not call this function itself, and the function prototype is intentionally not documented.

fh_Func2 is a second function pointer that is called whenever the buffer is full and is to be written by the handler. Users shall not call this function itself, and the function prototype is intentionally undocumented.

`fh_Func3` is a final function pointer that is called whenever the file handle is closed. This function then potentially writes the buffer content out when dirty, releases the buffer if it is system-allocated, and finally forwards the close request to the handler.

`fh_Arg1` is a file-system internal value the handler or file system uses to identify the file. The interpretation of this value is to the file system or handler, and the *dos.library* does not attempt to interpret it. The handler deposits the file identification here when opening a file, and the *dos.library* forwards it to the handler on `Read()` and `Write()`. See section **??** for details.

`fh_Arg2` is currently unused.

4.9.2 String Streams

It is sometimes useful to provide programs with (temporary) input not coming from a file system or handler directly, even though the program uses a file interface to access it. One solution to this problem is to deposit the input data on the `RAM` disk, then opening this file and providing it as input to such a program. The drawback of this approach is that additional tests are necessary to ensure that the file name is unique, and to avoid that other than the intended program accesses it.

AmigaDOS uses the technique documented here itself, for example to provide the command to be executed by the `Run` command. There, the string stream contains the command to be run in background, which is then provided as input file to the shell. The `System()` function of the *dos.library* makes use of the same trick to feed the command to be executed as input file. Thus, even though the shell can only execute commands from a file, AmigaDOS can generate *file handles* that do not correspond to a handler, but to a string in memory containing the commands.

The shell itself is using the same technique to pass arguments to the commands it executes; it deposits the command arguments in the file handle buffer of the input stream where `ReadArgs()` collects them.

The idea is to allocate a `struct FileHandle` and initialize its buffer to contain the string within the file. For this `fh->Buf` needs to point to the buffer containing the string, and `fh->End` needs to be its size. The function pointers in the *file handle* remain 0 such as to avoid that the *dos.library* reads, writes or flushes the buffer. The `FileHandle` shall be allocated by `AllocVec()` as the *dos.library* releases the handle through `FreeVec()`.

The following program demonstrates this technique:

```
#include <exec/memory.h>
#include <dos/dos.h>
#include <dos/stdio.h>
#include <string.h>
#include <proto/dos.h>
#include <proto/exec.h>

int main(int argc,char **argv)
{
  const char *test = "Hello World!\n";
  const int len = strlen(test)+1;
  struct FileHandle *fh;
  BPTR file;

  fh   = AllocVec(sizeof(struct FileHandle) + len,MEMF_PUBLIC|MEMF_CLEAR);
  if (fh) {
    UBYTE *c = (UBYTE *)(fh + 1);
    file     = MKBADDR(fh);
    memcpy(c,test,len);
```

```
    fh->fh_Buf = MKBADDR(c);
    fh->fh_End = len;
    {
      BPTR out = Output();
      LONG ch;
      while((ch = FGetC(file)) >= 0) {
        FPutC(out,ch);
      }
    }
    Close(file);
  }
  return 0;
}
```

Here the buffer is allocated along with the file handle, and thus released along with it. Setting `MEMF_PUBLIC` is of utter importance as it clears all function pointers, and in particular the `fh_Link` field to zero; the latter is an indication to the *dos.library* that this structure was not allocated through itself.

4.9.3 An FSkip() Implementation

Unlike most unbuffered functions, `Seek()` can be safely mixed with buffered input and output functions. However, this function is not very efficient, and seeking should be avoided if buffer manipulation is sufficient. Buffer manipulation has the advantage that small amounts of bytes can be skipped easily without going through the file system; skipping over larger amounts of bytes can be performed by a single function without requiring to read bytes.

The following function implements an `FSkip()` function that selects the most viable option and is more efficient that `Seek()` for buffered reads.

```
LONG FSkip(BPTR file,LONG skip)
{
  LONG res;
  struct FileHandle *fh = BADDR(file);
  if (fh->fh_Pos >= 0 && fh->fh_End > 0 && fh->fh_Func3) {
    LONG newpos = fh->fh_Pos + skip;
    if (newpos >= 0 && newpos < fh->fh_End) {
      fh->fh_Pos = newpos;
      return DOSTRUE;
    }
  }
  skip += fh->fh_Pos - fh->fh_End;
  fh->fh_Pos = -1;
  fh->fh_End = -1;
  if (Seek(fh,skip,OFFSET_CURRENT) != -1)
   return DOSTRUE;
  return DOSFALSE;
}
```

The first if-condition checks whether the buffer is actually present. Then, the new buffer position is computed. If it is within the buffer, the new buffer position is installed as the work is done.

Otherwise, the skip distance is adjusted by the buffer position. Initializing the buffer size and position to -1 ensures that the following `Seek()` does not attempt to call `Flush()` internally.

There is one particular catch, namely that the `file` needs to be initialized for reading immediately after opening the file, or the buffer will not be in the right state for the trick:

```
BPTR file = Open(filename,MODE_OLDFILE);
UnGetC(file,-1); /* initialize buffer */
```

This is only necessary if the first access to the file is an `FSkip()`.

4.9.4 An FGet() Implementation

While the `FRead()` function already provides a buffered read function, it is not very efficient prior release 47 of AmigaDOS. The following simple function provides in such cases a faster implementation that even allows inlining:

```
LONG FGet(BPTR f,void *buf,LONG size)
{
  struct FileHandle *cis = BADDR(f);

  if (cis->fh_Pos) {
    LONG end = cis->fh_Pos + size;
    if (end < cis->fh_End) {
      memcpy(buf,(UBYTE *)BADDR(cis->fh_Buf) + cis->fh_Pos,(size_t)(size));
      cis->fh_Pos = end;
      return size;
    }
  }

  return FRead(f,buf,1,size);
}
```

It reads `size` bytes from the file `fh` into the buffer `buf`, and returns the number of bytes read.

As seen from this implementation, the function attempts to satisfy the read if a partial buffer is present. If not, the above implementation runs into the operating system function. As for the `FSkip()` implementation presented in section 4.9.3, the file handle requires some preparation by a dummy `UnGetC()`, see there.

4.10 Formatted Output

The functions in this section print strings formatted to a file. Both files use the internal buffer of the *file handle*.

4.10.1 Print Formatted String using C-Syntax to a File

The `VFPrintf()` function prints multiple datatypes using a format string that closely reessembles the syntax of the C syntax. `FPrintf()` is based on the same entry point of the *dos.library*, though the prototype for the C language is different and thus arguments are expected directly as function arguments instead of requiring them to be collected in an array upfront.

```
count = VFPrintf(fh, fmt, argv)
D0               D1  D2   D3

LONG VFPrintf(BPTR, STRPTR, LONG *)
```

```
count = FPrintf(fh, fmt, ...)

LONG FPrintf(BPTR, STRPTR, ...)
```

This function uses the `fmt` string to format an array of arguments pointed to by `argv` and outputs the result to the file `fh`. The syntax of the format string is identical to that of the exec function `RawDoFmt()`, and shares its problems. In particular, format strings indicating integer arguments such as `%d` and `%u` assume 16bit integers, independent of the integer model of the compiler. On compilers working with a 32bit integer models, the format modifier `l` should be used, e.g. `%ld` for signed and `%lu` for unsigned integers.

As `RawDoFmt()` is also patched by the *locale.library*, additional syntax elements from the `FormatString()` function of this library become available for `VFPrintf()` and `FPrintf()`.

The result `count` delivers the number of characters written to the file, or -1 for an error. In the latter case, `IoErr` provides an error code.

4.10.2 BCPL Style Formatted Print to a File

The `VFWritef()` function formats several arguments according to a format string similar to `VFPrintf()`, but uses the formatting syntax of the BCPL language. The main purpose of this function is to offer formatted output for legacy BCPL programs where this function appears as an entry of the BCPL *Global Vector*. New code should not use this function but rather depend on `VFPrintf()` which also gets enhanced by the *locale.library*.

The `FWritef()` uses the same entry point of the *dos.library*, though the compiler prototype imposes a different calling syntax where the objects to be formatted are directly delivered as function arguments rather requiring the caller to collect them in an array upfront.

```
count = VFWritef(fh, fmt, argv)
D0                D1  D2   D3

LONG VFWritef(BPTR, STRPTR, LONG *)

count = FWritef(fh, fmt, ...)

LONG FWritef(BPTR, STRPTR, ...)
```

This function formats the arguments from the array pointed to by `argv` according to the format string in `fmt` and writes the output to the file `fh`. The format string follows the syntax of the BCPL language. The following format identifiers are supported:

- `%S` Write a `NUL` terminated string from the array to the output.
- `%Tx` Writes a `NUL` terminated string left justified in a field whose width is given by the character `x`. The length indicator is always a single character; a digit from `0` to `9` indicates the field widths from 0 to 9 directly. Characters `A` to `Z` indicate field widths from 10 onwards.
- `%C` Writes a single character whose ISO-Latin-1 code is given as a 32-bit integer on the `argv` array.
- `%Ox` Writes an integer in octal to the output where `x` indicates the maximal field width. The field width is a single character that is encoded similarly to the `%T` format string.
- `%Xx` Writes an integer in hexadecimal to the output in a field that is at most `x` characters long. `x` is a single character and encodes the width similar to that `%T` format string.
- `%Ix` Writes a (signed) integer in decimal to the output in field that is at most `x` characters long. The field length is again indicated by a single character.

%N Writes a (signed) integer in decimal to the output without any length limitation.

%Ux Writes an unsigned integer in decimal to the output, limiting the field length to at most x characters, where x is encoded in a single character.

%$ Ignores the next argument, i.e. skips over it.

This function is *not* patched by the *locale.library* and therefore is not localized or enhanced.

While the same function can also be found in the BPCL *Global Vector*, it there takes BSTRs instead of regular C strings for the format string and arguments of the %S and %T formats.

4.10.3 Setting the Console Buffer Mode

The SetMode() function sets the behaviour of a handler. It is typically used in conjunction with the graphical or serial console, i.e. the CON-Handler and the AUX-Handler, and there sets the input buffer mode of the console. Depending on this mode, the console either waits for an entire line to be completed to satisfy an input, or provides each individual key as input to programs, or provides a line buffer with the exception of some special control keys that are transmitted immediately.

```
success = SetMode(fh, mode)
D0                D1  D2

BOOL SetMode(BPTR, LONG)
```

This function sets the mode of the handler addressed by the *FileHandle* fh to the mode provided as second argument. The meaning of the modes is specific to the handler; however, this function is typically used in conjunction with both consoles provided by the system, the graphical console of the CON: and RAW: device, and the serial console corresponding to the AUX: device. All three devices are, actually, implemented by the CON-Handler, while the AUX-Handler is just a simple wedge to the first for historical reasons.

For the console(s), the interpretation of the mode argument is as follows:

Table 12: Console Modes

Buffer Mode	Description
0	Cooked mode
1	Raw mode
2	Medium mode
All other values	Reserved for future use

In the *cooked mode*, the console buffers entire lines, provides line-editing features, but only makes the input data available when the user terminates the input with the RETURN key. The CON: and AUX: devices operate by default in this mode, but can be switched to any other buffer mode with this function.

In the *raw mode*, every single keystroke is made available immediately, including control sequences corresponding to all cursor and function keys. That implies, however, that line editing is not available and pressed keys are not echoed on the console, but rather transmitted directly. If echoing is desired, it needs to be performed manually by the application. This mode corresponds to the RAW: device which is nothing but a console operating in this mode by default.

In the *medium mode*, the console also buffers lines, but some keystrokes are directly transmitted without requiring the user to press the RETURN key. In specific, key-combinations of the up- and down cursor keys and the TAB key are reported immediately to the caller through control sequences. The Amiga Shell uses this mode to offer a history and provides through it TAB expansion of commands and command line arguments. No device name corresponds to this mode; instead, the Shell switches a regular CON: window to this mode in order to offer additional services. Section 12.13 provides details.

Both the CON-Handler and the AUX-Handler implement this function, supporting all three modes. However, there is — unless explicitly mounted by the user — no device name that corresponds to the *medium mode* and no device name that corresponds to an `AUX:` console in the *raw mode*.

4.11 Record Locking

While locks control access to a *file system* object in total, record locks provide access control on portions of a file. Unlike locks, however, the *file system* does not block read or write access to the locked region. Instead, a record lock on a portion of a file only prevents another record lock on a region that overlaps with the locked region. Record locks therefore require the locking processes to follow the same locking protocol.

Record locks are a relatively modern protocol not all file systems implement. The Ram-Handler and the Fast File System support it.

4.11.1 Locking a Portion of a File

The `LockRecord` function locks a single region of a file, potentially waiting for a timeout for the region to become available.

```
success = LockRecord(fh,offset,length,mode,timeout)
D0                   D1  D2     D3    D4   D5

BOOL LockRecord(BPTR,ULONG,ULONG,ULONG,ULONG)
```

This function attempts to lock the region of the file identified by `fh` starting from the byte offset `offset` and the byte size `length`. The `mode` shall be taken from the following constants, defined in `dos/record.h`:

Table 13: Record Locking Modes

Record Locking Mode	Description
REC_EXCLUSIVE	Exclusive access to a region, honoring the timeout
REC_EXCLUSIVE_IMMED	Exclusive access to a region, ignoring the timeout
REC_SHARED	Shared access to a region, honoring the timeout
REC_SHARED_IMMED	Shared access to a region, ignoring the timeout

While the same byte within a file can be included in multiple regions locked through a shared record lock, only a single exclusive lock can be held on each byte of a file. Or put differently, shared regions can overlap with each other without failure, exclusivively locked regions cannot overlap with shared locked regions or with each other.

For the `REC_EXCLUSIVE` and `REC_SHARED` modes, the `timeout` value provides a time limit in ticks, i.e. $1/50^{\text{th}}$ of a second, after which an attempt to obtain a lock times out. This time limit may also be 0 in which case an attempt to lock a region fails immediately.

The `REC_EXCLUSIVE_IMMED` and `REC_SHARED_IMMED` modes ignore the timeout, i.e. they act as if the timeout is 0 and fail as soon as they can determine that the requested record cannot be locked.

This function returns 0 in case of failure and then returns a non-zero error code with `IoErr()`. In case the record lock cannot be obtained because the region overlaps with another locked region, the error will be `ERROR_LOCK_COLLISION`. If the region can be locked, the call returns a non-zero result code and sets `IoErr()` to 0.

4.11.2 Locking Multiple Portions of a File

The LockRecords() function locks multiple records at once, potentially within multiple files.

```
success = LockRecords(record_array,timeout)
D0                      D1           D2

BOOL LockRecords(struct RecordLock *,ULONG)
```

This function attempts to lock multiple records at once that are included in the the RecordLock structure. This structure is defined in dos/record.h and looks as follows:

```
struct RecordLock {
        BPTR    rec_FH;         /* filehandle */
        ULONG   rec_Offset;     /* offset in file */
        ULONG   rec_Length;     /* length of file to be locked */
        ULONG   rec_Mode;       /* Type of lock */
};
```

The record_array is a pointer to an array of the above structure that is terminated by a RecordLock structure with rec_FH equal to NULL. The elements of this structure correspond to the arguments of the LockRecord() function:

rec_FH is the file handle to the file within which a record is to be locked. It shall be NULL for the last element in the array.

rec_Offset and rec_Length specify the region in the file to be locked.

rec_Mode specifies the type of the lock that is to be obtained. It shall be one of the modes listed in table 13; the modes are all defined in dos/record.h.

The timeout specifies how long each of the attempts to obtain a lock is supposed to wait for a record to become available if a non-immediate record lock is requested. The timeout is applied to each of the records in the RecordLock array sequentially until either all records could be locked, or until locking one of the records fail. In such a case, the call unlocks all locks obtained so far, and then returns with failure.

On failure, i.e. if one of the records cannot be locked, the function returns 0 and sets IoErr() to an error code. On success, the function returns a non-zero result and sets IoErr() to 0.

Unlike what the function prototype suggests, this function is *not atomic*. Instead, it attempts to lock the records sequentially one after another, applying the same timeout for each call. Thus, it can happen that another task attempts for a lock of a conflicting region while the first caller is executing this function. It is therefore recommended to establish an order in which records within a file are locked, e.g. from smallest to largest start offset. Note that this also implies that the maximal time this function may take is given by the number of elements in the record_array times timeout.

4.11.3 Unlocking a Portion of a File

The UnLockRecord() function unlocks a region of a file, releasing it for further locks. The provided region shall be identical to one of the regions locked before, i.e. it is not possible to partially unlock a region and leave the remaining bytes of the region locked.

```
success = UnLockRecord(fh,offset,length)
D0          D1   D2      D3

BOOL UnLockRecord(BPTR,ULONG,ULONG)
```

This function unlocks a region of a file locked before by `LockRegion()` or `LockRegions()`. The region starts `offset` bytes within the file identified by `fh` and is `length` bytes large.

This function returns 0 on failure and sets an error code that can be obtained by `IoErr()`. A possible error code is `ERROR_RECORD_NOT_LOCKED` if an attempt is made to unlock a record that is actually not locked, or to partially unlock a record. On success, the function returns a non-zero result code and sets `IoErr()` to 0.

4.11.4 Unlocking Multiple Records of a File

The `UnLockRecords()` function unlocks multiple records provided in an array of `RecordLock` structures at once, sequentially releasing one record after another.

```
success = UnLockRecords(record_array)
D0                      D1

BOOL UnLockRecords(struct RecordLock *)
```

This function releases multiple records provided in an array of `RecordLock` structures. The last element of the structure is indicated by its `rec_FH` element set to `NULL`. This structure is defined in section 4.11.2.

The function calls `UnLockRecord()` in a loop, and is therefore *not atomic*. In case unlocking any of these records fails, the function returns 0 but attempts to unlock also any remaining records in the array. On success, it returns a non-zero result code and sets `IoErr()` to 0. Unfortunately, the function does not set `IoErr()` consistently in case of failure as the error code is not saved on a failed unlock.

Chapter 5

Locks

Locks are access rights to objects, such as files or directories, on a file system. Once an object has been locked, it can no longer be deleted, or in case of files, it can no longer altered either. Depending on the file system, locks may also prevent other forms of changes of the object.

Locks come in two types: *Exclusive* and *shared locks*. Only a single exclusive lock can exist on a file system object at a time, and no other locks on an exclusively locked object can exist. An attempt to lock an exclusively locked object results in failure, and attempting to exclusively lock an object that is already shared locked will also fail.

Multiple *shared locks* can be kept on the same object at the same time, though once a shared lock has been obtained, any attempt to lock the same object exclusively fails.

One particular use case of *locks* is to serve as an identifier of a particular directory or file on a file system. Since paths are limited to 255 characters, see 4.3, locks are the preferred method of indicating a position within a file system. Even though paths are length limited, there is no restriction on the depth within the directory structure of a file system. The `ZERO` lock identifies the boot volume, also known as `SYS:`, see also section 4.3.1.3.

Locks are also the building stone of files; in fact, every file is internally represented by a lock on the corresponding object, even if the file system does not expose this lock to the caller.

As long as at least a single lock is held of an object on a particular volume, the file system will keep the volume within the *device list* of the *dos.library*, see section 8. This has, for example, the consequence that the workbench will continue to show an icon representing the volume in its window.

5.1 Obtaining and Releasing Locks

Locks can be obtained either explicitly from a path, or can be derived from another lock or file. As locks block altering accesses to an object of a file system, locks need to be released as early as possible to allow other accesses to the locked object.

5.1.1 Obtaining a Lock from a Path

The `Lock()` function obtains a lock on an object given a path to the object. The path can be either absolute, or relative (see section 4.3) to the current directory of the calling process.

```
lock  = Lock( name, accessMode )
D0            D1        D2

BPTR Lock(STRPTR, LONG)
```

This function locks the object identified by `name`, which is the path to the object. The type of the lock is identified by `accessMode`. This mode shall be one of the two following modes, defined in `dos/dos.h`:

Table 14: Lock Access Modes

Access Mode	Description
`SHARED_LOCK`	Lock allowing shared access from multiple sources
`ACCESS_READ`	Synonym of the above, identical to `SHARED_LOCK`
`EXCLUSIVE_LOCK`	Exclusive lock, only allowing a single lock on the object
`ACCESS_WRITE`	Synonym of the above, identical to `EXCLUSIVE_LOCK`

The access mode `SHARED_LOCK` or `ACCESS_READ` allows multiple shared locks on the same object. This type of lock should be preferred. The access mode `EXCLUSIVE_LOCK` or `ACCESS_WRITE` only allows a single, exclusive lock on the same object.

The return code `lock` identifies the lock. It is non-`ZERO` (see 2.3) on success, or `ZERO` on failure. In either case, `IoErr()` is set to 0 indicating success, or an error code on failure.

> *No Wildcards Here!* Note that this function does not attempt to resolve wild cards, similar to `Open()`. All characters in the path are literals.

5.1.2 Duplicating a Lock

The `DupLock()` function replicates a given *lock*, returning a copy of the *lock* given as argument. This requires that the original *lock* is a *shared lock*, and it returns a *shared lock* if successful.

```
lock = DupLock( lock )
D0              D1

BPTR DupLock(BPTR)
```

This function copies the (shared) lock passed in as `lock` and returns a copy of it in `lock`. In case of error, it returns `ZERO`, and then `IoErr()` returns an error code identifying the error. On success, `IoErr()` is reset. It is not possible to copy an *exclusive lock*.

5.1.3 Obtaining the Parent of an Object

The `ParentDir()` function obtains a *shared lock* on the directory containing the locked object passed in. For directories, this is the parent directory, for files, this is the directory containing the file.

```
newlock = ParentDir( lock )
D0                   D1

BPTR ParentDir(BPTR)
```

The `lock` argument identifies the object whose parent is to be found; the function returns a *lock* on the directory containing the object. If such parent does not exist, or an error occurs, the function returns `ZERO`. The former case applies to the topmost directory of a file system, or the `ZERO` lock itself.

To distinguish the two cases, the caller should check the `IoErr()` function; if this function returns 0, then no error occurred and the passed in object is topmost and no parent exists. If it returns a non-zero error code, then the file system failed to identify the parent directory.

5.1.4 Creating a Directory

The `CreateDir()` object creates a new empty directory whose name is given by the last component of the path passed in. It does not create any intermediate directories between the first component of the path and its last component, such directories need potentially be created manually by multiple calls to this function.

```
lock = CreateDir( name )
 D0                 D1

BPTR CreateDir(STRPTR)
```

The `name` argument is the path to the new directory to be created; that is, the directory given by the last component of the path (see section 4.3) will be created. If successful, the function returns an *exclusive lock* in `lock`, otherwise it returns `ZERO`.

In either case, `IoErr()` is set to either an error code, or to 0 in case the function succeeds.

Note that not all file systems support directories, i.e. flat file systems (see section **??**) do not.

5.1.5 Releasing a Lock

Once you are done with a *lock* and no part of your program is using it anymore, you should release it to allow other processes or functions to access or modify the locked object. Note that setting the `CurrentDir()` to a particular lock implies usage of the lock, i.e. the lock installed as `CurrentDir()` shall not be unlocked.

```
UnLock( lock )
         D1

void UnLock(BPTR)
```

This function releases the *lock* passed in as `lock` argument. Passing `ZERO` as a lock is fine and performs no activity.

5.1.6 Changing the Type of a Lock

Once a *lock* has been granted, it is possible to change the nature of the lock, either from `EXCLUSIVE_LOCK` to `SHARED_LOCK`, or — if this is the only *lock* on the object — vice versa.

```
success = ChangeMode(type, object, newmode)
D0                   D1     D2      D3

BOOL ChangeMode(ULONG, BPTR, ULONG)
```

This function changes the access mode of `object` whose type is identified by `type` to the access mode `newmode`. The relation between `type` and the nature of the object shall be as in table 15, where the types are defined in `dos/dos.h`:

Table 15: Object Types for ChangeMode()

type	object Type
`CHANGE_LOCK`	`object` shall be a *lock*
`CHANGE_FH`	`object` shall be a *file handle*

The argument `newmode` shall be one of the modes indicated in Table 14, i.e. `SHARED_LOCK` to make either the file or the lock accessible for shared access, and `EXCLUSIVE_LOCK` for exclusive access.

On success, the function returns a non-zero result code, and `IoErr()` is set to 0. Otherwise, the function returns 0 and sets `IoErr()` to an appropriate error code.

Unfortunately, this function may not work reliable for *file handles* under all versions of AmigaDOS. In particular, the *RAM-Handler* does not interpret `newmode` correctly for `CHANGE_FH`.

5.1.7 Comparing two Locks

The `SameLock()` function compares two locks and returns information whether they are identical, or at least correspond to objects on the same volume.

```
value = SameLock(lock1, lock2)
 D0                D1      D2

LONG SameLock(BPTR, BPTR)
```

This function compares `lock1` with `lock2`. The return code, all of them defined in `dos/dos.h`, can be one of the following:

Table 16: Lock Comparison Return Code

Return Code	Description
`SAME_LOCK`	Both locks are on the same object
`SAME_VOLUME`	Locks are on different objects, but on the same volume
`LOCK_DIFFERENT`	Locks are on different volumes

This function does not set `IoErr()` consistently, and callers cannot depend on its value. Furthermore, the function does not compare a `ZERO` lock with lock on the boot volume, e.g `SYS:` as identical. It is recommended not to pass in the `ZERO` lock for either `lock1` or `lock2`.

5.1.8 Compare to Locks for the Device

The `SameDevice()` function attempts to check whether two locks refer to two file systems that reside on the same physical device, even if on potentially different partitions.

```
same = SameDevice(lock1, lock2)
D0     D1      D2

BOOL SameDevice( BPTR, BPTR )
```

The `SameDevice()` function takes two *Lock*s `lock1` and `lock2` and checks whether they were created by file systems that operate on the same physical device, even if the two *Lock*s refer to different file systems or different partitions. Only the *exec device* and the corresponding unit is compared, that is, this function is not able to determine whether whether the locks refer to file systems on the same or different physical volumes.

This function returns a non-zero result if the resonsible file systems operate on the same *exec device*, and it returns 0 otherwise. If the function is not able to identify the file systems, or cannot identify the lower level exec `device` on which the file systems operate, the function also returns 0.

A possible use case of this function is to determine whether the involved *file systems* can operate in parallel without imposing speed penalties due to conflicting medium accesses. Thus, copy functions may be optimized depending on the result as no intermediate buffering need to be used if source and destination are on different physical devices.

This function does not set `IoErr()`, even if it cannot determine the device a file system operates on.

5.2 Locks and Files

Each *file handle* is associated to a lock to the file that has been opened. The type of the *lock* depends on the access mode the file has been opened with, table 17 for how lock types and access modes relate.

Table 17: Lock and File Access Modes

Access Mode	Lock Type
MODE_OLDFILE	SHARED_LOCK
MODE_READWRITE	SHARED_LOCK
MODE_NEWFILE	EXCLUSIVE_LOCK

The association of MODE_READWRITE to SHARED_LOCK is unfortunate, and due to a defect in the *RAM-Handler* implementation in AmigaDOS 2.0 which was then later copied into the *Fast File System* implementation. Exclusive access to a file without deleting its contents can, however, be established through the OpenFromLock() function passing in an *exclusive lock* to the function as argument.

5.2.1 Duplicate the Implicit Lock of a File

The DupLockFromFH() function performs a copy of a lock implicit to a *file handle* of an opened file. For this to succeed, the file must be opened in the mode MODE_OLDFILE or MODE_READWRITE. Files opened with MODE_NEWFILE are based on an implicit *exclusive lock* that cannot be copied.

```
lock = DupLockFromFH(fh)
D0                   D1

BPTR DupLockFromFH(BPTR)
```

This function returns a copy of the lock the *file handle* fh is based on and returns it in lock. In case of failure, ZERO is returned. In either case, IoErr() is set to either 0 in case of success, or an error code on failure.

5.2.2 Obtaining the Directory a File is Located in

The ParentOfFH() function obtains a *shared lock* on the parent directory of the file associated to the *file handle* passed in. That is, it is roughly equivalent to first obtaining a lock on the file through DupLockFromFile(), and then calling ParentDir() on it, except that this function also applies to files opened in the MODE_NEWFILE mode.

```
lock = ParentOfFH(fh)
 D0                D1

BPTR ParentOfFH(BPTR)
```

This function returns in lock a shared lock on the directory containing the file opened through the fh *file handle*. It returns ZERO on failure or in case there is no parent directory because fh already represents the root directory.

In either case, IoErr() is set, namely to 0 in case of success or to an error code on failure. Attempting to obtain the parent of the root directory is not a failure case, and thus IoErr() is set to 0 in this case.

5.2.3 Opening a File from a Lock

The OpenFromLock() function uses a *lock* and opens the locked file, returning a *file handle*. If the lock is associated to a directory, the function fails. The *lock* passed in is then absorbed into the *file handle* and shall not be unlocked. It will be released by the file system upon closing the file.

```
fh = OpenFromLock(lock)
D0                D1

BPTR OpenFromLock(BPTR)
```

This function attempts to open the object locked by `lock` as file, and creates the *file handle* `fh` from it. It fails in case the `lock` argument belongs to a directory and not a file.

In case of success, the *lock* becomes an implicit part of the *file handle* and shall not be unlocked by the caller anymore. In case of failure, the function returns `ZERO` and the *lock* remains available to the caller, and also needs to be unlocked at a later time. In either case, `IoErr()` is set, to an error code in case of failure, or 0 on success.

This function allows to open files in exclusive mode without deleting its contents. For that, obtain an *exclusive lock* on the file to be opened, and then call `OpenFromLock()` as second step.

5.2.4 Get Information on the State of the Medium

The `Info()` function returns information on the medium on which the locked object is located, and fills an `InfoData` structure with the status of the *file system*. If it is instead intended to retrieve information on the currently inserted volume, i.e. without requiring a *lock*, direct communication with the *file system* on the packet level is required by sending a packet type of `ACTION_DISK_INFO`, see section **??**.

```
success = Info( lock, parameterBlock )
D0 D1    D2

BOOL Info(BPTR, struct InfoData *)
```

The `lock` is a *lock* to an arbitrary object on the volume to be querried; its only purpose is to identify it. The function fills out an `InfoData` structure that shall be aligned to long-word boundaries.

This structure is defined in `dos/dos.h` and reads as follows:

```
struct InfoData {
   LONG   id_NumSoftErrors;
   LONG   id_UnitNumber;
   LONG   id_DiskState;
   LONG   id_NumBlocks;
   LONG   id_NumBlocksUsed;
   LONG   id_BytesPerBlock;
   LONG   id_DiskType;
   BPTR   id_VolumeNode;
   LONG   id_InUse;
};
```

The elements of this structure are interpreted as follows:

`id_NumSoftErrors` counts the number of read or write errors the file system detected during its life-time. It is not particularly bound to the currently inserted medium.

`id_UnitNumber` is the unit number of the exec device on which the *file system* operates, and hence into which the volume identified by the *lock* is inserted.

`id_DiskState` identifies the status of the file system, whether the volume is writable and whether it is consistent. Disk states are also defined in `dos/dos.h` and set according to the following table:

Table 18: Disk States

Disk State	Description
`ID_WRITE_PROTECTED`	The volume is write protected
`ID_VALIDATING`	The volume is currently validating
`ID_VALIDATED`	The volume is consistent and read- and writeable

A volume in the state ID_WRITE_PROTECTED has been identified as consistent, but does not accept modifications, either because the medium is physically write-protected, or because it has been locked by software, see section **??**.

A volume gets the state `ID_VALIDATING` if its *file system* detected inconsistencies; some file systems, including the Fast File System, then trigger a consistency check of the volume. The Fast File System rebuilds the bitmap of the volume that describes which blocks are allocated and which are free. It cannot fix more severe errors and then presents a requester to the user indicating the problem. During validation, file systems typically refuse to accept write requests. If validation cannot bring the volume into a consistent state, the disk state will remain `ID_VALIDATING`.

A volume in state `ID_VALIDATED` is consistent and read- and writeable.

`id_NumBlocks` is the total number of blocks into which the medium is divided. This includes both free and occupied blocks, and thus indicates the total capacity of the volume. This number is not necessarily constant. The RAM-Handler adjusts this value according to the available memory; RAM-Handler versions prior version 45 set this to 0. In means, in particular, that care needs to be taken when the disk fill state in percent is computed by a dividing the number of used blocks by this number.

`id_NumBlocksUsed` is the number of blocks occupied by file system on the disk. As it is dependent on the file system how many blocks it needs in addition to the actual payload data, no conclusion can be derived from this number whether a particular file fits on the volume. RAM-Handlers prior to release 45 did not even fill this with a useful value.

`id_BytesPerBlock` is the number of bytes available for payload in a physical block of the medium, and not necessarily the physical block size into which the storage medium is divided. Some file systems require additional bytes of the physical block for administrating files. Even the RAM-Handler segments data into blocks and provides in this member the number of data bytes stored there.

`id_DiskType` identifies whether the *file system* that generated the `lock` argument can identify the disk structure and claims responsibility for it. Unlike what the name suggests, it is *not* a general identifier of the type *file system* itself and shall not be used to identify a paritcular file system. For legacy reasons, the various flavours of the Fast File System also leave their identifier here, though this principle should not be carried over to new designs. Instead, a file system should rather return the generic `ID_DOS_DISK` if it finds a medium for which it claims responsibility. Even if the file system recognizes the disk structure as one of its own, it is possible that the structure is considered inconsistent by setting `id_DiskState` to `ID_VALIDATING`.

AmigaDOS currently defines the following disk types in `dos/dos.h`:

Table 19: Disk Types

Disk Type	Description
`ID_NO_DISK_PRESENT`	No disk is inserted
`ID_UNREADABLE_DISK`	Reading disk data failed at exec device level
`ID_DOS_DISK`	The disk is in a format the file system attempts to interpret
`ID_NOT_REALLY_DOS`	While disk contents can be accessed, it is not in a suitable structure
`ID_KICKSTART_DISK`	A disk containing an A1000 kickstart
`'BUSY'`	The file system is currently inhibited
`'CON\0'`	Not a file system, but the Con-Handler
`'RAW\0'`	Not a file system, but the Con-Handler
All others	The first long word of the first block of the medium

As mentioned above `ID_DOS_DISK` is the `id_DiskType` *file systems* should return in case they recognize the structure and attempt to interpret them. Despite this fact, the Fast File System returns erroneously the `dostype` as reported in table 28.

> *Not the DosType* While mount lists include a `DOSTYPE` field that identifies the *file system* uniquely, the `id_DiskType` member *does not* represent this `DOSTYPE`. That it coincides with the `DOSTYPE` for the variants of the FFS is a historical error that shall not be mirrored by new *file system* designs. It is therefore advisable to check the first 3 bytes of the `id_DiskType` for the characters `DOS`, and if so, assume that the disk is valid and can be interpreted by the *file system*. Unfortunately, some third-party designs do not follow this convention.

`ID_NOT_REALLY_DOS` and `ID_UNREADABLE_DISK` both indicates disks the file system cannot make use of. The first because the logical structure of the disk content cannot be interpreted, and the second because the underlying exec device cannot gain access to the contents of the blocks, i.e. the physical layer of the disk is not readable.

`'BUSY'` is a four-character constant that is not documented in `dos/dos.h`, but returned whenever a file system has been inibited, i.e. its access to the physical layer has been stopped. Thus, any attempt to access this file system is currently suspended, probably because some program attempts to operate on the medium on a lower level. Disk editors or disk salvage programs will typically make use of this practise to avoid file systems from touching the medium while they work on it.

`'CON\0'` and `'RAW\0'` are indicators left by the Con-Handler (or console-type handlers) which use the `InfoData` structure for other purposes, see section 12.13. As they do not (in general) hand out locks, the `Info()` function will usually not return these two types, but direct handler communication with a packet type of `ACTION_DISK_INFO` can.

All other types are returned in case the *file system* cannot interpret the disk structure, and are then copied from the first 4 bytes of the medium or partition into `id_DiskType`. In case these bytes are all 0, it is changed to `ID_NOT_REALLY_DOS`.

`id_VolumeNode` in the `InfoData` structure is a BPTR to the `DosList` structure corresponding to the volume on which the object identified by the `lock` is located. For this structure, see section 8.

`id_InUse` counts the number of locks and files currently open on the medium identified by `lock`.

This function returns a non-zero result code on success and sets then `IoErr()` to 0. On failure, it returns 0 and sets `IoErr()` to an error code.

5.2.5 The struct FileLock

Locks have been so far been opaque identifiers; in fact, they are *BPTR*s to a `struct FileLock` that is defined in `dos/dosextens.h`.

```
#include <dos/dosextens.h>
lock = Lock("S:Startup-Sequence",SHARED_LOCK);
struct FileLock *flock = BADDR(lock);
```

While this structure is defined there, it is not allocated by the *dos.library* but by the *file system* itself. The file system may therefore allocate a structure that is somewhat larger and can have additional members that are not shown here.

```
struct FileLock {
    BPTR                fl_Link;        /* bcpl pointer to next lock */
    LONG                fl_Key;         /* disk block number */
    LONG                fl_Access;      /* exclusive or shared */
    struct MsgPort *    fl_Task;        /* handler task's port */
    BPTR                fl_Volume;      /* bptr to DLT_VOLUME DosList entry */
};
```

Most of the members of this structure are of no practical value, and they should not be interpreted in any way. What is listed here is the information callers can depend upon.

The `fl_Link` member has no practical value for users; the *file system* can use it to keep multiple links on object on the same volume in a list. This is particularly important if the volume is ejected from its drive and another file system needs to take over the *locks* if the volume is later inserted into another drive.

The `fl_Key` member can be used by the file system to identify the object that has been locked. It may not necessarily be an integer, but can be any data type, potentially a pointer to some internal management object. It shall not be interpreted in any particular way.

The `fl_Access` member keeps the type of the lock. It is either `SHARED_LOCK` or `EXCLUSIVE_LOCK`.

The `fl_Task` member points to the message port of the file system for processing requests on the lock. Any activity on the lock goes through this port.

The `fl_Volume` is a *BPTR* to the *volume node* on the *Device list*. The *volume node* identifies the volume the locked object is located on. Section 8 provides further information on this list and its entries.

Chapter 6

Working with Directories

As objects on a file system can be identified by a name, these names need to be stored somewhere on the data carrier. This object is called a *directory*. While a flat file system only contains a single, topmost directory which then contains all files, a directory of a hierarchical file system can contain other directories, thus creating a *tree* of nested objects, see also section **??**.

AmigaDOS provides functions to list the directory contents, to move objects in the file system hierarchy or change their name, and to access adjust their metadata, such as comments, protection bits, or creation dates.

AmigaDOS also supports *links*, that is, entries in the file system that point to some other object in the same, or some other file system. Therefore, links circumvent the hierarchy otherwise imposed by the tree structure of the file system.

6.1 Examining Objects on File Systems

Given a lock on a file or a directory, further information on such an object can be requested by the `Examine()` function of the *dos.library*. To read multiple directory entries at once and minimizing the calling overhead, `ExAll()` provides an advantage that is, however, harder to use, but also provides options to filter entries.

> *May go away while you look!* As AmigaDOS is a multitasking operating system, the directory may change under your feed while scanning; in particular, entries you received through the above functions may not be up to date, may have been deleted already when the above functions return, or new entries may have been added the current scan will not reach. While a *Lock* on a directory prevents that this directory goes away, it does *not* prevent other processes to add or remove objects to this directory, so beware.

While `ExAll()` seems to provide an advantage by reading multiple directory entries in one go, the AmigaOS ROM file system does usually not profit from this feature, at least not unless a directory cache is used. The latter has, however, other drawbacks and should be avoided for different reasons, see section **??**. Actually, `ExAll()` is (even more) complex to implement, and it is probably not surprising that multiple file systems have issues. The `dos.library` provides an `ExAll()` implementation for those file systems that do not implement it themselves, but even this (ROM-based) implementation had issues in the past. Therefore, `ExAll()` has probably less to offer than it seems.

`Examine()` and `ExNext()` fill a `FileInfoBlock` structure that collects information on an examined object in a directory. It is defined in `dos/dos.h` and reads as follows:

```
struct FileInfoBlock {
   LONG   fib_DiskKey;
```

```
   LONG   fib_DirEntryType;  /* Type of Directory. If < 0, then a plain file.
                              * If > 0 a directory */
   char   fib_FileName[108]; /* Null terminated. Max 30 chars used for now */
   LONG   fib_Protection;    /* bit mask of protection, rwxd are 3-0.      */
   LONG   fib_EntryType;
   LONG   fib_Size;          /* Number of bytes in file */
   LONG   fib_NumBlocks;     /* Number of blocks in file */
   struct DateStamp fib_Date;/* Date file last changed */
   char   fib_Comment[80];  /* Null terminated comment associated with file */

   /* Note: the following fields are not supported by all filesystems.  */
   /* They should be initialized to 0 sending an ACTION_EXAMINE packet. */
   /* When Examine() is called, these are set to 0 for you.             */
   /* AllocDosObject() also initializes them to 0.                      */
   UWORD  fib_OwnerUID;         /* owner's UID */
   UWORD  fib_OwnerGID;         /* owner's GID */
   char   fib_Reserved[32];
}; /* FileInfoBlock */
```

The meaning of the members of this structure are as follows:

`fib_DiskKey` is a file system internal identifier of the object. It shall not be used, and programs shall not make any assumptions on its meaning.

`fib_DirEntryType` identifies the type of an object. Object types are defined in `dos/dosextens.h`, replicated in table 20:

Table 20: Directory Entry Types

Value of fib_DirEntryType	Description
ST_SOFTLINK	Object is a soft link to another object
ST_LINKDIR	Object is a hard link to a directory
ST_LINKFILE	Object is a hard link to a file

All other types > 0 indicate directories, and all other types < 0 indicate files. Section **??** provides more details on soft links and hard links.

`fib_FileName` is the name of the object as `NUL` terminated string.

`fib_Protection` are the protection bits of the object. It defines which operations can be performed on it. The following protection bits are currently defined in `dos/dos.h`:

Table 21: Protection Bits

Protection Bits	Description
FIBB_DELETE	If this bit is 0, the object can be deleted.
FIBB_EXECUTE	If this bit is 0, the file is an executable binary.
FIBB_WRITE	If this bit is 0, the file can be written to.
FIBB_READ	If this bit is 0, the file content can be read.
FIBB_ARCHIVE	This bit is set to 0 on every write access.
FIBB_PURE	If 1, the executable is reentrant and can be made resident.
FIBB_SCRIPT	If 1, the file is a script.
FIBB_HOLD	If 1, the executable is made resident on first execution.

The flags `FIBB_DELETE` to `FIBB_READ` are shown inverted in the output of most tools, i.e. they are shown active if the corresponding flag is 0, i.e. a particular protection function is *not* active. The `FIBB_READ` and

FIBB_WRITE bits were ignored by early implementations of the ROM *file system*. This was fixed in release 36.

The `FIBB_EXECUTE` flag is only interpreted by the *Shell* (see section **??**) and the Workbench; if the bit is 1, the *Shell* and the Workbench refuse to load the file as command or program.

The `FIBB_ARCHIVE` flag is typically used by archival software. Such software will set this flag upon archiving the flag, whereas the file system will reset the flag when writing to or modifying a file, or when creating new files. The archiving software is thus able to learn which files had been altered since the last backup.

The `FIBB_PURE` flag indicates an additional property of executable binaries; if the flag is set, the binaries do not alter their segments and their code can be loaded in *RAM* and stay there to be executed from multiple processes in parallel. This avoids loading the binary multiple times. The *Shell* command `resident` can load such binaries into *RAM* for future usage.

The `FIBB_SCRIPT` flag indicates whether a file is a *Shell* or an *ARexx* script. If this flag is set, and the script is given as command to the *Shell*, it will forward this file to a suitable script interpreter, such as *ARexx* or `Execute`.

The `FIBB_HOLD` flag indicates whether a command shall be made resident upon loading it the first time. If the flag is 1, and the shell loads the file as executable binary, and the `FIBB_PURE` bit is also set, the file is kept in *RAM* and stays there for future execution.

The `fib_EntryType` member shall not be used; it can be identical to the `fib_DirEntryType`, but its use is not documented.

The `fib_Size` member indicates the size of the file in bytes. It should have probably be defined as an unsigned type. Its value is undefined for directories.

The `fib_NumBlocks` member indicates now many blocks a file occupies on the storage medium, if such a concept applies. Disks and harddisk organize their storage into blocks of equal size, and the file system manages these blocks to store data on the medium. The number of blocks can be meaningless for directories.

The `fib_Date` member indicates when the file was changed last; depending on the file system, the date may also indicate when the last modification was made for a directory, such as creating or deleting a file within. Which operations exactly trigger a change of a directory is file system dependent. The `DateStamp` structure is specified in section **??**.

The `fib_Comment` member contains a `NUL` terminated string to a comment on the file. Not all file systems support comments. The comment has no particular meaning, it is only shown by some *Shell* commands or utilities and can be set by the user.

The `fib_OwnerUID` and `fib_OwnerGID` are filled in by some multi-user aware file systems. The AmigaDOS ROM file systems do not support these fields, and no provision is made to moderate access to a particular file according to an owner or its group. The two concepts are alien to AmigaDOS itself.

The `fib_Reserved` field is currently unused and shall not be accessed.

6.1.1 Retrieving Information on an Directory Entry

The `Examine()` function retrieves information on the object identified by a *lock* and fills a `FileInfoBlock` from it.

```
success = Examine( lock, FileInfoBlock )
D0                 D1        D2

BOOL Examine(BPTR,struct FileInfoBlock *)
```

This function fills out the `FileInfoBlock` providing information on the object identified by `lock`. The structure is discussed in section 6.1 in more detail. The function returns non-zero in case of success, and 0 for failure. In either case, `IoErr()` is filled, by 0 on success, on an error code on failure.

> *Keep it Aligned!* As with most BCPL structures, the `FileInfoBlock` shall be aligned to a long-word boundary. For that reason, it should be allocated from the heap. Section 2.3 provides some additional hints on how to allocate such structures.

6.1.2 Retrieving Information from a File Handle

While `Examine()` retrieves information a locked object, `ExamineFH()` retrieves the same information from a *file handle*, or rather from the *lock* implicit to the handle.

```
success = ExamineFH(fh, fib)
D0                  D1  D2

BOOL ExamineFH(BPTR, struct FileInfoBlock *)
```

This function examines the object accessed through the *file handle* `fh`, and returns the information in the *FileInfoBlock*. Note that the file content and thus its change can be changed any time, and thus the information returned by this function may not be fully up-to-date, see also the general information in section 6.1.

This function returns non-zero in case of success, or 0 on error. In either case, `IoErr()` is set, namely to 0 on success and to an error code otherwise.

As for `Examine()`, the *FileInfoBlock* shall be aligned to a 4-byte boundary.

6.1.3 Scanning through a Directory Step by Step

The `ExNext()` function iterates through entries of a directory, retrieving information on one object after another contained in this directory. For scanning through a directory, first `Lock()` the directory itself. Then use `Examine()` on the *lock*. This provides information on the directory itself.

To learn about the objects in the directory, iteratively call `ExNext()` on the same `lock` and on the same `FileInfoBlock` until the function returns `DOSFALSE`. Each iteration provides then information on the subsequent element in the directory of the `lock`.

```
success = ExNext( lock, FileInfoBlock )
D0                 D1        D2

BOOL ExNext(BPTR, struct FileInfoBlock *)
```

This call returns information on the subsequent entry of a directory identified by `lock` and deposits this information in the `FileInfoBlock` described in 6.1. The `lock` shall be a *lock* on a directory, in particular.

On success, `ExNext()` returns non-zero. If there is no further element in the scanned directory, or on an error, it returns `DOSFALSE`. In either event, `IoErr()` is set, namely to 0 in case of success, or to an error code otherwise.

At the end of the directory, the function returns `DOSFALSE`, and the error code as obtained from `IoErr()` is set to `ERROR_NO_MORE_ENTRIES`.

Same Lock, Same FIB To iterate through a directory, a lock to the same directory as passed into `Examine()` shall be used. Actually, the same *lock* should be used, and the same *FileInfoBlock* should be used. As important state information is associated to the *lock* and *FileInfoBlock*, `UnLock()`ing the original *lock* and obtaining a new *lock* on the same directory looses this information; using a different *FileInfoBlock* also looses this state information, requiring the *file system* to rebuild this state information, which is not only complex, but also slows down scanning the directory. In particular, you shall *not* use the same *FileInfoBlock* you used for scanning one directory for scanning a second, different directory as this can confuse the *file system*. Also, as for `Examine()`, the `FileInfoBlock` shall be aligned to a long-word boundary.

6.1.4 Examine Multiple Entries at once

While scanning a directory with `ExNext()` requires one interaction with the *file system* for each entry and is therefore potentially slow, `ExAll()` retrieves as many entries as possible in one go. Whether a particular file system can take advantage of such a block transfer is a matter of its original organization, however.

```
continue = ExAll(lock, buffer, size, type, control)
D0               D1     D2     D3    D4     D5

BOOL ExAll(BPTR,STRPTR,LONG,LONG,struct ExAllControl *)
```

This function examines as many directory entries belonging to the directory identified by `lock` as fit into the buffer `buffer` of `size` bytes. This buffer is filled by a linked list of `ExAllData` structures, see below for their layout. `type` determines which elements of `ExAllData` is filled.

The `lock` shall be a lock on the directory to be examined. It shall not be `ZERO`.

To start a directory scan with `ExAll()`, first allocate a `ExAllControl` structure through `AllocDosObject()`, see **??**. This structure looks as follows:

```
struct ExAllControl {
  ULONG   eac_Entries;     /* number of entries returned in buffer      */
  ULONG   eac_LastKey;     /* Don't touch inbetween linked ExAll calls! */
  UBYTE  *eac_MatchString; /* wildcard string for pattern match or NULL */
  struct Hook *eac_MatchFunc; /* optional private wildcard function     */
};
```

`eac_Entries` is provided by the *file system* upon returning from `ExAll` and then contains the number of entries that fit into the `buffer`. Note that this number may well be 0, which does not need to indicate termination of the scan. Callers shall instead check the return code of `ExAll()` to learn on whether scanning may continue or not.

`eac_LastKey` is a *file system* internal identifier of the current state of the directory scanner. This member shall not be interpreted nor modified in any way.

`eac_MatchString` filters the directory entry names, and returns only those that match the wild card pointed to by this member. This entry shall be either `NULL`, or a pre-parsed pattern as generated by `ParsePatternNoCase()`.

`eac_MatchFunc` is a even more flexible option to filter directory entries. It shall be either `NULL` or point to a `struct Hook` as defined in `utility/hooks.h`. If set, then for each directory entry the hook function `h_Entry` is called as follows:

```
match = (hook->h_Entry)(struct Hook *hook, LONG *datap,
d0                                  a0          a2

                        struct ExAllData *buf )
                                    a1
```

that is, register a0 points to the called hook, register a1 to the data buffer that is part of the buffer supplied by the caller of ExAll() and which is already filled in with a candidate ExAllData structure to be checked for acceptance. Register a2 points to a LONG, which is a copy of the type argument supplied to ExAll(). If the hook function returns non-zero, a match is assumed and the directory entry remains in the output buffer. Otherwise, the data is discarded.

eac_MatchFunc and eac_MatchString shall not be filled in simultaneously, only one of the two shall be non-NULL. If both members are NULL, all entries match.

The buffer supplied to ExAll() is filled by a singly linked list of ExAllData structures that look as follows:

```
struct ExAllData {
        struct ExAllData *ed_Next;
        UBYTE  *ed_Name;
        LONG    ed_Type;
        ULONG   ed_Size;
        ULONG   ed_Prot;
        ULONG   ed_Days;
        ULONG   ed_Mins;
        ULONG   ed_Ticks;
        UBYTE  *ed_Comment;     /* strings will be after last used field */
        UWORD   ed_OwnerUID;    /* new for V39 */
        UWORD   ed_OwnerGID;
};
```

The members of this structure are as follows:

ed_Next points to the next ExAllData structure within buffer, or NULL for the last structure filled in.

ed_Name points to the file name of a directory entry, and supplies the same name as fib_FileName as in the FileInfoBlock.

ed_Type identifies the type of the entry. It identifies directory entries according to table 20 and corresponds to fib_DirEntryType.

ed_Size is the size of the directory element for files. It is undefined for directories. It corresponds to fib_Size.

ed_Prot collects the protection bits of the directory entry according to table 21 and by that corresponds to fib_Protection.

ed_Days, ed_Mins and ed_Ticks identifies the date of the last change to the directory element. It corresponds to fib_Date. Section 6.2.5 defines these elements more rigorously.

ed_Comment points to a potential comment on the directory entry and corresponds to fib_Comment.

ed_ed_OwnerUID and ed_OwnerGID contain potential user and group IDs if the file system is able to provide such information. All the AmigaDOS native file systems do not.

Which members of the ExAllData structure are filled in is selected by the type argument. It shall be selected according to table 22, whose elements are defined in dos/exall.h:

Table 22: Type Values

Type	Filled Members
`ED_NAME`	Fill only `ed_Next` and `ed_Name`
`ED_TYPE`	Fill all members up to `ed_Type`
`ED_SIZE`	Fill all members up to `ed_Size`
`ED_PROTECTION`	Fill all members up to `ed_Prot`
`ED_DATE`	Fill all members up to `ed_Ticks`, i.e. up to the date
`ED_COMMENT`	Fill all members up to `ed_Comment`
`ED_OWNER`	Fill all members up to `ed_OwnerGID`

The return code `continue` is non-zero in case the directory contents was too large to fit into the supplied `buffer` completely. In such a case, either `ExAll()` shall be called again to read additional entries, or `ExAllEnd()` shall be called to terminate the call and release all internal state information.

If `ExAll()` is called again, the `lock` shall be identical to the `lock` passed into the first call, and not only a copy on the same directory as for the first call.

The return code `continue` is `DOSFALSE` in case the scan result fit entirely into `buffer` or in case an error occurred.

Regardless of the return code, `IoErr()` is set to 0 in case `continue` is non-zero, or to an error code otherwise. If the error code is `ERROR_NO_MORE_ENTRIES`, then `ExAll()` terminated because all entries have been read and scanning the directory completed. In this case, `ExAllEnd()` should not be called.

Not all file systems — actually, none delivered with AmigaOs — support `ED_OWNER`. If `continue` is `DOSFALSE` and `IoErr()` is `ERROR_BAD_NUMBER`, try to reduce `type` and call `ExAll()` again.

Some file systems do not implement `ExAll()` themselves; in such a case, the *dos.library* provides a fall-back implementation keeping `ExAll()` workable regardless of the completeness of the target *file system*.

6.1.5 Aborting a Directory Scan

To abort an `ExAll()` scan through a directory, `ExAllEnd()` shall be called to explicitly release all state information associated to the scan. This is unlike an item-by-item scan through `ExNext()` which does not require explicit termination.

```
ExAllEnd(lock, buffer, size, type, control)
          D1     D2     D3    D4     D5

void ExAllEnd(BPTR,STRPTR,LONG,LONG,struct ExAllControl *)
```

This function aborts an `ExAll()` driven directory scan before it terminates due to an error or due to the end of the directory, i.e. whenever `ExAll()` returns with a non-zero result code which would indicate that the function should be called again.

`ExAll()` may also be the fastest way to terminate a directory scan once it is running, for example on network file systems where the scan may proceed offline on a separate server. The arguments to `ExAllEnd()` shall be exactly those supplied to `ExAll()` which it is supposed to terminate. Note in particular that the `lock` shall be identical to the *lock* passed into `ExAll()`, and not just a *lock* to the same object.

6.2 Modifying Directory Entries

While the functions in section 6.1 read directory entries, the functions listed here modify the directory and its entries.

6.2.1 Deleting Objects on the File System

The `DeleteFile()` function removes — despite its name — not only files, but also directories and links from a directory. For this to succeed, the object need to allow deletion through its protection bits (see section 6.1), and no *locks* are held on the object (see section 12.4). To be able to delete a directory, this directory needs to be empty in addition.

```
success = DeleteFile( name )
 D0                    D1

BOOL DeleteFile(STRPTR)
```

This function deletes the object given by the last component of the path passed in as `name`. It returns non-zero in case of success, or 0 in case of error. In either case, `IoErr()` is set, namely 0 on success or an error code in case of failure.

6.2.2 Rename or Relocate an Object

The `Rename()` function changes the name of an object, or even relocates it from one directory to another.

```
success = Rename( oldName, newName )
  D0                D1       D2

BOOL Rename(STRPTR, STRPTR)
```

This function renames and optionally relocates an object between directories. The `oldName` is the current path to the object, and its last component is the current name of the object to relocate and rename; `newName` is the target path and its last component the target name of the object. The target directory may be different from the directory the object is currently located in, and the target name may be different from the current name. However, current path and target path shall be on the same volume, and the target directory shall not already contain an object of the target name; otherwise, current and target path may be either relative or absolute paths.

A third condition is that if the object to relocate is a directory, then the target path shall not be a position within the object to relocate, i.e. you cannot move a directory into itself.

This function returns a boolean success indicator. It is non-zero on success, or 0 on error. In either case, `IoErr()` is set, to 0 on success, or to an error code otherwise.

6.2.3 Set the File Comment

The `SetComment()` function sets the comment of an directory entry, provided the *file system* supports comments.

```
success = SetComment( name, comment )
D0                    D1    D2

BOOL SetComment(STRPTR, STRPTR)
```

This function sets the comment of the *file system* object whose path is given by `name` to `comment`. It depends on the file system whether or how long comments can grow. The maximum comment length AmigaDOS supports is 79 characters, due to the available space in the `FileInfoBlock` structure.

This function returns non-zero on success and 0 on error. In either case, the function sets `IoErr()` to 0 on success or to an error code otherwise.

6.2.4 Setting Protection Bits

The `SetProtection()` function modifies the protection bits of a *file system* object, i.e. either a file or a directory.

```
success = SetProtection( name, mask )
D0  D1    D2

BOOL SetProtection (STRPTR, LONG)
```

This function sets the protection bits of the file system object `name` in the current directory to the combination given by `mask`. The protection bits are defined in `dos/dos.h` and their function is listed. in table 21. The `mask` value corresponds to what `Examine()` returns in the `FileInfoBlock` structure in `fib_Protection`, see also section 6.1.

This function returns a non-zero result code on success, or zero on error. In either case, `IoErr()` is altered, either to 0 on success or to an error code otherwise.

6.2.5 Set the Modification Date

The `SetFileDate()` function sets the modification date of an object of a *file system*. Despite its name, the function can also set the modification date of directories and links if the file system supports them.

```
success = SetFileDate(name, date)
D0                    D1    D2

BOOL SetFileDate(STRPTR, struct DateStamp *)
```

This function adjusts the modification date of the *file system* object identified by path as given by `name` to `date`. The `DateStamp` structure is specified in section **??**.

This function returns 0 on error or non-zero on success. In either case, `IoErr()` is set, either to 0 on success or to an error code otherwise.

Note that not all file systems may be able to set the date precisely to ticks, e.g. `FAT` has only a precision of 2 seconds. Some file systems may refuse to set the modification date if an object is exclusively locked, this is unfortunately not handled consistently.

6.2.6 Set User and Group ID

The `SetOwner()` function sets the user and group ID of an object within a *file system*. Both are concatenated to a 32-bit ID value. While this function seems to imply that the file system or AmigaDOS seems to offer some multi-user capability, this is not the case. User and group ID are purely metadata that is returned by the functions discussed in section 6.1, they usually ignore them. AmigaDOS has no concept of the current user of a *file system* and thus cannot decide whether a user is privileged to access an object on a file system. In fact, all ROM based file systems delivered with AmigaDOS do not support setting the user or group ID.

```
success = SetOwner( name, owner_info )
D0                  D1        D2

BOOL SetOwner (STRPTR, LONG)
```

This function sets the user and group ID of the *file system* object identified by the path in `name` to the value `owner_info`. How exactly the `owner_info` is encoded is *file system* specific. Typically, the owner is encoded in the topmost 16 bits, and the group in the least significant 16 bits.

This function returns a boolean success indicator which is non-zero on success and 0 on error. This function always sets `IoErr()`, either to 0 on success or to an error code otherwise.

6.3 Working with Paths

The *dos.library* contains a couple of support functions that help working with paths, see also section 4.3. What is different from the remaining functions is that the paths are not interpreted by the file system, but rather by the *dos.library* itself. This has several consequences: First, there is no 255 character limit as the path is never communicated into the *file system* as it was stated in section 4.3.3. Second, as the paths are constructed or interpreted by the library and not the *file system*, the syntax of the path is also that imposed by the library.

That is, for these functions to work, the separator between component must be the forwards slash ('`/`') and the parent directory must be indicated by an isolated single forward slash without a component upfront. This implies, in particular, that the involved file systems follow the conventions of AmigaDOS.

6.3.1 Find the Path From a Lock

The `NameFromLock()` function constructs a path to the locked object, i.e. if the constructed path is used to create a lock, it will refer to the same object.

```
success = NameFromLock(lock, buffer, len)
D0                     D1     D2     D3

BOOL NameFromLock(BPTR, STRPTR, LONG)
```

This function constructs in `buffer` an absolute path that identifies the object locked by `lock`. At most `len` bytes will be filled into `buffer`, including `NUL` termination of the string. The created string is always `NUL`-terminated, even if the buffer is too short. However, in such a case the function returns 0, and `IoErr()` is set to `ERROR_LINE_TOO_LONG`.

If the path cannot be constructed due to an error, `success` is also set to 0 and `IoErr()` is set to an error code. However, on success, `IoErr()` is not set consistently and cannot be depended upon. Possible cases of failure are that the volume the locked object is located on is currently not inserted in which case it will be requested. The `ZERO` lock is correctly interpreted, and resolves into the string `SYS:`. The `lock` remains valid after the call.

6.3.2 Find the Path from a File Handle

The `NameFromFH()` function constructs a path name from a *file handle*, i.e. it finds a path that is suitable to identify the file identified by the passed in *file handle*.

```
success = NameFromFH(fh, buffer, len)
D0                   D1    D2     D3

BOOL NameFromFH(BPTR, STRPTR, LONG)
```

This function takes a *file handle* in `fh` and from that constructs an absolute path of the opened file in the supplied `buffer` capable of storing `len` bytes, including a terminating `NUL` byte.

On success, the function returns a non-zero return code and sets `IoErr()` to 0. On error, it returns 0 and sets `IoErr()` to an error code. In particular, if the supplied buffer is not large enough, it is set to `ERROR_LINE_TOO_LONG`. Even in the latter case, the created path is `NUL` terminated, though not useful.

6.3.3 Append a Component to a Path

The `AddPart()` adds an absolute or relative path to an existing path; the resulting path is constructed as if the input path is a directory, and the attached (second) path identifies an object relative to this given directory. The function handles special cases such as the colon (':') and one or multiple leading slashes ('/') correctly and are interpreted according to the rules explained in section 4.3: The colon identifies the root of the volume, and a leading slash the parent directory, upon which the trailing component of the input path is removed.

```
success = AddPart( dirname, filename, size )
D0                 D1       D2        D3

BOOL AddPart( STRPTR, STRPTR, ULONG )
```

This function attaches to the existing path in `dirname` another path in `filename`. The constructed path will overwrite the buffer in `dirname`, which is able to hold `size` bytes, including a terminating `NUL` byte.

If the required buffer for the constructed path, including termination, is larger than `size` bytes, then the function returns 0 and `IoErr()` is set to `ERROR_LINE_TOO_LONG`, and the input buffers are not altered. Otherwise, the function returns non-zero, and `IoErr()` is not altered.

This function does not interact with a *file system* and does not check whether the paths passed in correspond to accessible objects. The output path is constructed purely based on the AmigaDOS syntax of paths.

6.3.4 Find the last Component of a Path

The `FilePart()` function finds the last component of a path; the function name is a bit misleading since the last component does not necessarily correspond to a file, but could also correspond to a directory once identified by a *file system*. If there is only a single component in the path passed in, this component is returned. If the path passed in terminates with at least two slashes ('/') indicating that the last component is at least one level above, a pointer to the terminating slash is returned.

```
fileptr = FilePart( path )
D0                  D1

STRPTR FilePart( STRPTR )
```

This function returns in `fileptr` a pointer to the last component of the path passed in as `path`, or a pointer to '/' in case the input path terminates with at least two slashes.

This function cannot fail, and does not touch `IoErr()`.

6.3.5 Find End of Next-to-Last Component in a Path

The `PathPart()` identifies the end of the next-to-last component in a path. That is, if a `NUL` is injected at the pointer returned by this function, the resulting string starting at the passed in buffer corresponds to a path that corresponds to the directory containing the last component of the path. If the passed in path consists only of a single component, the returned pointer is identical to the pointer passed in.

```
fileptr = PathPart( path )
D0                  D1

STRPTR PathPart( STRPTR )
```

This function returns in `fileptr` a pointer to the end of the next-to-last component of the `path` passed in. This function cannot fail and does not alter `IoErr()`.

The only difference between this function and `FilePath()` is that the latter advanced over a potential trailing slash. That is, if the last character of the input path of `PathPart()` would be a slash, then `PathPart()` would return a pointer to this slash, but `FilePart()` would advance beyond this slash. That is, the "file part" of a path that explicitly indicates a directory is empty, though the "path part" is the same path without the trailing slash.

6.3.6 Extract a Component From a Path

The `SplitName()` function extracts a component starting at a given offset from a path and delivers the component in a buffer. It also returns a new position at which to continue parsing a path. By iteratively calling `SplitName()`, a path can be resolved directory by directory, walking the *file system* tree from top to bottom.

```
newpos = SplitName(name, separator, buf, oldpos, size)
D0                   D1       D2      D3     D4     D5

WORD SplitName(STRPTR, UBYTE, STRPTR, WORD, LONG)
```

This function scans a path as given by `name` starting from position `oldpos`. It copies all characters starting from this position into the buffer `buf` which is `size` bytes large, terminating either at the end of the path, or at `separator`, or when `buf` runs full. The component string constructed in `buf` is `NUL`-terminated in either case. If the provided separator is found, the separator is not copied into `buf`.

If no separator is found, the function returns `−1` as `newpos` indicating that the entire path has been scanned. Otherwise, it returns the offset into `name` at which the next component starts, i.e. the offset behind the found separator. These return values are also valid even in case the found component was too large to fit into `buf` and it had to be truncated.

This function does not set error codes, even in case `buf` was too small to hold the copied component.

The intended purpose of this function is to walk a path component by component, identifying the names of the directories as scanning proceeds. That is, if result code `newpos` is not negative, it should be passed back into this function as `oldpos` for a subsequent scan which then extracts the next component of the path. The main user of this function are therefore *file systems* when locating an object in the file system tree. For most AmigaDOS *file systems* the sparator is therefore the forwards slash ("`/`").

6.4 Links

Links are tools to escape the tree-like hierarchy of directories, sub-directories and files. A *link* mirrors one object of a file system to another location such that if the object is changed using the path of one location, the changes are reflected in another location. Put differently, creating a link is like copying an object except that copy and original are always in sync. The storage for the payload data of a file is only required once, the link just points to the same data as the original directory entry. The same goes for links between directories: Whenever a new entry is made in one directory, the change also appears in the other.

AmigaDOS supports two (or, actually, three) types of links: *Hard-links* and *Soft-links*. The *RAM-Handler* supports a third type that will be discussed below. *Hard-links* establish the relation between two *file-system* objects on the same volume at the level of the file system. That is, whenever a link is accessed, the file system resolves the link, transparent to its user. While for the Amiga *Fast File System* and the *RAM-Handler* a *hard-link* is a distinct directory entry type, some file systems do not distinguish between the original object and a *hard-link* to it. For such file systems, the same payload data is just referenced by two directory entries. If the larger of a link is deleted on the *Fast File System* or the *RAM-Handler*, and (at least one) link to the object still exists, then (one of) the link(s) takes over and becomes the object itself. For other file systems, only a file system internal reference counter is decreased, and the payload data is removed only if this counter becomes zero.

Soft-Links work differently and can also be established between two different *file systems*, or between two different volumes. Here, the *soft-link* is a type of its own that contains the path of the referenced object. Unlike hard-links, soft-links are resolved through an interaction of the file-system and the *dos.library*.

The *dos.library* supports *Soft-Links* through the functions listed in Table 23:

Table 23: Softlink aware functions

Function	Purpose
`Open()`	Open a file
`Lock()`	Obtain access rights to an object
`CreateDir()`	Create a directory
`SetProtection()`	Modify protection bits
`SetFileDate()`	Set the modification date of a file
`DeleteFile()`	Delete an object on a file system
`SetComment()`	Modify object comment
`MakeLink()`	Create a link to an object
`SetOwner()`	Set User and Group ID

All of the above functions take a path of its first argument. If the path consists of multiple components, i.e. identifies an object in a nested directory, and one of the intermediate components are *soft-links*, the *dos.library* will automatically resolve such an intermediate link and construct internally a resolved path to the link destination. Whether a soft-link at the last component is resolved is typically *file system* and function dependent. For example, `Open()` will always resolve *soft-links*, but `Lock()` or `SetProtection()` may not and may instead affect the link, not the target object. `DeleteFile()` will never resolve a link at the final component of the path, and will therefore delete the link, not the object linked to.

Note that `Rename()` is currently not on the list supporting soft-links as part of the path to the object to be renamed, or as part of the target path.

If the target of a *soft-link* is deleted (and not the link itself), a link pointing to it becomes invalid, even though remains in the *file system*. Any attempt to resolve the link then, obviously, fails. AmigaDOS does not attempt to identify such invalid links. The same cannot happen for *hard-links*.

Soft-link resolution works as follows: Functions of the *dos.library* create a packet of a type that corresponds to the called function; these packets are specified in chapter 12. If the handler addressed by the packet determines that the path provided by the user contains a soft-link, it will respond with failure and the error code `ERROR_IS_SOFT_LINK`.

The *dos.library* then requests the handler to resolve the softlink via the *ReadLink()* function which sends a packet of type `ACTION_READ_LINK` back to the handler. The handler then computes from the original path and the target of the soft-link an updated path and provides it back to the *dos.library*, which then attempts again to perform the requested function. Details on how a file system merges a path and a softlink is provided in section 12.6.2. The additional round-trip is unfortunately necessary as the handler the soft-link points to may be a different handler than the one the soft-link is stored on.

This process continues until either the requested action could be performed, or a maximum number of attempts failed. Currently, the *dos.library* will perform at most 15 tries to resolve a soft-link until it finally fails.

Finally, the *RAM-Handler* supports a special type of *hard-links* that goes across volumes. These *external links* copy the linked object on a read-access into the RAM disk, i.e. the *RAM-Handler* implements a *copy on access*. This feature is used for the `ENV:` assign containing all active system settings. This assign points to a directory in the RAM disk which itself is externally linked to `ENVARC:`. Thus, whenever a program attempts to access its settings — such as the preferences programs — the *RAM-Handler* automatically copies the data from `ENVARC:` to `ENV:`, avoiding a manual copy and also saving RAM space for settings that are currently not accessed and thus unused.

The `FileInfoBlock` introduced in section 6.1 identifies links through the `fib_DirEntryType` member. As seen from table 20, *hard-links* to files are indicated by `ST_LINKFILE` and *hard-links* to directories by `ST_LINKDIR`. Note, however, that not all file systems are able to distinguish *hard-links* from regular directory entries, so this feature cannot be depended upon. In particular, *external links* of the *RAM-Handler* cannot be identified by any particular value of the `fib_DirEntryType`.

Table 20 also provides the `fib_DirEntryType` for *soft-links*, namely `ST_SOFTLINK`. As the target of a *soft-link* may not under control of the *file system*, it cannot know whether the link target is a file or a directory (or maybe another link), and therefore a single type is sufficient to identify them.

6.4.1 Creating Links

The `MakeLink()` function creates a *hard-link* or a *soft-link* to an existing object on a *file system*.

```
success = MakeLink( name, dest, soft )
D0                  D1    D2    D3

BOOL MakeLink( STRPTR, LONG, LONG )
```

This function creates a new link at the path `name` of the type given by `soft`. The destination the link points to is given by `dest`.

The third argument, `soft`, identifies the type of the link to be created. It shall be taken from table 24, defined in `dos/dos.h`:

Table 24: `Link Types`

Link Types	Description
`LINK_HARD`	Hard link, or external link
`LINK_SOFT`	Soft link

If `soft` is `LINK_HARD`, `dest` is a *lock* represented by `BPTR`. For most *file systems*, `dest` shall be on the same volume as the one identified by the path in `name`. The currently only exception is the *RAM-Handler* for which the destination *lock* may be on a different volume. In such a case, an *external link* is created. While the target object will be created, it may look initially like an empty file or an empty directory, depending on the type of the link destination. Its contents is copied, potentially recursively creating directories, by copying the contents of the link destination into the link, or to a file or directory within the link. Thus, the link becomes a mirror of the link destination whenever an object within the link or the link itself is accessed.

If `soft` is `LINK_SOFT`, `dest` is a `const UBYTE *` that shall be casted to a `LONG`. Then, this function creates a *soft-link* that is relative to the path of the link, i.e. `name`. For details on *soft-link* resolution, see section 6.4.2.

This function returns in `success` non-zero if creation of the lock succeeded, or 0 in case of failure. In either case, `IoErr()` is set to an error code on failure, or 0 on success.

6.4.2 Resolving Soft-Links

The `ReadLink()` function locates the destination of a *soft-link* and constructs from the path and directory of the link a new path that identifies the target of the link. A typical use case for this function is if a *dos.library* function returns with the error `ERROR_IS_SOFT_LINK`, indicating that the *file system* needs help from a higher layer to grant access to the object. You then typically retry the access to the object with the path constructed by this function. Note well that this path may be that of yet another *soft-link*, requiring recursive resolution of the link. To avoid endless recursion, this loop should be aborted after a maximum number of attempts, then generating an error such as `ERROR_TOO_MANY_LEVELS`. A suggested maximum level of nested *soft-links*, also used by the *dos.library*, is 15 links.

Note, however, that such steps would not be necessary for the functions listed in table 23 as they already perform such steps internally.

```
success = ReadLink( port, lock, path, buffer, size)
D0                    D1    D2    D3     D4     D5

BOOL ReadLink( struct MsgPort *, BPTR, STRPTR, STRPTR, ULONG)
```

This function creates in `buffer` of `size` bytes a path to the target of a *soft-link* contained in the input `path` relative to the directory represented by `lock`. Typically, `path` is the path given to some object you attempted to access, and `lock` is the *lock* as given by the current directory to which the path is relative. The output path constructed in `buffer` is then an updated path relative to the same directory, i.e. relative to `lock`.

The `port` is the message port of the file system that is queried to resolve the *soft-link*; this port should be obtained from `GetDeviceProc()`, see section **??**. For relative paths, this port is identical to the one in the `fl_Task` member of the `FileLock` structure representing `lock`, see section 5.2.5.

If `size` is too small to hold the adjusted path, the function returns 0 and sets `IoErr()` to `ERROR_LINE_TOO_LONG`.

The function returns non-zero in case of success, or 0 in case of error. In either case, `IoErr()` is set to ether 0 on success, or an error code otherwise.

6.5 Notification Requests

Notification requests allow programs to monitor file or directory changes. If so, either a signal or a message can be send to a specific task, informing it on the modification. If the notification request is issued on a file, any attempt to modify the contents of the file will trigger the notification request. However, in order to avoid too many request to be send out, the triggering the request is delayed until after the corresponding file is closed.

If issued on a directory, attempts to add or remove files or links will trigger the request, as well as renaming files. Whether changes of metadata such as protection bits or comments are considered modifications is not clearly defined and not all versions of all AmigaDOS file systems handle it consistently. The most recent version of AmigaDOS will consider such modifications sufficient to trigger a notification.

A typical application of notification requests is the `IPrefs` program which uses such requests to monitor changes of the preferences files. If it detects any changes of the preferences, it reloads the contents of the files and re-installs the preferences into the components it serves, most importantly `intuition`.

6.5.1 Request Notification on File or Directory Changes

The `StartNotify()` function starts monitoring a file or directory for changes, and if such modifications are found, a signal or a message is send to a task.

```
success = StartNotify(notifystructure)
D0                          D1

BOOL StartNotify(struct NotifyRequest *)
```

This function starts a notification request as described by the `notifystructure` argument. This structure shall be initialized by the caller, and is then enqueued in the file system until the notification request is terminated by `EndNotify()`. Once issued, the request shall not be touched anymore as the *file system* may access it any time. As some field require zero-initialization at this point, it is advisable to allocate it through exec with the `MEMF_CLEAR` flag set.

The `NotifyRequest` structure is defined in `dos/notify.h` and reads as follows:

```
struct NotifyRequest {
    UBYTE *nr_Name;
    UBYTE *nr_FullName;
    ULONG nr_UserData;
    ULONG nr_Flags;
    union {
        struct {
            struct MsgPort *nr_Port;
        } nr_Msg;

        struct {
           struct Task *nr_Task;
           UBYTE nr_SignalNum;
           UBYTE nr_pad[3];
        } nr_Signal;
    } nr_stuff;
    ULONG nr_Reserved[4];
    /* internal use by handlers */
    ULONG nr_MsgCount;
    struct MsgPort *nr_Handler;
};
```

The elements of this structure shall be initialized as follows:

`nr_Name`: The path to the object to be monitored, relative to the current directory. While it seems plausible that issuing a notification request on a not yet existing object will trigger a notification once such an object is created, this type of notification is currently not supported by AmigaDOS.

`nr_FullName` is initialized by the file system and shall be left alone by the caller. The *dos.library* uses it to store the full path of the object to monitor.

`nr_UserData` is free for use by the calling application. It may be used to distinguish multiple notification requests that have been issued in parallel.

`nr_Flags` identifies the activity that is performed when a change has been detected by a *file system*. Currently, the following flags are defined in `dos/notify.h`:

Table 25: Notification Flags

Flag	Purpose
`NRF_SEND_MESSAGE`	Send a message on a file system change
`NRF_SEND_SIGNAL`	Set a signal on a change
`NRF_WAIT_REPLY`	Wait for a reply before notifying again
`NRF_NOTIFY_INITIAL`	Notify immediately when queuing the request

All other bits are currently reserved. In specific, bits 16 upwards are free for the file system to use.

The flags `NRF_SEND_MESSAGE` and `NRF_SEND_SIGNAL` are mutually exclusive. Exactly one of the two shall be included in the request to identify the activity that is performed when the monitored object changes.

`NRF_WAIT_REPLY` indicates to the file system that it should not continue to send a notification message while it has already send one message before that has not yet been replied. Thus, setting this flag prevents notification requests to pile up at the recipient. However, if one or multiple changes were detected while the first request was triggered but not yet responded, replying to this first notification message will immediately trigger a *single* subsequent request.

`NRF_NOTIFY_INITIAL` will instruct the file system to trigger a notification message or signal immediately after the request has been received. This allows applications to roll both the initial action and the response of the notification into a single function — for example, for reading or re-reading a preferences file.

`nr_Port` is only used if the `NRF_SEND_MESSAGE` flag is set in `nr_Flags`. It points to a `MsgPort` structure to which a `NotifyMessage` is send when a change has been detected. This structure is specified at the end of this section.

`nr_Task` and `nr_SignalNum` are only used if the `NRF_SEND_SIGNAL` flag is set in `nr_Flags`. `nr_Task` is a pointer to the `Task` that will be informed, and `nr_SignalNum` the bit number of the signal that is set. It is not a bit mask. Clearly, `NRF_WAIT_REPLY` does not work in combination with signal bits.

`nr_Pad` are only present for alignment and shall be left alone.

`nr_Reserved` shall be zero-initialized by the caller and are reserved for future extensions.

`nr_MsgCount` shall not be touched by the caller and reserved purely for the purpose of the *file system*. It is there used to count the number of messages that have been send out to the client, but have not yet been responded. The client, i.e. the caller, shall not interpret or modify this member.

`nr_Handler` shall neither be touched by the caller; it is used by AmigaDOS to store the `MsgPort` of the *file system* responsible for this notification request, and in particular, which to contact for ending a notification request.

If `NRF_SEND_MESSAGE` is set, then the *file system* sends a `NotifyMessage` to `nr_Port` upon detection of a change; this structure is also defined in `dos/notify.h` and looks as follows:

```
struct NotifyMessage {
    struct Message nm_ExecMessage;
    ULONG  nm_Class;
    UWORD  nm_Code;
    struct NotifyRequest *nm_NReq;
    ULONG  nm_DoNotTouch;
    ULONG  nm_DoNotTouch2;
};
```

`nm_ExecMessage` is a standard `exec` message as documented in `exec/ports.h`.

`nm_Class` is always set to `NOTIFY_CLASS`, also defined in `dos/notify.h`, to identify this message as notification.

`nm_Code` is always set to `NOTIFY_CODE`, again defined in `dos/notify.h`. This again may be used to identify notifications.

`nm_NReq` is a pointer to the `NotifyRequest` through which this message was triggered. This may allow clients to identify the source of the request and by that the object that has been changed.

`nm_DoNotTouch` and `nm_DoNotTouch2` are strictly for use by the *file system* and shall not be touched or interpreted by the caller or the client.

This function returns a boolean success indicator. It returns a non-zero result code on success and then sets `IoErr()` to 0. On error, the function returns 0 and sets `IoErr()` to a non-zero error code.

6.5.2 Canceling a Notification Request

The `EndNotify()` function cancels an issued notification request.

```
EndNotify(notifystructure)
D1

void EndNotify(struct NotifyRequest *)
```

This function cancels the notification request identified by `notifystructure`. This function shall only be called on notification requests that have been successfully issued by `StartNotify()`. If caller did not yet reply all `NotifyMessage` messages and some are still piled up in the `nr_Port`, the *file system* will manually dequeue them from this port.

Afterwards, the `notifystructure` is again available for the caller, for example to either release its memory, or to start another notification request.

Chapter 7

File System Support Functions

Functions in this section act on a *file system* as a whole; thus, they do not need a file or a lock to operate on, but modify the file system globally.

7.0.1 Adjusting File System Buffers

The `AddBuffers()` function increases or reduces the number of buffers of a file system.

```
success = AddBuffers(filesystem, number)
D0        D1          D2

BOOL AddBuffers(STRPTR, LONG)
```

This function adds `number` buffers to the file system whose name is given by `filesystem`. This name consists of a filename, volume, or assign on the *file system* whose buffer count shall be modified, see also `GetDeviceProc()` in section **??** how a file system is located.

The `number` argument may be both positive — for adding buffers to the file system — or negative, to reduce the number of buffers. The purpose of these buffers is file-system dependent. The Fast File System in ROM uses it to buffer administrative information such as directory contents, but also blocks that describe the location of file content on the disk; thus adding more buffers can help to improve the performance of random-access into the file with `Seek()`.

A third purpose of the buffers is to store input and output data of `Read()` or `Write()` if the operation is not aligned to block boundaries or if the source or target buffer is considered unsuitable for direct transfer to the underlying hardware exec device.

This function returns a non-zero result on success and 0 on failure. In first case, it sets `IoErr()` to 0, otherwise it is set to an error code. Some file systems return the current number of buffers allocated; callers should thus be prepared that the return code is not equal to `DOSTRUE` to indicate success.

7.0.2 Change the Name of a Volume

The `Relabel()` function changes the name of a volume a file system operates on.

```
success = Relabel(volumename,name)
D0                    D1      D2

BOOL Relabel(STRPTR,STRPTR)
```

This function relables the volume that resides on the *file system* corresponding to the `volumename` path. This path is resolved through `GetDeviceProc()` and thus may be a relative or absolute path, the device or the volume name. As `filesystem` is interpreted as a path, a device or volume name passed in shall include a colon (“`:`”) as it would be otherwise interpreted as a path relative to the current directory.

The volume name of the medium or partition is then changed to `name`. Unlike the first argument, `name` shall *not* contain a colon (“`:`”) nor a slash (“`/`”).

This function returns a non-zero result code for success or 0 for an error. In the first case, it sets `IoErr()` to 0, in the latter case to an error code.

7.0.3 Initializing a File System

The `Format()` function initializes a complete file system, writing administration information on the file system that corresponds to an empty medium. Thus, this function erases all information stored in it.

```
success = Format(filesystem, volumename, dostype)
D0                     D1          D2          D3

BOOL Format(STRPTR, STRPTR, ULONG)
```

This function erases all information on the medium or partition identified by `filesystem`, which is interpreted as a path. Thus, it may be a device or volume name, which shall then be terminated by a colon (“`:`”). However, all other path names also work; however, if they do not include a colon, the argument is interpreted as a path name relative to the current directory, and thus will initialize the file system corresponding to it. This is probably not desirable.

To block processes from accessing information on the file system while it is initializing, it should be inhibited upfront, e.g by `Inhibit(filesystem,DOSTRUE)` or lower level direct communication to the handler, see section **??**. Initializing is the only operation file systems are able to perform while being inhibited.

The `Format()` function *does not* attempt a low-level initialization of the corresponding medium; that is, it does not attempt to low-level format it on the physical layer as required when a floppy disk shall be prepared for initial use. This step needs to be performed manually by first blocking access of the file system to the floppy through `Inhibit()`, then initializing the physical layer through the exec device driver upfront, e.g. by the command `TD_FORMAT`, and then finally by calling this function.

The volume name of the medium or partition is initialized to `volumename`, which *shall not* contain a colon (“`:`”) nor a slash (“`/`”). Note that not all file systems support volume names. In such cases, this argument is ignored.

The `dostype` defines the flavour of file system created on the device if the file system allows multiple variations. The variations the Fast File System supports along with other file systems are listed in table 28. This corresponds to the `DOSTYPE` in the mount list. File systems may also ignore this argument if they only support a single flavour.

Unfortunately, AmigaDOS does not provide an easy way to access the flavours supported by a file system. The `Format` command of the workbench offers the types listed in the first half of table 28 if the mount entry of the file system indicates that it is the FFS, and otherwise does not offer any choices and just copies the `dostype` from the `de_DosType` of the `DosEnvec` structure, see also section **??**.

After initializing the *file system*, use `Inhibit(filesystem,DOSFALSE)` or the corresponding lower level packet `ACTION_INHIBIT` to grant the file system access to the partition or medium again. As the volume name can be different and *locks* or *file handles* on the original file system clearly became invalid, it is advisable to pass the *device name* of the *file system* to `Inhibit()` if this call is used, see also sections 4.3.1.1 and 7.0.4.

This function returns a boolean success indicator that is non-zero on success or 0 on error. In either case, `IoErr()` is set to 0 on success or an error code on failure.

7.0.4 Inhibiting a File System

The `Inhibit()` function disables or enables access of the *file system* to the underlying exec device driver. Typical application for this function are disk editors or file system salvage tools that require exclusive access to the file system structure.

```
success = Inhibit(filesystem, flag)
D0                    D1       D2

BOOL Inhibit(STRPTR,LONG)
```

This call controls whether the file system identified by the path name given as `filesystem` is allowed to access the medium or partition it usually operates on. The `filesystem` argument is interpreted through `GetDeviceProc()` to find the process responsible for the medium. That is, the function resolves relative and absolute paths, device and volume names, and even assigns. As `filesystem` is interpreted as a path, a device or volume name passed in shall include a colon ("`:`") as it would be otherwise interpreted as a path relative to the current directory.

The `flag` argument controls whether access to the medium is allowed or disallowed. If `flag` is set to `DOSTRUE`, access is inhibited and the *file system* stops accessing the partition or volume. It also sets `id_DiskType` to the four-character code `'BUSY'`, which will be interpreted by the workbench to ghost the corresponding drive icon. Application programs are then allowed to access the exec device driver directly to access or modify blocks within the partition managed by the inhibited *file system*.

If `flag` is set to `DOSFALSE`, access to the medium is allowed again. The *file system* then performs a consistency check of the file system structure of the disk, i.e. validates it.

This function returns a non-zero result code for success and then sets `IoErr()` to 0. On error, it returns 0 and provides an error code in `IoErr()`.

Chapter 8

Administration of Volumes, Devices and Assigns

The *dos.library* is just a layer of AmigaDOS that provides a common API for input/output operations; these operations are not implemented by the library itself, but forwarded to *file systems* or *handlers*. This forwarding is based on the exec *message* and *message port* system, and to this end, the `FileLock` structure and the `FileHandle` structure contain a pointer to a `MsgPort`.

However, the *dos.library* also needs to obtain this port from somewhere; for relative paths (see section 4.3), the current directory (see section 10.2.8) provides it. For absolute paths, i.e. paths that contain a colon (':'), the string upfront the colon identifies handler, directly or indirectly. If this string is empty, i.e. the path starts with a colon, it is again the handler of the current directory that is contacted, but otherwise, the dos searches the *device list* to find a suitable *message port*. This algorithm is also available as a function, namely `GetDeviceProc()`, which is documented in section **??**.

Internally, the *dos.library* keeps the relation between such names and the corresponding ports in the `DosList` structure. Such a structure is also created when *mounting* a handler, i.e. advertizing the handler to the system, or when creating an *Assign*, see section 4.3.1.3, or when inserting a disk into a drive, thus making a particular *volume* available to the system (see also 4.3.1.2). Only the names from table 5 in 4.3.1.1 are special cases and hard-coded into the *dos.library* without requiring an entry in the *device list* in the form of a `DosList` structure.

This structure, defined in `dos/dosextens.h` reads as follows:

```
struct DosList {
    BPTR                dol_Next;
    LONG                dol_Type;
    struct MsgPort     *dol_Task;
    BPTR                dol_Lock;
    union {
      struct {
        BSTR    dol_Handler;
        LONG    dol_StackSize;
        LONG    dol_Priority;
        ULONG   dol_Startup;
        BPTR    dol_SegList;
        BPTR    dol_GlobVec;
      } dol_handler;

      struct {
```

```
      struct DateStamp        dol_VolumeDate;
      BPTR                    dol_LockList;
      LONG                    dol_DiskType;
    } dol_volume;

    struct {
      UBYTE   *dol_AssignName;
      struct AssignList *dol_List;
    } dol_assign;

  } dol_misc;

  BSTR                dol_Name;
};
```

and its members have the following purpose:

dol_Next is a *BPTR* to the corresponding next entry in a singly linked list of DosList structures. However, this list should not be walked manually, but instead FindDosEntry() should be used for iterating through this list.

dol_Type identifies the type of the entry, and by that also the layout of the structure, i.e. which members of the unions are used. The following types are defined in dos/dosextens.h:

Table 26: *DosList* Entry Types

dol_Type	Description
DLT_DEVICE	A *file system* or *handler*, see 4.3.1.1
DLT_DIRECTORY	A regular assign, see 4.3.1.3
DLT_VOLUME	A volume, see 4.3.1.2
DLT_LATE	A late binding assign, see 4.3.1.3
DLT_NONBINDING	A non-binding assign, see 4.3.1.3

dol_Task is the *MsgPort* of the handler to contact for the particular *handler*, *assign* or *volume*. It may be NULL if the *handler* is not started, or a new handler process is supposed to be started for each file opened. This is, for example, the case for the console which requires a process for each window it handles. *File systems* usually provide their port here such that the same process is used for all objects on the volume. *Volumes* keep here the *MsgPort* of the *file system* that operates the volume, but it to NULL in case the volume goes away, e.g. is ejected. For *regular assigns*, this is also the pointer to the *MsgPort* of the *file system* the assign binds to; in case the assign is a *multi-assign*, this is the *MsgPort* of the first directory bound to. All additional ports are part of the AssignList. For *late assigns* this member is initially NULL, but will be filled in as soon as the assign in bound to a particular directory, and then becomes the pointer to the *MsgPort* of the handler the assign is bound to. Finally, for *non-binding assigns* this member always stays NULL.

dol_Lock is only used for *assigns*, and only if it is bound to a particular directory. That is, the member remains ZERO for *non-binding assigns* and is initially ZERO for *late assigns*. For all other types, this member stays ZERO.

dol_Name is a *BPTR* to a *BSTR* is the name under which the *handler*, *volume* or *assign* is accessed. That is, this string corresponds to the path component upfront the colon. As a courtesy to C and assembler functions, AmigaDOS ensures that this string is NUL terminated, i.e. dol_Name + 1 is a regular C string whose length is available in dol_Name[0].

The members within dol_handler are used by *handlers* and *file systems*, i.e. if dol_Type is DLT_DEVICE.

`dol_Handler` is a *BPTR* to a *BSTR* containing the file name from which the *handler* or *file system* is loaded from. It corresponds to the `Handler`, `FileSystem` and `EHandler` fields of the mount list. They all deposit the file name here.

`dol_StackSize` specifies the size of the stack for creating the *handler* or *file system* process. Interestingly, the unit of the stack size depends on the `dol_GlobVec` entry. If `dol_GlobVec` is negative indicating a C or assembler handler, `dol_StackSize` is in bytes. Otherwise, that is, for BCPL handlers, it is in 32-bit long words. This member corresponds to the `Stacksize` entry of the mount list.

`dol_Priority` is priority of the handler process. Even though it is a `LONG`, it shall be a number between -128 and 127 because priorities of the exec task scheduler are `BYTE`s. For all practical purposes, the priority should be a value between 0 and 19. It corresponds to the `Priority` entry of the mount list.

`dol_Startup` is a handler-specific startup value that is used to commumicate a configuration to the handler during startup. While this value may be whatever the handler requires, the `mount` command either deposits here a small integer, or a pointer to the `FileSysStartupMsg` structure defined in `dos/filehandler.h`. Section **??** provides more details on mounting handlers and how the startup mechanism works. Unfortunately, it is hard to interpret `dol_Startup` correctly. One way to set this member is to set `Startup` in the mount list, see 8.1.2 for details.

`dol_SegList` is a *BPTR* to the chained segment list of the handler if it is loaded. For disk-based handlers, this member is initially `ZERO`. When a program attempts to access a file on the handler, the *dos.library* first checks whether this field is `ZERO`, and if so, attempts to find a segment, i.e. a binary, for the handler. If the `FORCELOAD` entry of the mount list is non-zero, the `mount` command already performs this activity. The process of loading a handler depends on the nature of the handler and explained in more detail in section **??**.

`dol_GlobVec` identifies the nature of the handler as AmigaDOS supports (still) BPCL and C/assembler handlers and defines how access to the *dos list* is secured for handler loading and startup. BCPL handlers use a somewhat more complex loading and linking mechanism as the language-specific *global vector* needs to be populated. This is not required for C or assembler handlers where a simpler mechanism is sufficient, more on this in section **??**. Another aspect of the startup process is how the *device list* is protected from conflicting accesses from multiple processes. Two types of access protection are possible: Exclusive access to the list, or shared access to the list. Exclusive access protects the *device list* from any changes while the handler is loaded and until handler startup completed. This prevents any other modification to the list, but also read access from any other process to the list. Shared access allows read accesses to the list while preventing exclusive access to it.

The value in `dol_GlobVec` corresponds to the `GlobVec` entry in the mount list. It shall be one of the values in table 27.

Table 27: GlobVec Values

dol_Type	Description
`-1`	C/assembler handler, exclusive lock on the *dos list*
`-2`	C/assembler handler, shared lock on the *dos list*
`0`	BCPL handler using system GV, exclusive lock on the *dos list*
`-3`	BCPL handler using system GV, shared lock on the *dos list*
`>0`	BPCL handler with custom GV, exclusive lock on the *dos list*

The values 0, -3 and > 0 all setup a BCPL handler, but differ in the access type to the *device list* and how the BCPL *global vector* is populated. This vector contains all global objects and all globally reachable functions of a BCPL program, including functions of the *dos.library*. The values 0 and -3 fill this vector with the system functions first, and then use the BPCL binding mechanism to extend or override entries in this vector with the values found in the loaded code. Any values > 0 defines a *BPTR* to a custom vector which is used instead for initializing the handler. This startup mechanism has never been used in AmigaDOS and is not quite practical as this vector needs to be communicated into the *dos.library* somehow. For new code, BCPL linkage and binding should not be used anymore.

Members of the dol_volume structure are used if dol_Type is DLT_VOLUME, identifying this entry as belonging to a known specific data carrier.

dol_VolumeDate is the creation date of the volume. It is a DateStamp**??** structure that is specified in section **??**. It is used to uniquely identify the volume, and to distinguish this volume from any other volume of the same name.

dol_LockList is a pointer to a singly-linked list of *locks* on the volume. This list is created by the *file system* when the volume is ejected, and contains all locks on this volume. It is stored here to allow a similar file system to pick up the locks once the volume is re-inserted, even if it is re-inserted into another device. Note that the linkage is performed with *BPTR*s and the fl_Link member of the FileLock structure.

dol_DiskType is an identifier of the *file system type* that operated the volume and placed here such that an alternative process of the same file system is able to pick up or refuse the locks stored here for non-available volumes.

Members of the dol_assign structure are used for all other types, i.e. all types of *assigns*.

dol_AssignName is pointer to the target name of the assign for *non-binding* and *late assigns*. The *dos.library* uses this string to locate the target of the assign. For *late assigns*, this member is used only on the first attempt to access the assign at which dol_Lock is populated.

dol_List contains additional locks for *multi-assigns* and is only used if dol_Type is DLT_DIRECTORY. In such a case, dol_Lock is the lock to the first directory of the *multi-assign*, while dol_List contains all following *locks* in a singly-linked list of AssignList structures:

```
struct AssignList {
        struct AssignList *al_Next;
        BPTR               al_Lock;
};
```

al_Next points to the next *lock* that is part of the *multi-assign* and al_Lock is the lock itself. This structure is also defined in dos/dosextens.h.

8.1 The Device List and the Mount List

Entries of the type DLT_DEVICE can be created through a Mountlist and the Mount command. Other sources of these entries are the *expansion.library* which is called from autoconfiguring boot devies, such as SCSI hostadapters or other media interfaces.

Many keywords in the Mountlist map directly to entries in the DosList structure, others to entries in the FileSysStartupMsg and the DosEnvec structure pointed to there.

8.1.1 Keywords defining the DosList structure

The HANDLER, EHANDLER and FILESYSTEM keywords in the Mountlist do all three into the dol_Handler member. Which keyword is used impacts, however, other elements of the DosList, most notably dol_Startup.

The STACKSIZE keyword sets dol_StackSize element. This is in bytes for C and assembler handlers, and in long-words for BCPL handlers. The type of the handler is determined by GLOBVEC.

The PRIORITY keyword sets dol_Priority and with that the priority of the process running the handler.

The GLOBVEC keyword sets dol_GlobVec element, and by that also the type of the handler. Table 27 in 8 lists the possible values and their interpretation.

If the HANDLER keyword is present, the STARTUP entry in the Mountlist sets dol_Startup. It can be either an integer value, or if the argument is enclosed in double quotes, a string. In the latter case, `dol_Startup` is set to a *BPTR* to a *BSTR* that is, to ease handler implementation, also `NUL` terminated. The terminator is, however, not included in the size of the *BSTR*. It is therefore up to the user to ensure that the arguments in the `Mountlist` are what the handler expects.

8.1.2 Keywords controlling the FileSysStartupMsg

If the `EHANDLER` or `FILESYSTEM` keyword is present, `dol_Startup` is instead a *BPTR* to a `FileSysStartupMsg` structure, defined in `dos/filehandler.h`:

```
struct FileSysStartupMsg {
    ULONG       fssm_Unit;
    BSTR        fssm_Device;
    BPTR        fssm_Environ;
    ULONG       fssm_Flags;
};
```

It is again up to the user to ensure that the handler is really expecting such a structure and setup the `Mountlist` appropriately.

The elements of the above structure identify an exec type device on top of which the *handler* or *file system* is supposed to operate. Some extended handlers, i.e. `EHANDLER`s, also use this structure; the V47 `Port-Handler` can be setup this way to operate on top of a third-party serial device driver.

The `DEVICE` keyword of the `Mountlist` sets `fssm_Device` entry. This element is initialized to a *BSTR*. To avoid further string conversion when calling `OpenDevice()`, this *BSTR* is `NUL`-terminated.

The `UNIT` keyword sets `fssm_Unit` and therefore the unit number of the exec device on top of which the file system or handler should operate.

The `FLAGS` keyword sets `fssm_Flags` element, and thus the flags for opening an exec type. Its purpose and meaning is specific to the device identified by `fssm_Device`.

8.1.3 Keywords controlling the Environment Vector

The `fssm_Environ` element of the `FileSysStartupMsg` is a *BPTR* to another structure that describes, amongst others, the layout of a *file system* on a disk; beyond *file systems*, extended handlers mounted by the `EHANDLER` keyword may also make use of it.

This structure is also defined in `dos/filehandler.h` and looks as follows:

```
struct DosEnvec {
    ULONG de_TableSize;      /* Size of Environment vector */
    ULONG de_SizeBlock;      /* in longwords: physical disk block size */
    ULONG de_SecOrg;         /* not used; must be 0 */
    ULONG de_Surfaces;       /* # of heads (surfaces). drive specific */
    ULONG de_SectorPerBlock; /* physical sectors per logical block */
    ULONG de_BlocksPerTrack; /* blocks per track. drive specific */
    ULONG de_Reserved;       /* DOS reserved blocks at start of partition. */
    ULONG de_PreAlloc;       /* DOS reserved blocks at end of partition */
    ULONG de_Interleave;     /* usually 0 */
    ULONG de_LowCyl;         /* starting cylinder. typically 0 */
    ULONG de_HighCyl;        /* max cylinder. drive specific */
    ULONG de_NumBuffers;     /* Initial # DOS of buffers.  */
    ULONG de_BufMemType;     /* type of mem to allocate for buffers */
    ULONG de_MaxTransfer;    /* Max number of bytes to transfer at a time */
    ULONG de_Mask;           /* Address Mask to block out certain memory */
```

```
    LONG  de_BootPri;         /* Boot priority for autoboot */
    ULONG de_DosType;         /* ASCII (HEX) string showing filesystem type;
                               * 0X444F5300 is old filesystem,
                               * 0X444F5301 is fast file system */
    ULONG de_Baud;            /* Baud rate for serial handler */
    ULONG de_Control;         /* Control word for handler/filesystem */
    ULONG de_BootBlocks;      /* Number of blocks containing boot code */

};
```

The elements in this structure, except the first one, are also initialized by keywords in the mount list.

de_TableSize defines how many elements in this structure are actually valid and thsu may be accessed by the *handler* or *file system*. It is *not* a byte count, but an element count, excluding de_TableSize. In other words, the DosEnvec is a typical BCPL vector whose vector size is indicated in its first element — note that all elements of the structure are 32-bits wide.

The keyword SECTORSIZE and BLOCKSIZE set both de_SizeBlock. While the Mountlist keywords take a byte count, this byte count is divided by 4 to form a long-word count that is inserted into de_SizeBlock. As the name suggests, it defines the size of a storage unit on a medium. Typical values are 128 for 512 byte blocks, or 1024 for 4096 byte blocks. However, not all file systems support all block sizes, and some only support the default value of 128, i.e. 512 byte blocks, the Mount command fills in without further information.

de_SecOrg is not used and shall be 0; consequently, the Mount command does not provide a keyword to set it.

The SURFACES keyword sets de_Surfaces. A possible meaning for this member is to interpret it as the number of read-write heads of a magnetic disk drive. However, as the exec device trackdisk interface for magnetic storage media does not actually allow access to such low-level features that are rather abstracted away by the device, *file systems* rather use this value along with de_BlocksPerTrack the number of cylinders computed from de_LowCyl and de_HighCyl to determine the capacity of the medium.

The SECTORSPERBLOCK keyword sets the de_SectorsPerBlock, and thus the number of physical sectors on a disk the *file system* combines to one longical storage block. Not all *file systems* support values different from 1 here; the FFS does, and always reads and writes data in units of de_SectorsPerBlock times de_SizeBlock of long-words. For the exec trackdisk interface, the byte size is the only value that matters; however, the "direct SCSI" transfer latest FFS releases offer addresses the disk in terms of physical sectors, and then de_SizeBlock defines the size of a sector in long-words as addressed by SCSI commands, whereas de_SectorsPerBlock is the number of physical sectors the FFS reads for one logical block.

The SECTORSPERTRACK and BLOCKSPERTRACK keywords set both the de_BlocksPerTrack element of the DosEnvec structure. The first name is actually most appropriate as this element defines the number of physical sectors, and not the number of logical blocks a track of a disk contains. Thus, naming is a historical accident. As for the SURFACES keyword, the number of sectors per track is only in so far relevant as it defines along with the first and last cylinder the storage capacity of the medium or partition. The values never enter the exec layer.

The RESERVED keyword sets the de_Reserved element of DosEnvec and defines the number of (logical) blocks not used by the *file system* at the start of the disk or partition. For floppies, these reserved blocks hold a (minimal) boot procedure that initializes the *dos.library*.

The PREALLOC keyword installs the de_PreAlloc element, which is supposed to be the number of logical blocks set aside at the end of the partition. However, current FFS versions completely ignore this element.

The INTERLEAVE keyword defines the lower 16 bits of the de_Interleave element. TRIPOS might have reserved the entire long-word to define the interleave factor of the disk, and the difference between two sector addresses the file system is supposed to reserve for subsequent storage. This interleave factor helped to speed up transfers for ancient harddisks, but neither the original OFS nor the latest FFS make use of this mechanism and allocate sectors contiguously, i.e. with an interleave factor of 1. The upper 16 bits of `de_Interleave` suit now a different purpose and are set by separate keywords of `Mount`.

The `LOWCYL` keyword initializes the `de_LowCyl` element of the `DosEnvec` structure. It sets the lower end of the partition on the storage medium, i.e. `de_LowCyl` × `de_Surfaces` × `de_BlocksPerTrack` + `de_Reserved` × `de_SectorsPerBlock` is the first physical sector number on a disk that can carry payload data of the file system.

The `HIGHCYL` keyword sets the `de_HighCyl` element; it defines the (inclusive) upper end of the partition in units of cylinders. That is, (`de_HighCyl` + 1) × `de_Surfaces` × `de_BlocksPerTrack` −1 is the last sector of the partition or medium the *file system* can allocate for payload data.

The `BUFFERS` keyword sets the `de_NumBuffers` element; it defines the (initial) number of file system buffers allocated for caching metadata and storing data not directly accessible through the exec device driver. The number of buffers may be changed later with `AddBuffers()`, see section 7.0.1. Each buffer is one (logical) block large.

The `BUFMEMTYPE` defines the `de_BufMemType` element. It defines the memory type, i.e. the second argument of `AllocMem()`, for allocating memory keeping the file system buffers. While exec device drivers should be able read and write data to any memory type, several legacy rivers may not be able reach all memory; this may be due to limitations of the hardware such that Zorro-II hardware cannot reach 32-bit memory. Thus, depending on limitations of the `fssm_Device`, it is unfortunately up to the user to provide a suitable `BUFMEMTYPE`.

The `MASK` keyword defines the `de_Mask` element of the `DosEnvec` structure. The mask is a workaround for defect device drivers that cannot read or write to all memory types. In particular, if the address of the host memory buffer has bits set in positions where the mask contains 0 bits, the*file system* shall assume that the device cannot reach this memory. Instead, it shall perform input or output indirectly through its buffers, and copy with the CPU between those buffers and the target or source memory block.

> *Masking Defects* The purpose of the mask is to hide defects in device drivers and provide a working system in the absence of a fully functional device driver. A rather typical value for the mask is `0x00ffffff`, indicating that the device cannot reach 32-bit memory. A suitable memory type would then be `MEMF_24BITDMA | MEMF_PUBLIC`, i.e. 513 as decimal value. This requests 24-bit memory for the buffers. Note that providing a mask is useless if the memory type does not allocate memory that fits to the mask.

The `MAXTRANSFER` keyword sets `de_MaxTransfer`. This value sets the maximum number of bytes the *file system* shall read or write by a single I/O operation. Similar to `MASK`, it is a workaround required to avoid problems with defect device drivers that corrupt data if too many bytes are read or written in one go.

> *MaxTransfer is not a rate* The MaxTransfer keyword or element describe a byte count that, when exceeded, requests the file system to break up transfers. While that implicitly limits the throughput of the device, it does not define a rate (i.e. in units of bytes per second), as the problem device drivers have is typically not the transfer rate, but the amount of data to transfer.

The `BOOTPRI` keyword sets the `de_BootPri` element which defines the order in which the system attempts to boot from a partition or medium. Obvously, it makes little sense to set this keyword in a `Mountlist` that is interpreted after the system had already booted. However, autobooting devices may set an appropriate value here, for example by reading it from the RDB of its disk.

The `DOSTYPE` keyword sets the `de_DosType` element, identifying the type and flavour of the file system to use for the medium or partitiion. If the `FILESYSTEM` keyword is present, but the `FORCELOAD` is either not present or set to 0, then the `Mount` command first attempts to find a suitable file system in the

FileSystem.resource whose fse_DosType matches de_DosType, avoiding to load the same file system again. If a match is found, the FileSysEntry of the resource is used to initialize the DosEnvec, in particular dol_SegList. Table 28 in lists the available file systems.

Table 28: Fast File System Flavours

FFS Flavour	Description
ID_DOS_DISK	Original file system (OFS)
ID_FFS_DISK	First version of FFS
ID_INTER_DOS_DISK	International variant of OFS
ID_INTER_FFS_DISK	International variant of FFS
ID_FASTDIR_DOS_DISK	OFS variant with directory cache
ID_FASTDIR_FFS_DISK	FFS variant with directory cache
ID_LONG_DOS_DISK	OFS variant with 106 character file name size
ID_LONG_FFS_DISK	FFS variant with 106 character file name size
ID_COMPLONG_FFS_DISK	FFS with 54 character file names compatible to FFS
'MSD\0'	FAT on a disk without partition table
'MDD\0'	identical to the above, FAT on a floppy
'MSH\0'	FAT on a partition
'FAT\0'	FAT, switched by the SuperFloppy disk
'CD0\0'	Original CD File system
'CD0\1'	CD File System with Joliet support

The first part of the table indicates various versions of the ROM file system; the original version from TRIPOS is here denoted as OFS, though this name mostly distignuishes it from its later reimplementation, the FFS.

The OFS variants embed additional administration information into the data blocks and thus carry less payload data per block, and for that are more robust, but are slower as the data cannot be transmitted by DMA into the host memory but requires an additional copy. The first FFS variant addresses this issue. Both first types use, however, a non-suitable algorithm for case-insensitive comparison of file names and thus do not interpret character from the extended ISO-Latin-1 set (i.e. printable characters outside the ASCII range) correctly. Thus, the first two types should be avoided.

Proper case-insensitive interpretation of file names was added afterwards, leading to the next two flavours which are otherwise identical. All types from that point on in table 28 until its end use the correct algorithm to compare file names.

The next two versions administrate an additional directory cache; while this cache typically speeds up listing the directory, it also requires additional update steps when adding or renaming files, making such operations slower and more error prone. These variants unfortunately also lack a good algorithm to clean up the cache if objects are continuously added and removed from directories. These variants are not generally recommended and should be considered experimental.

The LONG variants of OFS and FFS allow file names of up to 106 characters by using a slightly modified block syntax which overcomes the 30 character file name limit all above variants suffer from. They also use the correct case-insensitive file name comparison. In some rare cases, the administration information is augmented by one additional block keeping a long comment.

The last variant offers a compatible form of long file names that is backwards compatible to earlier variants of the FFS. The file name limit is here 54 characters, though older versions of the FFS can still read the disk correctly, even though they will not be able to locate or list longer file names. This variant is also experimental.

The next group of types indicates various flavours of the MS-DOS FAT file system. The first two types are identical and correspond to a file system on a single disk without a partition table, as found on floppy disks. They are unsuitable for harddisk partitions and thumbdrive partitions.

The second type indicates FAT on a Master Boot Record (MBR) partition as used on (legacy) PC hardware. As AmigaDOS does not natively support the MBR, the file system here (as an architectural tweak) interprets the partition table. Which partition is used is then depending on the last character of the device name, i.e. dol_Name. The C character indicates the first partition, adpoting the convention of the operating system to which FAT is native, the second partition is indicated by the last character of dol_Name being D and so on.

The last type indicates a file system either on a floppy or the first partition of a MBR-formatted disk, depending on the SUPERFLOPPY keyword, see below.

The last group indicates various versions of the CD-Rom — actually ISO Rock Ridge — file system. The first type is the original file system that came with V40 of AmigaDOS, the second the extended version that includes support for Joliet extensions and audio track support. Otherwise, the types are identical.

The BAUD keyword fills the de_Baud element; it is obviously not used by *file systems* but extended handlers that are indicated by the EHANDLER keyword. For them, it provides the baud rate for an (assumed) serial connection.

The CONTROL keyword sets the de_Control element. Even though this element is here indicated as an ULONG, it can be either an integer or a string. In the latter case, the argument to CONTROL shall be enclosed in double quotes, and the Mount command then places a *BPTR* to a *BSTR* in this element. Again, it is up to the user to learn from the handler documentation what the handler expects to find in the DosEnvec structure as there is no type check and no place where the type is indicated.

The BOOTBLOCKS keyword initializes the de_BootBlocks element; it is currently not used by any AmigaDOS file system. The FFS instead depends on de_Reserved.

The SUPERFLOPPY keyword takes a boolean 0 or 1 argument and by that either sets or clears the ENVF_SUPERFLOPPY flag. This flag has been cut off (or reserved) from the otherwise deprecated and thus unused de_Interleave element. It is by default cleared.

If this flag in de_Interleave is set, then the file system is informed that the partition extends over the entire medium and no partition table or RDB is found. Instead, to find the size of the medium, the file system is authorized to issue a TD_GETGEOMETRY command to the low level device driver which will report the layout of the disk. This driver information is then used to adjust de_LowCyl, de_HighCyl, de_SizeBlock and de_Surfaces. Thus, a file system mounted with this flag set is able to extract the device layout directly from the hardware driver. This is important for drives that allow variously sized media, such as floppy disks (supporting both DD and HD disks) as well as ZIP drives (supporting 100MB to 250MB drives).

AmigaDOS up to release V40 hardwired this special case to the trackdisk.device and carddisk.device, i.e. the floppy and memory cards in the PCMCIA slot, though newer releases allow to extend this mechanism to other device drivers as well. As of V47, the FAT and ROM file system both support this mechanism, though it has to be enabled with the 'FAT\0' dostype for the former driver.

The SCSIDIRECT keyword is also a boolean 0/1 indicator and controls the ENVF_SCSIDIRECT flag which is also part of the otherwise deprecated de_Interleave element. It is cleared by default, indicating that the file system should use the trackdisk command set to access data.

If this flag is enabled, the file system is instructed to communicate with the underlying device through the HD_SCSICMD interface, i.e. SCSI commands. This may help some legacy device drivers that do not speak the 64-bit dialect of the trackdisk commands to access data beyond the 4GB barrier. Very anchient device drivers may not even support this command type.

The ENABLENSD keyword is again a boolean 0/1 indicator for the ENVF_DISABLENSD flag cut off from the de_Interleave field; it is, however, set in inverse logic, i.e. the ENVF_DISABLENSD is set if the mount parameter is 0, and reverse.

If the flag in de_Interleave is set, and thus ENABLENSD is set to 0 in the mount list, the file system is instructed not to attempt to use NSD-style commands to access data beyond the 4GB barrier. This may be necessary on some device drivers that ignore the most significant bits of the `io_Command` field or react otherwise allergic to commands beyond the usual range.

Unfortunately, multiple command sets exist to access (moderately) large disks. If `DIRECTSCSI` is enabled, SCSI commands will always be used, even for probing the medium size if `SUPERFLOPPY` is set. If SCSI commands are not enabled, the FFS first attempts to use regular `trackdisk` commands if the requested region of the device does not cross the 4GB barrier. If that is not possible, it probes the `TD64` command set as it is historically the most popular extension. As last resort, it tries `NSD` commands. This last step can be disabled by the line `ENABLENSD = 0` in the `Mountlist` if it creates problems.

The `ACTIVATE` keyword in the `Mountlist` is synonym to the `MOUNT` keyword, and it also takes a boolean 0/1 indicator. If it is set, then the `Mount` command will already load and initiate the handler corresponding to the mount entry, even if it is at this point not yet needed.

The `FORCELOAD` keyword of the `Mountlist`, finally, is another boolean 0/1 flag. If it is set to 1, it indicates to the `Mount` command not to scan the `FileSystem.resource` for a fitting `dostype` but rather forcibly load the *file system* from the path indicated by the `FILESYSTEM` keyword. This option is, for example, useful for testing.

8.2 Finding Handler or File System Ports

The following functions find the *MsgPort* of the *handler* or *file system* that is responsible for a given object. The functions search the *device list*, check whether the handler is already loaded or load it if necessary, then check whether the handler is already running, and if not, launch an instance of it. If *multi-assigns* are involved, it can become necessary to contact multiple *file systems* to resolve the task and thus to iterate through multiple potential *file systems* to find the right one.

8.2.1 Iterate through Devices Matching a Path

The `GetDeviceProc()` find a handler, or the next handler responsible for a given path. Once the handler has been identified, or iteration through matching handlers is to be aborted, `FreeDeviceProc()` shall be called to release temporary resources.

```
devproc = GetDeviceProc(name, devproc)
D0                      D1     D2

struct DevProc *GetDeviceProc(STRPTR, struct DevProc *)
```

This function takes a path in `name` and either `NULL` on the first iteration or a `DevProc` structure from a previous iteration and returns either a `DevProc` structure in case a matching handler could be identified, or `NULL` if no matching handler could be found or all possible matches have been iterated over already already.

> *Give back what you got* To release all temporary resources, the `DevProc` structure returned by `GetDeviceProc()` shall be either be released through `FreeDeviceProc()` then aborting the scan, or used as first argument for `GetDeviceProc()` to continue the iteration. The last call to this function will return `NULL` and then also release all resources.

The `DevProc` structure, defined in `dos/dosextens.h` looks as follows:

```
struct DevProc {
        struct MsgPort *dvp_Port;
        BPTR            dvp_Lock;
        ULONG           dvp_Flags;
        struct DosList *dvp_DevNode;    /* DON'T TOUCH OR USE! */
};
```

dvp_Port is a pointer to a candidate *MsgPort* that should be tried to resolve name.

If the matching handler is a *file system*, then dvp_Lock is a *lock* of a directory. The path in nameis a path relative to this directory. This *lock* shall not be released, but it may be copied with DupLock.

dvp_Flags identifies the nature of the found port. If the bit DVPB_ASSIGN is set, i.e dvp_Flags & DVPF_ASSIGN is non-zero, then the found match is part of a *multi-assign* and GetDeviceProc() may be called again with the devproc argument just returned as second argument. This will return another candidate for a path. DVPB_UNLOCK is another bit of the flags but shall not be interpreted and is only used internally by the function.

The member dvp_DevNode shall not be touched or used and is required internally by the function.

If the function returns NULL, then IoErr() provides additional information on the failure. If the error code is ERROR_NO_MORE_ENTRIES, then the last directory of a *multi-assign* has been reached. If the error code is ERROR_DEVICE_NOT_MOUNTED, then no matching device could be found. Other errors may be returned, e.g. if the function could not allocate sufficient memory for its operation.

Unfortunately, the function does not set IoErr() consistently if GetDeviceProc() is called again on an existing DevProc structure as second argument with DVPB_ASSIGN cleared. IoErr() remains then unaltered and it is therefore advisable to clear it upfront.

The function also returns NULL if name corresponds to the NIL: pseudo-device and then sets IoErr() to ERROR_DEVICE_NOT_MOUNTED. This is not fully correct, and callers need to be aware of this defect.

Also, GetDeviceProc does not handle the path "*" at all, even though it indicates the current console and the *Console-Handler* is responsible for it. This case also needs to be detected by the caller, and in such a case, GetConsoleTask() delivers the correct port.

> *Does not like all paths* The GetDeviceProc() function unfortunately does not handle all device specifiers correctly, and some special cases need to be filtered out by the caller. Namely "*" indicating the current console, and NIL: for the NIL pseudo-device are not handled here.

8.2.2 Releasing DevProc Information

The FreeDeviceProc() function releases a DevProc structure previously returned by GetDeviceProc() and releases all temporary resources allocated by this function. It shall be called as soon as the DevProc structure is no longer needed.

```
FreeDeviceProc(devproc)
               D1

void FreeDeviceProc(struct DevProc *)
```

This function releases the DevProc structure and all its resources from an iteration through one or multiple GetDeviceProc() calls. If GetDeviceProc() returned NULL itself it had already released such resources itself and no further activity is necessary.

The dvp_Port or dvp_Lock within the DevProc structure shall not be used after releasing it with FreeDeviceProc(). If a *lock* is needed afterwards, a copy of dvp_Lock shall be made with DupLock(). If the port of the *handler* or *file system* is needed afterwards, a resource of this handler shall be obtained, e.g. by opening a file or obtaining a lock on it. Both the FileHandle and the FileLock structures contain a pointer to the port of the corresponding handler.

It is safe to call FreeDeviceProc() with a NULL argument; this performs no activity.

This function does not set IoErr() consistently and no particular value may be assumed. It may or may not alter its value.

8.2.3 Legacy Handler Port Access

The `DeviceProc()` function is a legacy variant of `GetDeviceProc()` that should not be used anymore. It is not able to reliably provide locks to *assigns* and will not work through all directories of a *multi-assign*.

```
process = DeviceProc( name )
 D0                    D1

struct MsgPort *DeviceProc (STRPTR)
```

This function returns a pointer to a port of a *handler* or *file system*able to handle the path `name`. It returns `NULL` on error in which case it sets `IoErr()`.

If the passed in `name` is part of an *assign*, the handler port of the directory the assign binds to is returned, and `IoErr()` is set to the *lock* of the assign. Unfortunately, one cannot safely make use of this *lock* as the *device list* may be altered any time, including the time between the return from this function and its first use by the caller. Thus, `GetDeviceProc()` shall be used instead which locks resources such as the *device list*; they are released through `FreeDeviceProc()`.

> *Obsolete and not fully functional* `DeviceProc()` function does not operate properly on *multi-assigns* where it only provides the port and *lock* to the first directory participating in the assign. It also returns `NULL` for *non-binding assigns* as there is no way to release a temporary lock obtained on the target of the *assign*. Same as `GetDeviceProc()`, it does not properly handle `NIL:` and "`*`".

8.2.4 Obtaining the Current Console Handler

The `GetConsoleTask()` function returns the *MsgPort* of the handler responsible for the console of the calling process, that is, the process that takes care of the file name "`*`" or paths relative to `CONSOLE:`.

```
port = GetConsoleTask()
 D0

struct MsgPort *GetConsoleTask(void)
```

This function returns a port to the handler of the console of the calling process, or `NULL` in case there is no console associated to the caller. The latter holds for example for programs started from the workbench. It does not alter `IoErr()`.

8.2.5 Obtaining the Default File System

The `GetFileSysTask()` function returns the *MsgPort* of the default *file system* of the caller. The default *file system* is used as fall-back if a *file system* is required for a path relative to the `ZERO` lock, and the path itself does not contain an indication of the responsible handler, i.e. is a relative path itself.

The default *file system* is typically the boot file system, or the file system of the `SYS:` *assign*, though it can be changed with `SetFileSysTask()` at any point.

```
port = GetFileSysTask()
 D0

struct MsgPort *GetFileSysTask(void)
```

This function returns the port of the default file system of this task. It does not alter `IoErr()`. Note that `SYS:` itself is an *assign* and paths starting with `SYS:` do therefore not require resolution through this function, though the default *file system* and the file system handling `SYS:` are typically identical. However, as the former is returned by `GetFileSysTask()` and the latter is part of the *device list assign*, they can be different.

8.3 Iterating and Accessing the Device List

While `GetDeviceProc()` uses the *device list* to locate a particular *MsgPort* and *Lock*, all other members of the `DosList` structure remain unavailable. For them, the *device list* containing these structures need to be scanned manually. The *dos.library* provides functions to grant access, search and release access to this list.

8.3.1 Gaining Access to the Device List

The `LockDosList()` function requests shared or exclusive access to a subset of entries of the *device list* containing all *handlers*, *volumes* and *assigns* and blocks until access is granted. It requires as input multiple sets that specify which parts of the list to access:

```
dlist = LockDosList(flags)
 D0                   D1

struct DosList *LockDosList(ULONG)
```

This function grants access to a subset of entries of the *device list* indicated by `flags`, and returns an opaque handle through which elements of the list can be accessed. For this, see `FindDosEntry()`.

The `flags` value shall be combination of the following values, all defined in `dos/dosextens.h`:

Table 29: LockDosList Flags

Flags	**Description**
LDF_DEVICES	Access *handlers* and *file system* entries, see 4.3.1.1
LDF_VOLUMES	Access *volumnes*, see 4.3.1.2
LDF_ASSIGNS	Access *assigns*, see 4.3.1.3
LDF_ENTRY	Lock access to a `DosList` entries
LDF_DELETE	Lock *device list* for deletion
LDF_READ	Shared access to the *device list*
LDF_WRITE	Exclusive access to the *device list*

At least `LDF_READ` or `LDF_WRITE` shall be included in the flags, they shall not be set both. The three first flags may also be combined to access multiple types.

`LDF_ENTRY` and `LDF_DELETE` are additional flags that moderate access to entries of the *device list*. If `LDF_ENTRY` is set, then exclusive access to the selected entries is requested and entries shall not be altered or removed. The `LDF_ENTRY` flag shall not be combined with `LDF_READ`. If `LDF_DELETE` is set, then access is granted for removing entries from the list.

The result code `dlist` is *not* a pointer to a `DosList` structure, but only a handle that may be passed into `FindDosEntry()` or `NextDosEntry()`. If `dlist` is `NULL`, then locking failed because the combination of `flags` passed in was invalid.

This function does not alter `IoErr()`.

8.3.2 Requesting Access to the Device List

The `AttemptLockDosList()` requests access to the *device list* or a subset of its entries, and, in case it cannot gain access, returns `NULL`. Unlike `LockDosList()`, it does not block.

```
dlist = AttemptLockDosList(flags)
D0                         D1

struct DosList *AttemptLockDosList(ULONG)
```

The `flags` argument specifies which elements of the *device list* are requested for access, and which type of access is required. The flags are a combination of the flags listed in table 29, and the semantics of the flags are exactly as specified for `LockDosList()`, see there for details.

The result code is either a (non-`NULL`) handle that may be passed into `FindDosEntry()` or `NextDosEntry()` in case access could be granted, or `NULL`. In the latter case, the list is either currently locked and access cannot be granted without blocking, or flags are invalid. These two cases of failure cannot be distinguished unfortunately.

This function does not alter `IoErr()`.

8.3.3 Release Access to the Device List

The `UnLockDosList()` function releases access to the *device list* once obtained through `LockDosList()`.

```
UnLockDosList(flags)
                D1

void UnLockDosList(ULONG)
```

This function releases access to the *device list* again. The `flags` argument shall be identical to the `flags`argument provided to `LockDosList()`.

8.3.4 Iterate through the Device List

The `NextDosEntry()` iterates to the next entry in the *device list* given the current entry or the handle returned by `LockDosList()`.

```
newdlist = NextDosEntry(dlist,flags)
 D0                       D1    D2

struct DosList *NextDosEntry(struct DosList *,ULONG)
```

This function returns the next `DosList` structure of the *device list* which shall have been locked with `LockDosList()`. The `dlist` argument shall be either the return code of a previous `NextDosEntry()` or `FindDosEntry()` call, or the handle returned by `LockDosEntry()`.

The `flags` argument shall be a subset of the `flags` argument into `LockDosList()` and specifies the type of `DosList` structures that shall be found. Only the first 3 elements of Table 29 are relevant here, all other flags are ignored but may be included.

The `newdlist` result is either a pointer to a `DosList` structure of the requested type, or `NULL` if the end of list has been reached. This function does not alter `IoErr()`.

8.3.5 Find a Device List Entry by Name

The `FindDosEntry()` function finds a `DosList` structure of a particular type and particular name, from a particular entry on, or the handle returned by `LockDosList()`.

```
newdlist = FindDosEntry(dlist,name,flags)
D0                       D1    D2   D3

struct DosList *FindDosEntry(struct DosList *,STRPTR,ULONG)
```

This function scans through the *device list* starting at the entry `dlist`, or the handle returned by `LockDosList()`, and returns the next `DosList` structure that is of the type indicated by `flags` and has the name `name`.

The `flags` shall be a subset of the `flags` argument passed into `LockDosList()`. Only the first 3 elements of Table 29 are relevant here, all other flags are ignored but may be included.

The `name` argument is the (case-insensitive) name of the assign, handler, file system or volume the function should look for. The name *shall not* include the colon (':') that separates the name from the remaining components of a path, see section 4.3. It may be `NULL` in which case every entry of the requested type matches.

The returned `newdlist` is a pointer to a `DosList` structure that matches the name (if provided) and flags passed in, or `NULL` in case no match could be found and the entire list has been scanned. Note that the returned `DosList` may be identical to the `dlist` passed in if it already fits the requirements. Thus potentially, `NextDosList()` may be called upfront to scan from the subsequent entry.

Passing `NULL` as `dlist` is safe and returns `NULL`, i.e. the end of the list. Note that the (pseudo-) devices from tables 5 and 7 are not part of the *device list*, i.e. `NIL`, `CONSOLE`, `*` and `PROGDIR` cannot be found and are special cases of `GetDeviceProc()`.

This function does not alter `IoErr()`.

8.3.6 Accessing Mount Parameters

Once a `DosList` structure has been identified, e.g. by `FindDosEntry()`, it is tempting to understand whether the entry belongs to an assign or a volume, or a handler or file system, and in the latter two cases, to find the mount parameters of the handler or file system.

The first level of identification is easy and works through the `dol_Type` element of the `DosList` structure; table 26 in section 8 lists the possible entry types. As seen there, however, *handlers* and *file systems* share the same type, namely `DLT_DEVICE`.

Information on how a *file system* or a *handler* should be configured is found in the `dol_Startup` field; it is, however, up to the handler to interpret it, and AmigaDOS does not define what exactly it can contain. The `Mount` command can place three different types of objects here: An integer value, a *BPTR* to a *BSTR*, or a *BPTR* to a `FileSysStartupMsg`.

Unfortunately, there is no totally safe way how to distinguish these types, and AmigaDOS does not provide any further source of information to learn which type a handler expects here — thus a heuristics is needed to tell them apart.

In the first step, one should check whether the `dol_Startup` field is actually a *BPTR* pointing to valid memory. This is even the case for *file systems* mounted by the ROM, e.g. the `df0:` device:

```
void AnalyzeDosList(struct DosList *dl)
{
LONG *startup;

  s=(LONG *)(dl->dol_Startup);
  if (s && TypeOfMem(BADDR(s)) && (LONG)s!=-1L && (LONG)s>0x100
        && ((LONG)s & 0xc0000000)==0) {
        /* Looks like a plausible BPTR */
        AnalyzeStartup((LONG *)(BADDR(s)));
  } else {
        /* Likely some sort of handler, and s is
        ** probably some integer
        */
```

```
        ....
  }
}
```

The above algorithm uses `TypeOfMem()` to test whether a pointer goes into valid memory, and also checks the topmost two bits of the *BPTR*. As *BPTR*s are created by right-shifting a pointer by 2 bits, the two MSBs should thus be zero.

In the second step, the heuristics attempts to understand whether the *BPTR* in `dol_Startup` actually points to a `FileSysStartupMsg` or to a *BSTR*. For that, it attempts to learn whether the `fssm_Device` element is a valid *BSTR* and whether the `fssm_Envion` element is also a valid *BPTR*.

```
void AnalyzeStartup(LONG *startupmsg)
{
BOOL isfsstart=TRUE;
UBYTE *text;

  /* This checks whether fssm_Device
  ** is meaningful in order to derive
  **
  if (startupmsg[1] & 0xc0000000) {
     /* Certainly not a BPTR to
     ** a device name, bail out
     */
     isfsstart = FALSE;
  } else {
     /* Hopefully, a BPTR to a BSTR */
     text=((char *)BADDR(startupmsg[1]))+1;
     if (!TypeOfMem(text)) {
       /* No, that does not work. */
       isfsstart = FALSE;
     } else {
       /* Now check the want-to-be fssm_Envion */
       if (startupmsg[2] & 0xc0000000) {
         isfsstart = FALSE;
       } else if (startupmsg[2]!=NULL &&
                (!TypeOfMem(BADDR(startupmsg[2])))) {
         isfsstart = FALSE;
       }
     }
   }

   /*
   ** But could possibly be a string
   */
   if (isfsstart==FALSE) {
    if (TypeOfMem(startupmsg)) {
     /* This is probably a string.
     ** "mount" puts NUL-terminated strings in
     ** here.
     */
     text = ((UBYTE *)startupmsg)+1;
     ...
```

```
    } else {
     struct FileSysStartupMsg *fssm;
     fssm = (struct FileSysStartupMsg *)startupmsg;
     /*
     ** Access fssm->fssm_Device,fssm_Unit,fssm_Flags
     */
     ...
     if ((fssm->fssm_Environ & 0xc0000000) == 0) {
      LONG *ptr = BADDR(fssm->fssm_Environ);
      if (ptr && (TypeOfMem(ptr))) {
       struct DosEnvec *env;
       env = (struct DosEnvec *)ptr;
       /* Hopefully an environment */
       if (env->de_TableSize > 0) {
         /* Ok, this is probably good enough... use the
         ** elements of the environment up to the
         ** one indicated by env->de_TableSize
         */
       }
     }
   }
  }
}
```

Even if this function is able to identify an `DosEnvec` structure with high probability, it can happen that the environment vector identified this way does not contain all the elements documented in `dos/filehandler.h`. Only the first `de_TableSize` elements are present and can be accessed, so some additional care shall be taken when interpreting this structure.

While the above is just a heuristic and is therefore not guaranteed to work, practical experience of the author has shown that it has so far been able to extract environment information from all handlers or file systems that came into his hand.

Nevertheless, getting hands on the `FileSysStartupMsg` from an unknown handler is not completely waterproof at this moment, and to this end the author of [10] proposed to introduce a `DosPacket` (see section **??**) by which a handler can be requested to reveal its startup message. Unfortunately, to date this packet has not found wide adoption, and the above heuristics may be used as an interim solution.

Authors of *handlers* and *file systems* have less to worry about. When they document their requirements properly, e.g. by including an example `Mountlist` with their product, “only” user errors can generate startup messages the handler cannot interpret properly. Thus, in general, handlers should be written in an “optimistic” way (unlike the above heuristic) assuming that `dol_Startup` is what they do expect. All AmigaDOS handlers are written in such a way, e.g. the FFS expects without verification that the value in `dol_Startup` is, indeed, a `FileSysStartupMsg`, even though it can be fooled by an incorrect `Mountlist` and by that crash the system.

8.4 Adding or Removing Entries to the Device List

The *dos.library* provides two service functions to add or remove `DosList` structures from the *device list*. They secure the *dos.library* internal state from inconsistencies as other processes may attempt to access the *device list* simultaneously, and they also ensure proper linkage of the structures.

> *Locking the device list in file systems* There is one particular race condition *file system* authors should be aware of. When opening a file, or obtaining a *lock*, the *dos.library* calls through `GetDeviceProc()` to identify a *handler* responsible for the requested path. As `GetDeviceProc()` requires access to the *device list*, it will secure access to it through `LockDosList()`, then possibly start up the *handler*, and then unlock the list. Thus, at the time the handler is initiated, it may find the *device list* unaccessible. Attempting to lock it would result in a *deadlock* situation as the *dos.library* waits for the *handler* to reply its startup packet, and the *handler* waits for the *dos.library* to grant access to the *device list*. The following sections provide workarounds how to avoid this situation, see also section **??** for details on the *handler* and *file system* startup mechanism.

8.4.1 Adding an Entry to the Device List

The `AddDosEntry()` adds an initialized `DosList` structure to the *device list*.

```
success = AddDosEntry(dlist)
D0                    D1

LONG AddDosEntry(struct DosList *)
```

This function takes an initialized `DosList` entry pointed to by `dlist` and attempts to add it to the *device list*. For this, it requests write access to the list, i.e. locking of the *device list* through the caller is not necessary. The `DosList` may be either created manually, by `MakeDosEntry()` of the *dos.library* or by `MakeDosNode()` of the *expansion.library*. While there the structure is called a `DeviceNode`, it is still a particular incarnation of a `DosList` and may be safely used here.

Assigns shall not be added to the *device list* through this function, but rather through the functions in section 8.6. This avoids memory management problems when releasing or changing assigns.

Particular care needs to be taken if this function is called from within a *handler* or *file system*, e.g. to add a *volume* representing an inserted medium. As the list may be locked by the *dos.library* to secure the list from modifications within a `GetDeviceProc()` function, a deadlock may result where *file system* and *dos.library* mutually block access. To prevent this from happening handlers should check upfront whether the *device list* is available for modifications by `AttemptLockDosList()`, e.g.

```
if (AttemptLockDosList(LDF_VOLUMES|LDF_WRITE)) {
  rc = AddDosEntry(volumenode);
  UnLockDosList(LDF_VOLUMES|LDF_WRITE);
}
```

when adding a `DosList` entry of type `DLT_VOLUME`. If attempting to get write access failed, the handler should check for incoming requests, handle them, and attempt adding the entry later.

The function fails if an entry is to be added and an entry of the same name, regardless its type, is already present on the list. The only exception is that the list may contain two *volumes* of the same name, provided provided their creation date `dol_VolumeDate` differs, see section 8.

If successful, the function returns non-zero, but then does not alter `IoErr()`. The `DosList` is then enqueued in the *dos.library* database and it and its members shall then no longer be altered or released by the caller. On failure, the function returns 0 and `IoErr()` is set to `ERROR_OBJECT_EXISTS`.

8.4.2 Removing an Entry from the Device List

The `RemDosEntry()` removes a `DosList` entry from the *device list*, making it unacessible for AmigaDOS.

```
success = RemDosEntry(dlist)
D0                     D1

BOOL RemDosEntry(struct DosList *)
```

This function attempts to find the `DosList` structure pointed to by `dlist` in the *device list* and, if present, removes it. Unlike what some other documentation says, this function locks the *device list* properly before attempting to remove an entry, locking it upfront is not necessary.

The function does *not* attempt to release the memory allocated for the `DosList` passed in, or any of its members, it just removes the `DosList` from the *device list*. While *file systems* may know how they allocated the `DosList` structures represening their *volumes* and hence should be aware how to release the memory taken by them, there is no good solution on how to recycle memory for `DosList` structures representing *handlers*, *file systems* or *assigns*. Some manual footwork is currently required, see also `FreeDosNode()`. In particular, as entries representing *handlers* and *file systems* may have been created in multiple ways, their memory cannot be safely recycled.

Particular care needs to be taken if this function is called from within a *handler* or *file system*, e.g. to remove a *volume* representing a removed medium. As the list may be locked by the *dos.library* to secure the list from modifications within a `GetDeviceProc()` function, a deadlock may result where *file system* and *dos.library* mutually block access. To prevent this from happening handlers should check upfront whether the *device list* is available for modifications by `AttemptLockDosList()`, e.g.

```
if (AttemptLockDosList(LDF_DELETE|LDF_ENTRY|LDF_WRITE)) {
  rc = RemDosEntry(volumenode);
  UnLockDosList(LDF_DELETE|LDF_ENTRY|LDF_WRITE);
}
```

when removing a `DosList` entry. If attempting to get write access failed, the handler should check for incoming requests, handle them, and attempt adding the entry later.

This function returns a success indicator; it returns non-zero if the function succeeds, and `0` in case it fails. The only reason for failure is that `dlist` is not a member of the *device list*. This function does not touch `IoErr()`.

8.5 Creating and Deleting Device List Entries

AmigaOs offers multiple functions to create `DosList` structures. The `MakeDosEntry()` function is a low-level function that allocates a `DosList` but only performs minimal initialization of the structure. For *assigns*, the functions in section 8.6 shall be used as they include complete initialization of the `DosList`, and for *handlers* and *file systems*, the *expansion.library* function `MakeDosNode()` is a proper alternative. Releasing `DosLists` along with all its resources is unfortunately much harder. For *assigns*, the algorithm in section 8.5.2 provides a workable function based on `FreeDosEntry()`.

`DosLists` representing *Volumes* are build and released by *file systems*; it depends on them which resources need to be released along with the `DosList` structure itself. While it is recommended that *file systems* should go through `MakeDosEntry()` and `FreeDosEntry()`, it is not a requirement.

Releasing a `DosList` representing a *handler* or *file system* is currently not possible in a completely robust way. It is suggested just to unlink such nodes if absolutely necessary, but tolerate the memory leak.

8.5.1 Creating a Device List Entry

The `MakeDosEntry()` creates an empty `DosList` structure of the given type, and makes all elementary initializations. It does not acquire any additional resources, and neither inserts it into the *device list*.

If an *assign* is to be created, the functions in section 8.6 are better alternatives and should be preferred as they perform a more sophisticated initialization.

```
newdlist = MakeDosEntry(name, type)
D0                      D1    D2

struct DosList *MakeDosEntry(STRPTR, LONG)
```

This function allocates a `DosList` structure and initializes its `dol_Type` to `type`. The `type` argument shall be one of the values from table 26. The function also makes a copy of `name` and initializes the `dol_Name` to a *BSTR* copy of `name`, which is a `NUL` terminated C string.

Note that this function performs only minimal initialization of the `DosList` structure. All other members except `dol_Type` and `dol_Name` are initialized to 0.

This function either returns the allocated structure, or `NULL` for failure. In the latter case, `IoErr()` is set to `ERROR_NO_FREE_STORE`. On success, `IoErr()` remains unaltered.

8.5.2 Releasing a Device List Entry

The `FreeDosEntry()` function releases a `DosList` structure allocated by `MakeDosEntry()`. The `DosList` shall be already removed from the *device list* by *RemDosEntry()*. While this call releases the memory holding the name of the entry, and also the `DosList` structure itself, it does not release any other resources. They shall be released by the caller of this function. Furthermore, this function shall not be called if the `DosList` structure was allocated by any other means than `MakeDosEntry()`.

```
FreeDosEntry(dlist)
               D1

void FreeDosEntry(struct DosList *)
```

This function releases the `DosList` structure pointed to by `dlist` and its name, but only these two resources, and no other resources.

If `dol_Type` is `DLT_DEVICE`, corresponding to *handlers* or *file systems*, this function should better not be called at all as the means of how the `DosList` was allocated is unclear. In such a case, a memory leak is the least dangerous side effect.

If `dol_Type` is `DLT_DIRECTORY` or `DLT_LATE`, then `dol_Lock` should be unlocked. If `dol_List` is non-`NULL`, then each entry of the `AssignList` structure shall be released, along with the lock kept within. For `DLT_LATE` and `DLT_NONBINDING`, the `dol_AssignName` function shall also be released. The following code segment releases all resources for *assigns*:

```
struct AssignList *al,*next;
UnLock(dol->dol_Lock);
al = dol->dol_misc.dol_assign.dol_List;
while(al) {
    next = al->al_Next;
    UnLock(al->al_Lock);
    FreeVec(al);
    al = next;
}
FreeVec(dol->dol_misc.dol_assign.dol_AssignName);
FreeDosEntry(dol);
```

The above code reflects the way how resources were originally allocated by the *dos.library*.

If the type is `DLT_VOLUME`, it is up to the *file system* to release any resources it allocated along with the `DosList`. It is file system dependent which resources can or should be released. `DosList` entries of this type should only be touched by the *file system* that created them.

This function cannot fail, and it does not touch `IoErr()`.

8.6 Creating and Updating Assigns

While `MakeDosEntry()` creates a `DosList` entry for the *device list*, it only performs minimal initialization of the structure. For *assigns*, specifically, the *dos.library* provides specialized functions that allocate, initialize and enqueue `DosList` structures representing assigns in a single call and are thus easier to use.

8.6.1 Create and Add a Regular Assign

The `AssignAdd()` function creates a new assign to a directory from a *lock*, and then enqueues it into the *device list*.

```
success = AssignLock(name,lock)
D0                   D1   D2

BOOL AssignLock(STRPTR,BPTR)
```

This function creates a (regular) *assign* onto the directory identified by `lock`. The *assign* created under the name as given by `name`. The name shall not include a trailing colon ("`:`") that separates the *assign* name from the rest of the path. The lock shall be a *shared lock*.

If the function is successful, it returns a non-zero result code. The `lock` is then absorbed into the *assign* and shall no longer be used by the calling program. On success, `IoErr()` is not altered.

On error, the function returns 0 and the `lock` remains available to the caller. `IoErr()` is set to an error code identifying the cause of the failure. `ERROR_NO_FREE_STORE` is returned if the function run out of memory. If a `DosList` of the same name (regardless of which type) already exists, the error code is `ERROR_OBJECT_EXISTS`.

8.6.2 Create a Non-Binding Assign

The `AssignPath()` function creates a *non-binding assign* and adds it to the *device list*. This type of assign binds to a path independent of the volume the path is located on; that is, the *assign* resolves to whatever *volume*, *handler* or even other *assign* matches the path.

```
success = AssignLate(name,path)
D0                   D1   D2

BOOL AssignLate(STRPTR,STRPTR)
```

This function creates a *non-binding* assign whose name is given by the first argument, and which resolves to the path given as second argument, and then adds the *assign* to the *device list*. The `name` shall not contain a trailing colon ("`:`"). While not a formal requirement of the function or *non-binding assigns*, the `path` should better be an absolute path as otherwise resolution of the created *assign* can be very confusing — it is then resolved relative to the current directory of the calling process.

If the function is successful, it returns a non-zero result code. On success, `IoErr()` is not altered.

On error, the function returns 0 and `IoErr()` is set to an error code identifying the cause of the failure. `ERROR_NO_FREE_STORE` is returned if the function run out of memory. If a `DosList` of the same name (regardless of which type) already exists, the error code is `ERROR_OBJECT_EXISTS`.

8.6.3 Create a Late Assign

The `AssignLate()` function creates a *late assign* whose target is initially given by a path; but after its first resolution, the *assign* reverts to a *regular assigns* such that the target of the *assign* will point to the same directory of the volume from that point on. This has the advantage that the target of the assign does not need to be available at creation time of the assign, yet remains unchanged after its first usage.

```
success = AssignLate(name,path)
D0                    D1   D2

BOOL AssignLate(STRPTR,STRPTR)
```

This function creates a *late binding assign* of the name `name` pointing to `path` as its destination and adds it to the *device list*. The `name` shall not contain a trailing colon ("`:`"). While not explicitly required by this function, the `path` should better be an absolute path as otherwise resolving the *assign* can be very confusing. The `path` is then relative to the current directory of the process using the *assign* the first time.

If the function is successful, it returns a non-zero result code. On success, `IoErr()` is not altered.

On error, the function returns 0 and `IoErr()` is set to an error code identifying the cause of the failure. `ERROR_NO_FREE_STORE` is returned if the function run out of memory. If a `DosList` of the same name (regardless of which type) already exists, the error code is `ERROR_OBJECT_EXISTS`.

8.6.4 Add a Directory to a Multi-Assign

The `AssignAdd()` function adds a directory, identified by a *lock*, to an already existing *regular* or *multi-assign*. On success, a *regular assign* is then converted into a *multi-assign*.

```
success = AssignAdd(name,lock)
D0                   D1   D2

BOOL AssignAdd(STRPTR,BPTR)
```

This function adds the `lock` at the end of the target directory list of the *assign* identified by `name`. The `name` does not contain a trailing colon ("`:`").

A `DosList` of the given `name` shall already when entering this function, and this `DosList` shall be a *regular assign*. Attempting to add a directory to a *handler*, *file system*, *volume* or any other type of *assign* fails.

On success, the function returns a non-zero result code. In such a case, the `lock` is absorbed into the *assign* and shall no longer be used by the caller. The *assign* is converted into a *multi-assign* on access if it is not already one. The `lock` is added at the end of the directory list, i.e. the new directory is scanned last when resolving the *assign*.

On error, the function returns 0 and the `lock` remains available to the caller. Unfortunately, this function does not set `IoErr()` consistently, i.e. it is unclear on failure what caused the error, i.e. whether the function run out of memory, whether no fitting *device list* entry was found, or whether the entry found was not a *regular assign*.

8.6.5 Remove a Directory From a Multi-Assign

The `RemAssignList()` function removes a directory, represented by a `lock`, from a `multi-assign`. If only a single directory remains in the *multi-assign*, it is converted into a *regular assign*. If the *assign* was a regular assign, and the only directory is removed from it, the *assign* itself is removed from the *device list* and released, destroying it and releasing all resources.

```
success = RemAssignList(name,lock)
D0                       D1   D2

BOOL RemAssignList(STRPTR,BPTR)
```

This function removes the directory identified by `lock` from a *regular* or *multi-assign* identified by `name`. The name shall not contain a trailing colon ("`:`"). If only a single directory remains in the *assign*, it is converted to a *regular assign*. If no directory remains at all, the *assign* is deleted and removed from the *device list*. The `lock` remains available to the caller, regardless of the result code. Note that the `lock` passed in does not need to be identical to the *lock* contained in the *assign*, but it needs to be a *lock* on the same directory. This function uses `SameLock()` function to compare the two locks.

On success, the function returns a non-zero result code in `success`. On error, the function returns 0. Unfortunately, it does not set `IoErr()` consistently in all cases, and thus, the cause of an error cannot be determined upon return. Possible causes of error are that `name` does not exist, or that it is not a *assign* or a *multi-assign*.

Chapter 9

Pattern Matching

Unlike other operating systems, it is neither the file system nor the shell that expands wild cards, or patterns. Instead, separate functions exist that, given a wildcard, scan a directory or an entire directory tree and deliver all files, links and directories that match a given pattern.

The pattern matcher syntax is build on special characters or *tokens* that define which names to match. The following tokens are currently defined:

`?` The question mark matches a single, arbitrary character within a component. When using the pattern matcher for scanning directories, the question mark does not match the component separator, i.e. the slash ("`/`) and the colon ("`:`") that separates the path from the device name. Note in particular that the question mark also matches the dot ("`.`") which is not a special character under AmigaDOS.

`#` The hash mark matches zero or more repeats of the token immediately following it. In particular, the combination "`#?`" matches zero or more arbitrary characters. If a group of more than one token is required to describe which combination needs to match, this group needs to be enclosed in brackets.

`()` The brackets bind tokens together forming a single token. This is particularly useful for the hash mark `#` as it allows to formulate repeats of longer character or token groups. For example, `#(ab)` indicates zero or more repeats of the character sequence `ab`, such as `ab`, `abab` or `ababab`.

`~` The ASCII tilde ("~") matches names that do not match the next token. This is particularly valuable for filtering out the workbench icon files that end on `.info`, i.e. `~(#?.info)` matches all files that do not end with `.info`.

`[]` The square brackets ("`[]`") matches a single character from a range, e.g. `[a-z]` matches a single alphabetic character and `[0-9]` matches a single digit. Multiple ranges and individual characters can be combined, for example `[ab]` matches the characters `a` and `b`, whereas `[a-cx-z]` matches the characters from `a` to `c` and from `x` to `z`. If the minus sign ("`-`") is supposed to be part of the range, it shall appear first, directly within the bracket, e.g. `[-a-c]` matches the dash and the characters `a` to `c`. If the dash is the last character in the range, all characters up to the end of the ASCII range, i.e. `0x7f` match, but none of the extended ISO Latin 1 characters match. If the closing square bracket ("`]`") is to matched, it shall be escaped by an apostroph ("`'`"), i.e. `[[-']]` matches the opening and the closing bracket. If the pattern matcher is used for scanning directories, the above example does not match the slash ("`/`") even though its code point lies between the opening and closing bracket because the slash cannot be part of a component name and rather separates components. If the first character of the range is an ASCII tilde ("~"), then the character class matches all characters *not* in the class, i.e. `[~a-z]` matches all characters except alphabetic characters. In all other places, the tilde stands for itself.

- `'` The apostroph (`'`) is the escape character of the pattern matcher and indicates that the next character is not a token of the matcher, but rather stands for itself. Thus, `'?` matches the question mark, and only the question mark, and no other character.

- `%` The percent sign ("`%`") matches the empty string.

- `|` The vertical bar ("`|`") defines alternatives and matches the token to its left or the token to its right. The alternatives along with the vertical bar shall be enclosed in round brackets to bind them, i.e. `(a|b)` is either the character `a` or `b` and therefore matches the same strings `[ab]` matches. A particular example is `~((#?.info)|.backdrop)` which matches all files not used by the workbench for storing meta-information.

> *The Asterisk `*` is not a Wildcard* Unlike many other operating systems, the asterisk ("`*`") has a (two) other meanings under AmigaDOS. It rather refers to the current console as file name, or is the escape character for quotation and control sequences; those are properties AmigaDOS inherits from the BCPL syntax and TRIPOS. While there is a flag in the *dos.library* that makes the asterisk *also* available as a wildcard, such usage is discouraged because it can lead to situations where the asterisk is interpreted differently than intended — as it has already two other meanings.

Pattern matching works in in two steps: In the first step, the pattern is tokenized into an internal representation, which is then later on used to perform the actual match of a string against a wildcard. The directory scanning function `MatchFirst()` performs this conversion internally, and thus no additional preparation is required by the caller in this case. However, if the pattern matcher is used to search for strings or wildcards within a text file, the pattern tokenizers `ParsePattern()` or its case-insensitive counterpart `ParsePatternNoCase()` shall be called first.

> *Only ISO-Latin Codepoints* The pre-parsing step that prepares from the input pattern its tokenized version uses the code points `0x80` to `0x9f` for tokenized versions of wild-cards and other instructions for the pattern matcher. This is identical to the extended ISO-Latin control sequence region, and does not represent printable characters. While file names on AmigaDOS *file systems* may in principle include such code-points, patterns of the pattern matcher *shall not* contain unprintable code points from the region `0x00` to `0x1f` or from `0x80` to `0x9f`. These regions are reserved for the pattern matcher.

9.1 Scanning Directories

The prime purpose of the pattern matcher is to scan a directory, or even a tree of directories, identifying all *file system* objects such as files, links or directories that match a given pattern. The pattern matcher can even descend recursively into sub-directories if instructed to do so. This service is used by many shell commands stored in the `C:` *assign*. The directory scanner requires the following steps:

First, the user shall provide an `AnchorPath` structure. This structure contains the state of the directory matcher, including the `FileInfoBlock` structure of the matched object. This structure is defined in section 6.1. Optionally, the `AnchorPath` structure may also contain the complete (relative) path of the matched object. This structure shall then be initialized, setting all flags required, see below for their definition.

> *Must be Long-Word Aligned* As the `AnchorPath` structure embeds a `FileInfoBlock` structure that requires long-word alignment, the `AnchorPath` structure shall be aligned to long-word boundaries as well. The simplest way to ensure this is to allocate it with either `AllocMem()` or `AllocVec()`, see also section 2.3.

Then, with the initialized `AnchorPath` structure, `MatchFirst()` shall be called, returning the first match of the pattern if there is any. The `AnchorPath` structure then contains all information on the found match.

If there is any match, and the match is a directory the caller wants to enter recursively, the `APF_DODIR` flag of the `AnchorPath` structure may be set. Then, `MatchNext()` may be called to continue the scan, potentially entering this directory. Once the end of a recursively entered directory has been reached, `MatchNext()` sets the `APF_DIDDIR` flag, then reverts back to the parent directory continuing the scan there. As `APF_DIDDIR` is never cleared by the pattern matcher, the caller should clear it once the end of a sub-directory had been noticed.

The above iterative procedure of `MatchNext()` may continue, either until the user or the running program requests termination, or until `MatchNext()` returns an error. Then, finally, the scan is aborted and all resources but the `AnchorPath` structure shall be released by calling `MatchNext()`.

The `AnchorPath` structure is defined in `dos/dosasl.h` and looks as follows:

```
struct AnchorPath {
        struct AChain   *ap_Base;
#define ap_First ap_Base
        struct AChain   *ap_Last;
#define ap_Current ap_Last
        LONG    ap_BreakBits;
        LONG    ap_FoundBreak;
        BYTE    ap_Flags;
        BYTE    ap_Reserved;
        WORD    ap_Strlen;
        struct  FileInfoBlock ap_Info;
        UBYTE   ap_Buf[1];
};
```

The members of this structure are as follows:

`ap_Base` and `ap_Last` are pointers to an `AChain` structure that is also defined in `dos/dosasl.h`. This structure is allocated and released by the *dos.library*, transparently to the caller. The `AChain` structure describes a directory in the potentially recursive scan through a directory tree. `ap_Base` describes the topmost directory at which the scan started, whereas `ap_Last` describes the directory which is currently being scanned.

The `AChain` structure is also defined in `dos/dosasl.h`:

```
struct AChain {
struct AChain *an_Child;
struct AChain *an_Parent;
BPTR an_Lock;
struct FileInfoBlock an_Info;
BYTE an_Flags;
UBYTE an_String[1];
};
```

`an_Child` and `an_Parent` are only used internally and shall not be interpreted by the caller.

`an_Lock` is a lock to the directory described by this `AChain` structure. In particular, `ap_Last->an_Lock` is a *lock* to the directory that is currently being scanned, and `ap_Base->an_Lock` a lock to the topmost directory at which the scan started. These two locks have been obtained and will be unlocked by the *dos.library*; they may be used by the caller provided they are not unlocked manually.

an_Info is only used internally and is the FileInfoBlock of the directory being describes by the AChain structure, see section 6.1.

an_Flags is only used internally, and an_String can contain potentially the path to the directory; both shall not be modified or interreted by the caller.

ap_BreakBits of the AnchorPath structure shall be initialized to the signal mask upon which MatchNext() aborts a directory scan. This is typically a combination of signal masks found in dos/dos.h, e.g. SIGBREAKF_CTRL_C to abort on Ctrl-C in the console.

ap_FoundBreak contains, if MatchNext() aborts with ERROR_BREAK, the signal mask that caused the abortion.

ap_Flags contains multiple flags that can be set or inspected by the caller while scanning a directory. In particular:

APF_DOWILD while documented, is not used nor set at all by the pattern matcher.

APF_ITSWILD is set by MatchFirst() if the pattern includes a wildcard and more than a single *file system* object may match. Otherwise, no directory scan is performed. The user may also set this flag to enforce a scan. This may resolve situations in which matching an explicit path without a wildcard is not possible because the object is locked exclusively.

APF_DODIR may be set or reset by the caller of MatchNext() to enforce entering a directory recursively, or avoid entering a directory. This flag is cleared by MatchNext() when entering a directory, and it shall only be set by the caller if a match describes a directory.

APF_DIDDIR is set by MatchNext() if the end of a recursively entered directory has been reached, and thus the parent directory is re-entered. As this flag is never cleared by the pattern matcher, it should be cleared by the caller.

APF_NOMEMERR is an internal flag that should not be interpreted; it is set if an error is encountered while scanning a directory. It is not necessarily restricted to memory allocation errors.

APF_DODOT is, even though documented, not actually used.

APF_DirChanged is a flag that is set by MatchNext() if the scanned directory changes, either by entering a directory recursively, or by leaving a directory. It is also cleared if the directory is the same as in the previous call.

APF_FollowHLinks may be set by the caller to indicate that hard links to directories shall be followed, and such directories shall be recursively entered if APF_DODIR is set as well. Otherwise, hard links to directories are not entered. Softlinks are neither entered, this this cannot be changed by any flag. A potential danger of links is that they may cause endless recursion if a link within a directory points to a parent directory. Thus, callers should be aware of such situations and store directories that have already been analyzed. Otherwise, it is safer to keep this flag cleared.

ap_Strlen is the size of the buffer ap_Buf that contains the full path of the matched entry. This buffer shall be allocated by the user at the end of the AnchorPath structure. Unlike what the name suggests, this is not a string length, but the byte size of the buffer, including the terminating NUL byte of a string. If the full path of the match does not fit into this buffer, it is truncated *without* proper string termination and the error code ERROR_BUFFER_OVERFLOW is returned. If the full path is not required, this member shall be set to 0.

ap_Info contains the FileInfoBlock of the matched entry, including all metadata the file system has available for it. Note that fib_FileFile only contains the name of the object, not its full path.

ap_Buf is filled with the full path to the matched object if ap_Strlen is non-zero. This buffer shall be allocated by the caller at the end of the AnchorPath structure, i.e. for a buffer of l bytes, in total sizeof(AnchorPath)+l-1 bytes are required to store the structure and the buffer. The byte size of this additional buffer shall be placed in ap_Strlen. If this buffer is not required, ap_Strlen shall be set to 0.

9.1.1 Starting a Directory Scan

The `MatchFirst()` function starts a directory scan, locating all objects matching a pattern and potentially entering directories recursively.

```
error = MatchFirst(pat, AnchorPath)
D0                 D1       D2

LONG MatchFirst(STRPTR, struct AnchorPath *)
```

This function starts a directory scan, locating all objects matching the pattern `pat`. This pattern does *not* require pre-parsing (e.g. the functions in section 9.2), `MatchFirst()` performs the parsing.

`AnchorPath` shall be a pointer to an `AnchorPath` structure allocated and initialized by the caller. In particular, `ap_BreakBits` shall be initialized to a signal mask on which the scan terminates, `ap_FoundBreak` to 0, and `ap_Strlen` to the size of the buffer `ap_Buf` which is filled by the path name of the matching objects. If this path name is not required, `ap_Strlen` shall be set to 0. `ap_Flags` shall be set to the flags you need, see the parent section.

Unlike many other functions, `MatchFirst()` returns an error code directly, and not a success/failure indicator. That is, 0 indicates success. In particular, if `ERROR_BREAK` is returned in case any of the signal bits in `ap->ap_BreakBits` have been received during the scan.

On success, `ap->ap_Info.fib_FileName` contains the name of the first matched object, the directory represented as a *lock* containing the object is available in `ap->ap_Current->an_Lock`. You would typically set the current directory to this lock, then access this object, then revert the lock. This lock *shall not* be released; this is performed by the pattern matcher itself as needed.

If the full path of the matching object is needed, an additional buffer shall be allocated at the end of the `AnchorPath`, and the size of the buffer shall be placed into `ap_Strlen`. The function then fills in the path into `ap_Buf`.

If the matching object is a directory, i.e. `ap->ap_Info.fib_DirEntryType` is positive and not equal to `ST_SOFTLINK`, the caller may request to enter this directory by setting `APF_DODIR` in `ap->ap_Flags`.

9.1.2 Continuing a Directory Scan

The `MatchNext()` function continues a directory scan initiated by `MatchFirst()`, returning the next matching object, or an error.

```
error = MatchNext(AnchorPath)
D0                    D1

LONG MatchNext(struct AnchorPath *)
```

This function takes an existing `AnchorPath` structure, as prepared by a previous `MatchFirst()` or `MatchNext()` function, and finds the next matching object. Unlike most other functions of the *dos.library*, this function returns an error code on failure and 0 for success. It does *not* return a boolean success indicator. In particular, if `ERROR_BREAK` is returned in case any of the signal bits in `ap->ap_BreakBits` have been received.

As for `MatchFirst()`, this call fills `ap->ap_Info` with meta information on the found object, in particular its file name, and `ap->ap_Current->an_Lock` the lock of the directory containing the object. As for `MatchFirst()`, `APF_DODIR` can be set to enter directories recursively, and `ap->ap_Buf` will be filled with the full path of the found object if `ap->ap_Strlen` is non-zero.

9.1.3 Terminating a Directory Scan

The `MatchEnd()` function terminates a running scan, and releases all resources associated with the scan. It does not release the `AnchorPath` structure.

```
MatchEnd(AnchorPath)
             D1

VOID MatchEnd(struct AnchorPath *)
```

This function ends a directory scan started by `MatchFirst()` and releases all resources associated to the scan. This function shall be called regardless whether the scan is aborted due to exhaustion (i.e. `ERROR_NO_MORE_ENTRIES`, by error, or by choice of the scanning program (i.e. the desired object has been detected and no further matches are required).

9.2 Matching Strings against Patterns

While the prime purpose of the pattern matcher is to scan directories, it can also be used to check whether an arbitrary string matches a wildcard, for example to scan for a pattern within a text document. This requires two steps: In the first step, the wildcard is preparsed, generating a tokenized version of the pattern. The second step checks whether a given input string matches the pattern. You would typically tokenize the pattern once, and then use it to match multiple strings to the pattern.

Two versions of the tokenizer and pattern matcher exist: One pair that is case-sensitive, and the second pair is case-insensitive. Note that AmigaDOS file names are case-insensitive, so the `MatchFirst()` and `MatchNext()` functions internally only use the second pair.

The buffer for the tokenized version of the pattern shall be allocated by the caller. It requires a buffer that is at least `2 + (n « 1)` bytes large, where n is the length of the input wildcard.

9.2.1 Tokenizing a Case-Sensitive Pattern

The `ParsePattern()` function tokenizes a pattern for case-sensitive string matching. This tokenized version is then later on used to test a string for a match.

```
IsWild = ParsePattern(Source, Dest, DestLength)
d0                      D1     D2      D3

LONG ParsePattern(STRPTR, STRPTR, LONG)
```

This function tokenizes a wildcard pattern in `Source`, generating a tokenized version of the pattern in `Dest`. The size (capacity) of the target buffer is `DestLength` bytes. This size shall be at least `2 + (n « 1)` bytes large, where `n` is the length of the input pattern. However, as future implementations can require larger buffers, the result code shall be checked nevertheless for error conditions. The result code `IsWild` is one of the following:

`1` is returned if the source contained wildcards.

`0` is returned if the source contains no wildcards. In this case, the tokenized pattern may still be used to match a string against the pattern, though a simple string comparison would also work.

`-1` is returned in case of an error, either because the input pattern is ill-formed, or because `DestLength` is too short. In such a case, `IoErr()` should be used to obtain the reason of the failure.

9.2.2 Tokenizing a Case-Insensitive Pattern

The `ParsePatternNoCase()` function tokenizes a pattern for case-insensitive string matching. This tokenized version is then later on used to test a string for a match. This version is suitable for matching file names, but is otherwise similar to `ParsePattern()`.

```
IsWild = ParsePatternNoCase(Source, Dest, DestLength)
d0                          D1      D2      D3

LONG ParsePatternNoCase(STRPTR, STRPTR, LONG)
```

This function tokenizes a wildcard pattern in `Source`, generating a tokenized version of the pattern in `Dest`. The size (capacity) of the target buffer is `DestLength` bytes. This size shall be at least `2 + (n « 1)` bytes large, where `n` is the length of the input pattern. However, as future implementations can require larger buffers, the result code shall be checked nevertheless for error conditions. The result code `IsWild` is one of the following:

`1` is returned if the source contained wildcards.

`0` is returned if the source contains no wildcards. In this case, the tokenized pattern may still be used to match a string against the pattern, though a simple case-insensitive string comparison would also work.

`-1` is returned in case of an error, either because the input pattern is ill-formed, or because `DestLength` is too short. In such a case, `IoErr()` should be used to obtain the reason of the failure.

9.2.3 Match a String against a Pattern

The `MatchPattern()` function matches an input string against a tokenized pattern, in a case sensitive way.

```
match = MatchPattern(pat, str)
D0                   D1   D2

BOOL MatchPattern(STRPTR, STRPTR)
```

This function matches the string `str` against the tokenized pattern `pat`, returning an indicator whether the string matches the pattern. This function is case-sensitive. The pattern `pat` shall have been tokenized by `ParsePattern()`.

The result code `match` is non-zero in case the string matches, or 0 in case either the string did not match, or the function run out of stack. The latter two cases can be distinguished by `IoErr()`. In case the string did not match, `IoErr()` returns 0, or a non-zero error code otherwise. A possible error code is `ERROR_TOO_MANY_LEVELS` indicating that the pattern matcher run out of stack due to too many levels of recursion.

The caller shall have at least 1500 bytes of stack space available to avoid race conditions, despite the function checking for out-of-stack conditions.

9.2.4 Match a String against a Pattern ignoring Case

The `MatchPatternNoCase()` function matches an input string against a tokenized pattern ignoring the case.

```
match = MatchPatternNoCase(pat, str)
D0                         D1   D2

BOOL MatchPatternCase(STRPTR, STRPTR)
```

This function matches the string `str` against the tokenized pattern `pat`, returning an indicator whether the string matches the pattern. This function is case-insensitive. The pattern `pat` shall have been tokenized by `ParsePatternNoCase()`.

The result code `match` is non-zero in case the string matches, or 0 in case either the string did not match, or the function run out of stack. The latter two cases can be distinguished by `IoErr()`. In case the string did not match, `IoErr()` returns 0, or a non-zero error code otherwise. A possible error code is `ERROR_TOO_MANY_LEVELS` indicating that the pattern matcher run out of stack due to too many levels of recursion.

The caller shall have at least 1500 bytes of stack space available to avoid race conditions, despite the function checking for out-of-stack conditions.

Chapter 10

Processes

Processes are extensions of exec *tasks*, and as such scheduled by exec. The most important extensions are that processes include a message port in the form of a *MsgPort* structure for inter-process communication to *handlers*, a current directory to resolve relative paths, and the last input/output error as returned by the `IoErr()` function.

Processes are represented by the `Process` structure documented in `dos/dosextens.h`. It reads as follows:

```
struct Process {
    struct  Task    pr_Task;
    struct  MsgPort pr_MsgPort;
    WORD    pr_Pad;
    BPTR    pr_SegList;
    LONG    pr_StackSize;
    APTR    pr_GlobVec;
    LONG    pr_TaskNum;
    BPTR    pr_StackBase;
    LONG    pr_Result2;
    BPTR    pr_CurrentDir;
    BPTR    pr_CIS;
    BPTR    pr_COS;
    APTR    pr_ConsoleTask;
    APTR    pr_FileSystemTask;
    BPTR    pr_CLI;
    APTR    pr_ReturnAddr;
    APTR    pr_PktWait;
    APTR    pr_WindowPtr;

    /* following definitions are new with 2.0 */
    BPTR    pr_HomeDir;
    LONG    pr_Flags;
    void    (*pr_ExitCode)();
    LONG    pr_ExitData;
    UBYTE   *pr_Arguments;
    struct MinList pr_LocalVars;
    ULONG   pr_ShellPrivate;
    BPTR    pr_CES;
};  /* Process */
```

The members of this structure are as follows:

pr_Task is the exec task structure defined in exec/tasks.h. It is required by the exec scheduler. The only difference between an exec Task and a Process is that pr_Task.tc_Node.ln_Type is set to NT_PROCESS instead to NT_TASK. Prior starting the process, the *dos.library* also pushes the stack size onto the stack, i.e. (ULONG *)(pr_Task.tc_Upper)[-1] contains the size of the stack in bytes. Some binaries, in particular those compiled with the Aztec (Manx) compiler depend on this value.

pr_MsgPort is a message port structure as defined in exec/ports.h. This port is used by many functions of the *dos.library* to communicate with *handlers* and *file systems*. Details of the communication protocol are given in section 12.

pr_Pad is unused and only included in the structure to ensure that all following members are aligned to 32-bit boundaries.

pr_SegList contains an array of *segments* containing AmigaDOS functions. The first entry in this array is a 32-bit integer indicating the number of valid elements, the remaining entries are *BPTRs* to segments of AmigaDOS and the loaded binary. Some entries may be ZERO indicating that the corresponding entry is currently not used. Segments are explained in more detail in section **??**. Typically, entries 1 and 2 are system segments containing AmigaDOS functions, entry 3 is used for the loaded binary, and entry 4 the segment of the shell. This, however, only reflects the current usage of segments, and later versions of AmigaDOS may populate this vector differently. The segments contained in this vector are used by the AmigaDOS runtime binder to build the *Global Vector* of processes using BCPL linkage. As BPCL is phased out, this vector is of no particular importance today anymore, and can be ignored for almost all purposes. The only exception is the *Shell* which shall prepare this vector to ensure that commands written in BCPL function properly. More on this in section **??**.

pr_StackSize is the size of the process stack in bytes. It is always a multiple of 4 bytes long.

pr_GlobVec is another BCPL legacy. It contains the *Global Vector* of the process. For binaries using the BCPL linkages, this is a custom-build array of global data and function entry points from pr_SegList. For C and assembler binaries, the *Global Vector* is the system shared vector; it contains *dos.library* global data required by some of its functions, such as base pointers to system libraries. As no particular advantage can be taken from this vector (anymore) as all functions available in it are also available as *dos.library* entry points, it should be left alone.

pr_TaskNum is an integer allocated by the system for processes that execute a shell, or are binaries that have been launched by the shell. The number here corresponds to the integer printed by the Status command. Note that AmigaDOS does not use task numbers consistently, i.e. processes that are started from the workbench or have been created by some other means are not identified by a task number. In such a case, this member remains 0.

pr_StackBase is a *BPTR* to the address of the lower end of the stack, i.e. the end of the C or assembler stack. As the BCPL stack grows in opposide direction, it is the start of the BCPL stack. While it is initialized, it is not used by the *dos.library* at all.

pr_Result2 is the secondary result code set by many functions of the *dos.library*. The value stored here is delivered by IoErr().

pr_CurrentDir is the *lock* representing the current directory of the process. All relative paths are resolved from this *lock*, i.e. they are relative to pr_CurrentDir. If this member is ZERO, the current directory is the root directory of the file system stored in pr_FileSystemTask. As the latter is (unless altered) the file system of the boot volume, this is usually identical to the directory identified by the SYS assign.

pr_CIS is *file handle* of the standard input stream of the process. It is also returned by Input(). It can be ZERO in case the process does not have a standard input stream. This is *not* equivalenqt to a NIL: input handle — in fact, any attempt to read from a non-existing input stream will crash. Processes started from the workbench do not have an input stream, unless one is installed here with SelectInput().

pr_COS is the *file handle* of the standard output stream of the process. It is also returned by the Output() function of the *dos.library*. It can be ZERO in case the process does not have a standard output stream, which is not equivalent to a NIL: file handle. Any attempt to output to ZERO will crash the system. Processes started from the workbench do not have an output stream, unless one is installed with SelectOutput().

pr_ConsoleTask is the *MsgPort* of the console within which this process is run, if such a console exists. This *handler* is contacted when opening "*" or a path relative to CONSOLE:. Processes started from the workbench do not have a console, unless one is installed with SetConsoleTask().

pr_FilesSystemTask is the *MsgPort* of the file system that is contacted in case a relative path is to be resolved relative to the ZERO lock. This member is initialized to the *MsgPort* of the file system the system was booted from, but can be changed by SetFileSysTask(). This member is also returned by GetFileSysTask().

pr_CLI is a ***BPTR*** to the CommandLineInterface structure containing information on the Shell this process is running in. If this process is not part of a Shell, this member is ZERO. This is for example the case for programs started from the workbench, or *handler* or *file system*.

pr_ReturnAddr is another *BCPL* legacy and should not be used by new implementations. It points to the BCPL stack frame of the process or the command overloading the process, and used there to restore the previous stack frame for the Exit() function. This is typically the process cleanup code for processes initialized by CreateProc() or CreateNewProc(), or the shell command shutdown code placed there by RunCommand(). This cleanup process does not, however, release any other resources obtained by user code. BCPL code or custom startup code could deposit here pointer to a BCPL stack frame for a custom shutdown mechanism.

The BCPL stack frame is described by the following (undocumented) structure:

```
struct BCPLStackFrame {
       ULONG bpsf_StackSize;
       APTR  bpsf_PreviousStack;
};
```

where bpsf_StackSize is the stack size of the current (active) stack, and bpsf_PreviousStack the stack of the caller; to restore the previous stack, this value is placed in the CPU register A7.

pr_PktWait is a function that is called when waiting for inter-process communication, in particular when waiting for a returning packet set out to a handler. If this is NULL, the system default function is used. The signature of this function is

```
msg = (*pr_PktWait)(void)
D0

struct Message *(*pr_PktWait)(void)
```

that is, no particular arguments are delivered, the process must be obtained from exec, and the message received shall be delivered back into register D0. The returned pointer shall not be NULL, rather, this function shall block until a message has been received. For details, see the DoPkt() function and section 12.

pr_WindowPtr is, unlike what the name suggests, a pointer to an *intuition* Screen structure, see intuition/screens.h, on which error requesters will appear. If this is NULL, error requesters appear on the workbench screen, and if this is set to (APTR)(-1L), error requesters will be suppressed at all, and the implied response to them is to cancel the operation. This error requester is specified in more detail with the ErrorReport() function.

pr_HomeDir is the *lock* to the directory containing the binary that is currently executed as this process, if such a directory exists. It is ZERO if the binary is resident. This *lock* is filled in by the Shell or the

Workbench when loading and starting a process. It is used to resolve paths relative to the PROGDIR pseudo-assign, see section 7. If this lock is ZERO, any attempt to resolve a path within PROGDIR: will create a request to inserted a volume PROGDIR:, which is probably not a very useful reaction of AmigaDOS.

pr_Flags are system-use only flags that shall not be used or interpreted. They are used by the system process shutdown code to identify which resources need to be released, but future systems may find additional uses for this member.

pr_ExitCode() is a pointer to a function that is called by AmigaDOS as part of the process shutdown code, and as such quite more useful that pr_ReturnAddr. The function prototype is as follows:

```
returncode = ExitFunc(rc,exitdata)
D0                    D0 D1

LONG ExitFunc(LONG,LONG)
```

The value of rc is the return code process, i.e. the value left in register D0 when the code drops off the final RTS, and exitdata is taken from pr_ExitData. The returncode is a modified version of the process return code that is, however, ignored.

pr_ExitData is used as argument for the pr_ExitCode() function, see above.

pr_Arguments is a pointer to the command line arguments of the process if it corresponds to a command started from the Shell. This is a NUL terminated string. This argument string can also be found in register A0 for programs started from the Shell, or in the buffer of pr_CIS. The ReadArgs() function takes it from the latter source, and not from pr_Arguments. Otherwise, this member remains NULL.

pr_LocalVars is a MinList structure, as defined in exec/lists.h, that contains local variables specific to the shell within which the process is executed, if any. The structure of such variables is defined in dos/var.h. This structure is specified in section **??**.

pr_ShellPrivate is reserved for the Shell and its value shall not be used, modified or interpreted. It is currently unused, but can be used by future releases.

pr_CES is the *file handle* to be used for error output. This stream gues usually to the console the process runs in, if such a console exists. This handle can be changed by SelectError(). If pr_CES is NULL, processes should fall back to pr_COS for printing errors. Preferably, processes should use the ErrorOutput() function to obtain an error stream, though.

10.1 Creating and Terminating Processes

AmigaDOS provides several functions to create functions: CreateNewProc() is the revised and most flexible function for launching a process, taking many parameters in the form of a tag list. The legacy functionCreateProc() supports less options, but available under all Os versions. Shells as created by the System() function implicitly also create processes, but are not discussed here, but in section **??**. Therefore, System() shares a couple of options with CreateNewProc().

There is surprisingly not a single function to delete processes. Processes die whenever their execution drops off at the end of the main() function, or whenever execution reaches the final RTS instruction of the main program function. The Exit() function also terminates a process, but shall be called from within the process, and is typically not suitable as it does not release resources acquired by the program itself, but only those allocated by the system itself.

10.1.1 Creating a New Process from a TagList

The CreateNewProc() function takes a TagItem array as defined in utility/tagitem.h and launches a new process from this list. The tags this function takes are defined in dos/dostags.h.

```
process = CreateNewProc(tags)
D0                     D1

struct Process *CreateNewProc(struct TagItem *)

process = CreateNewProcTagList(tags)
D0                            D1

struct Process *CreateNewProcTagList(struct TagItem *)

process = CreateNewProcTags(Tag1, ...)

struct Process *CreateNewProcTags(ULONG, ...)
```

The above functions are all equivalent, just the calling conventions are different. For `CreateNewProcTags()`, the `TagList` is created by the compiler on the stack and a pointer is then implicitly passed into the function. The following tags are recognized by the function:

`NP_Seglist` takes a *BPTR* to a segment list as returned by `LoadSeg()` and launches the process at the first byte of the first segment of the list.

`NP_FreeSeglist` is a boolean indicator that defines whether the segment provided to `NP_Seglist` is released when the process terminates. Unlike what the official documentation claims, the default value of this tag is `DOSFALSE`, i.e. the segment is *not* released.

`NP_Entry` is mutually exclusive to `NP_Seglist` and defines an absolute address (and not a segment) as entry point of the process to be created. If this tag is provided, then `NP_FreeSeglist` shall *not* be set a non-zero value. Either `NP_Entry` or `NP_Seglist` shall be included.

`NP_Input` sets the input file handle, i.e. `pr_CIS` of the process to be created. This tag takes a *BPTR* to a *file handle*. The default is *not* to set the input file handle, e.g. to leave it `ZERO`.

`NP_CloseInput` selects whether the input file handle, if provided, will be closed when the process terminates. If non-zero, the input file handle will be closed, otherwise it remains opened. The default is to close the input file handle.

`NP_Output` sets the output file handle, i.e. `pr_COS` of the process to be created. This tag takes a *BPTR* to a *file handle*. The default is to leave the output at `ZERO`.

`NP_CloseOutput` selects whether the output file handle, if provided, will be closed when the process terminates. If non-zero, the output file handle will be closed, otherwise it remains open. The default is to close the output file handle.

`NP_Error` sets the error file handle, i.e. `pr_CES` of the process to be created. This tag also takes a *BPTR* to a *file handle*. The default is to leave the error output handle at `ZERO`.

`NP_CloseError` selects whether the rror file handle, if provided, will be closed when the process terminates. If non-zero, the error file handle will be closed, otherwise it remains open. The default is *not* to close the error file handle. This (different) default is to ensure backwards compatibility.

`NP_CurrentDir` sets the current directory of the process to be created. The argument is a *Lock*. The default is to duplicate the current directory of the caller with `DupLock()` if the caller is a process, or leave the current directory at `ZERO`. The current directory of the process, i.e. `pr_CurrentDir`, is released when the process terminates, unless `NP_CurrentDir` is set to `ZERO`.

`NP_StackSize` sets the stack size of the process to be created in bytes. The default is a stack size of 4000 bytes.

`NP_Name` is a pointer to a `NUL` terminated string to which the task name of the process to be created is set. This string is copied before the process is launched, and the copy is released automatically when the process terminates. The default process name is “`New Process`”.

NP_Priority sets the priority of the process to be created. The tag value shall be an integer in the range -128 to 127, though useful values are in the range of 0 to 20. The default is 0.

NP_ConsoleTask specifies a pointer to a *MsgPort* to the handler that is responsible for the console of the process to be created. That is, if the created process opens "*" or a path relative to CONSOLE:, it will use the specified handler. The default is to use the console handler if the caller is a process, or NULL if the caller is only a task.

While not explicitly available as a tag, the default file system of the created process, i.e. pr_FileSystemTask, is set to the default file system of the calling process if the caller is a process, or otherwise use the default file system from the *dos.library*. This file system is contacted to resolve paths relative to the ZERO lock.

NP_WindowPtr specifies a pointer to a Screen on which error requesters will be displayed, 0 to display requesters on the workbench, or -1 to suppress error requesters. It will be installed in the pr_WindowPtr of the process to be created. The default is to copy the pointer from the calling process if the window pointer of the parent is 0 or -1. The tag does not copy any other value of pr_WindowPtr from the parent. To set the pr_WindowPtr of the created process to the value of the calling process, the tag must be explicitly provided. If called from a task and not a process, the default is NULL. The reason why pr_WindowPtr is not explicitly copied is that the caller shall ensure that the screen is not closed while any pointers are still pointing to its structure.

NP_HomeDir sets the pr_HomeDir *lock* which is used to resolve paths relative to the PROGDIR: pseudo-assign. The default is to copy pr_HomeDir of the calling process, or ZERO in case the caller is a task. This *lock* is released when the process terminates, i.e. the *lock* provided as argument here remains available to the caller, and shall be released by the caller in one way or another.

NP_CopyVars determines if the local shell variables in pr_LocalVars of the calling process are copied into the variables of the process to be created. If set to non-zero, a copy of the variables of the calling process are made, otherwise the new process does not receive any shell variables by itself. The latter also happens if the caller is a task and not a process. The variables are automatically released when the new process terminates.

NP_Cli determines whether the new process will receive a new shell environment in the form of a CommandLineInterface structure. If non-zero, a new CLI structure will be created and a *BPTR* to this structure will be filled into the pr_CLI member of the process to be created. The new shell environment will be a copy of the shell environment of the caller if one is present, or a shell environment initialized with all defaults. This means that the prompt, the path, and the command name will be copied over. If 0, no such environment will be created. The latter is also the default.

NP_Path provides a chained list of *locks* within which commands are searched. This is the same list the PATH command adjusts, see section **??** for details on this structure. This tag only applies if NP_Cli is non-zero to create a shell environment. This chained list is *not* copied, and will be released when the created process terminates; hence, the locks provided here are *no longer* available to the caller if CreateNewProc() succeeds. If CreateNewProc() fails, the entire lock list remains a property of the caller and thus needs to be potentially released there. The default, if this tag is not provided, is to copy the paths of the caller if the calling process has a non-zero pr_CLI structure.

NP_CommandName provides the name of the command being executed within the shell environment if NP_Cli indicates that one is to be created. The default is to copy the command name of the shell environment of the calling process if one exists, or to leave the command name empty if none is provided. The command name is copied into the shell environment of the process being created and thus remains available to the caller. More on the shell environment is found in section **??**.

NP_Arguments provides command line arguments for the process to be created. This is a NUL terminated string that is copied into the process to be created, and will also be released there. If provided, the arguments are copied in pr_Arguments of the process to be created, and will also be loaded into registers A0 and its length into D0. If NP_Arguments are non-zero, a non-ZERO NP_Input file handle shall also provided. This is because the arguments are also copied into the buffer associated to the input *file handle* to make them available to `ReadArgs()`, or any other function that performs buffered read from `pr_CIS`, see section 4.8 for details.

`NP_ExitCode` determines a pointer to function that is called when the created process terminates. This pointer is filled into `pr_ExitCode`. See section 10 for the description and the signature of this function.

`NP_ExitData` provides an argument that will be passed into the `NP_ExitCode` function in register `D1` when the process terminates.

While the official documentation also mentions the tags `NP_NotifyOnDeath` and `NP_Synchronous`, these tags are currently ignored and do not perform any function.

The `CreateNewProc()` function returns on success a pointer to the `Process` structure just created. At this stage, the process has already been launched and, depending on its priority, may already be running. On failure, the function returns `NULL`. Unfortunately, it does not set `IoErr()` consistently on failure.

10.1.2 Create a Process (Legacy)

The `CreateProc()` function creates a process from a segment list, a name, a priority and a stack size. It is a legacy call that is not as flexible as `CreateNewProc()`, and only exists for backwards compatibility reasons.

```
process = CreateProc( name, pri, seglist, stackSize )
D0                    D1    D2   D3       D4

struct MsgPort *CreateProc(STRPTR, LONG, BPTR, LONG)
```

This function creates a process of the name `name` running at priority `pri`. The process starts at the first byte of the first segment of the segment list passed in as `seglist`, and a stack size of `stackSize` bytes will be allocated for the process.

The process is initialized as follows: `pr_ConsoleTask` and `pr_WindowPtr` are copied from the calling process, or are set to `NULL` respective 0 if called from the task. The member `pr_FileSystemTask` is also copied from the calling process, or is initialized from the default file system from the *dos.library* if called from a task.

Input, output and error file handles are set to `ZERO`, and no shell environment is created either. The current directory and home directory are also left at `ZERO`. No arguments are provided to the called function, and no shell variables are copied.

If the call succeeds, the returned value `process` is a pointer to the *MsgPort* of the created process. It is *not* a pointer to a process itself.

On failure, the function returns `NULL`. Unfortunately, it does not set `IoErr()` consistently in case of failure, thus the cause of the problem cannot be easily identified.

10.1.3 Terminating a Process

The `Exit()` function terminates the calling process or the calling command line executable. In the latter case, control is returned to the calling shell, in the former case, the process is removed from the exec scheduler.

However, tis function does not release any resources except those implicitly allocated when creating the process through `CreateNewProc()`, `CreateProc()` or `RunCommand()` and the calling shell. As it misses to release resources allocated by you or the compiler startup code, this function *should not be used* and rather a compiler or language specific shutdown function should be preferred. The C standard library provides `exit()` which releases resources allocated through this library.

```
Exit( returnCode )
      D1

void Exit(LONG)
```

This call either terminates the calling process, in which case the argument is ignored, or returns to the calling shell, then delivering `returnCode` as result code. It uses the BCPL stack frame pointed to by `pr_ReturnAddr`, removes this stack frame, initializes the new stack from the stack frame there and then returns to whatever created the stack frame. This is typically either the process shutdown code of AmigaDOS, or the shell command shutdown code installed by `RunCommand()`. In the former code, `pr_ExitCode()` may be used to implement additional cleanup activities.

This function is a BCPL legacy function that is also part of the *Global Vector*; BCPL programs would typically overload its entry in this vector to implement a custom shutdown mechanism.

10.2 Process Properties Accessor Functions

The most important members of the process structure described in section 10 are accessible through getter and setter functions. They implicitly relate to the calling process, and are the preferred way of getting access to the `Process` structure. The functions listed in this section do not touch `IoErr()` except explicitly stated.

10.2.1 Retrieve the Process Input File Handle

The `Input()` function returns the input file handle of the calling process if one is installed. If no input file handle is provided, the function returns `ZERO`.

```
file = Input()
D0

BPTR Input(void)
```

This function returns a *BPTR* to the input *file handle* of the calling process, or `ZERO` if none is defined. This is approximately identical to `stdin` of ANSI-C. Depending on process creation, this file handle can be closed by the process shutdown code or the calling shell and thus should in general not be closed explicitly. It can be changed through `SelectInput()`.

10.2.2 Replace the Input File Handle

The `SelectInput()` function replaces the input *file handle* of the calling process with its argument and returns the previously used input handle.

```
old_fh = SelectInput(fh)
D0                   D1

BPTR SelectInput(BPTR)
```

This call replaces the input *file handle* of the calling process with the file handle given by `fh` and returns the previously used input *file handle*.

10.2.3 Retrieve the Output File Handle

The `Output()` function returns the output file handle of the calling process if one is installed. If no output file handle is provided, the function returns `ZERO`.

```
file = Output()
D0

BPTR Output(void)
```

This function returns a *BPTR* to the output *file handle* of the calling process, or `ZERO` if none is defined. This is approximately identical to `stdout` of ANSI-C. Depending on process creation, this file handle can be closed by the process shutdown code or the calling shell and thus should in general not be closed explicitly. It can be changed through `SelectOutput()`.

10.2.4 Replace the Output File Handle

The `SelectOutput()` function replaces the output *file handle* of the calling process with its argument and returns the previously used output handle.

```
old_fh = SelectOutput(fh)
D0                    D1

BPTR SelectOutput(BPTR)
```

This call replaces the output *file handle* of the calling process with the file handle given by `fh` and returns the previously used output *file handle*.

10.2.5 Retrieve the Error File Handle

The `ErrorOutput()` function returns the file handle through which diagnostic or error outputs should be printed. It uses either `pr_CES` if this handle is non-`ZERO`, or `pr_COS` if the former is `ZERO`. If neither an error output nor a regular output is provided, this function returns `ZERO`.

```
file = ErrorOutput()
D0

BPTR ErrorOutput(void)
```

This function returns a *BPTR* to the error *file handle* of the calling process, or falls back to the *BPTR* of the output *file handle* if the former is not available. This is the file handle through which diagnostic output should be printed and is therefore approximately identical to `stderr` of ANSI-C. Depending on process creation, this file handle can be closed by the process shutdown code or the calling shell and thus should in general not be closed explicitly. It can be changed through `SelectError()`.

10.2.6 Replace the Error File Handle

The `SelectError()` function replaces the error *file handle* of the calling process with its argument and returns the previously used error handle.

```
old_fh = SelectError(fh)
D0                   D1

BPTR SelectError(BPTR)
```

This call replaces the error *file handle* of the calling process with the file handle given by `fh` and returns the previously used error *file handle*.

10.2.7 Retrieve the Current Directory

The `GetCurrentDir()` function returns the current directory of the directory, indicated by a *lock* on this object. This *lock*, and the *file system* that created the lock are used to resolve relative paths, see also section 4.3.

```
lock = GetCurrentDir(void)
D0

BPTR GetCurrentDir()
```

This function returns the *lock* to the current directory, unlike the `CurrentDir()` function which also changes it.

10.2.8 Replace the Current Directory

The `CurrentDir()` selects and retrieves the current directory of the calling process. The directory is indicated by a *lock* to this object. This *lock*, and the *file system* that created the lock are used to resolve relative paths, see also section 4.3.

```
oldLock = CurrentDir( lock )
D0                    D1

BPTR CurrentDir(BPTR)
```

This function sets the current directory to `lock` and returns in `oldLock` the previously installed current directory. The passed in `lock` then becomes part of the process and shall not be released by `UnLock()` until another *lock* is installed as current directory.

If the current directory is `ZERO`, paths are relative to the root directory of the *file system* set in the `pr_FileSystemTask` member of the calling process. It may be changed by `SetFileSysTask()` described in section 10.2.12. AmigaDOS installs there the *file system* of the boot volume, unless a user installs a different default *file system*.

10.2.9 Return the Latest Error Code

The `IoErr()` function returns the secondary result code of the most recent AmigaDOS operation. This code is, in case of failure, typically an error code indicating the nature of the failure.

```
error = IoErr()
D0

LONG IoErr(void)
```

This function returns the secondary result code of the last call to the *dos.library* that provides such result. Unfortunately, not all functions set `IoErr()` consistently; all unbuffered operations in section 4.7 provide an error code in case of failure, or deliver 0 as secondary result in case of success. The buffered functions in section 4.8 generally only set a secondary result code in case an I/O operation is required, but do not touch `IoErr()` if the call can be satisfied from the caller. Whether a function of the *dos.library* touches `IoErr()` is stated in the description of the corresponding function — unfortunately, the *dos.library* does not handle `IoErr()` consistently.

Some functions provide a secondary result code different from an error code, and thus make such additional return value available through `IoErr()`. Such additional return values are also explicitly mentioned in the description of the corresponding function. A particular example is `DeviceProc()`, which returns the (first) lock of a regular assign in `IoErr()`, but additional functions exist.

Most error codes are defined in `dos/dos.h`, with some additional error codes only used by the pattern matcher (see section 9) in `dos/dosasl.h`. Generally, *handlers* and *file systems* can select error codes as they seem fit, the list below provides a general indication how the codes are used by the *dos.library* itself, or what their suggested usage is:

`ERROR_NO_FREE_STORE`: This error code is set if the system run out of memory. Actually, this error code is not set by the *dos.library*, but rather by the *exec.library* memory allocation functions.

`ERROR_TASK_TABLE_FULL`: This error code is no longer in use. Previous releases of AmigaDOS created it if more than 10 shell processes were about to be created. As this limitation was removed, the error code remains currently unused.

`ERROR_BAD_TEMPLATE`: This error code indicates that the command line template for `ReadArgs()` is syntactical incorrect. It is also set by the pattern matcher in case the pattern is syntactically incorrect.

`ERROR_BAD_NUMBER`: This error code indicates that a string could not be converted to a number.

`ERROR_REQUIRED_ARG_MISSING`: This error code is set by `ReadArgs()` if a non-optional argument is not provided.

`ERROR_KEY_NEEDS_ARG`: This error code is also used by the argument parser `ReadArgs()` if an argument key is provided on the command line, but a corresponding argument value is missing.

`ERROR_TOO_MANY_ARGS`: This error code can also be set by `ReadArgs()`; it indicates that more arguments are provided than indicated in the template.

`ERROR_UNMATCHED_QUOTES`: This error code indicates that a closing quote is missing for at least one opening quote. It is also set by the argument parser and `ReadItem()`.

`ERROR_LINE_TOO_LONG`: This error code is a general indicator that a user provided buffer is too small to buffer a string. It is for example used again by the argument parser and the path manipulation functions in section 6.3.

`ERROR_FILE_NOT_OBJECT`: This error code is generated by the *Shell* if an attempt is made to execute a file that is neither a script, nor an executable nor a file that can be opened by a viewer.

`ERROR_INVALID_RESIDENT_LIBRARY`: While this error code is not in use by the *dos.library*, several *handlers* and other Os components use it to indicate that a required library or device is not available.

`ERROR_NO_DEFAULT_DIR`: This is error code is also not in use. Its intended purpose is unclear.

`ERROR_OBJECT_IN_USE`: This error code is used by multiple Os components to indicate that a particular operation cannot be performed because the object to be modified is in use. AmigaDOS uses it, for example, to indicate that a *lock* was obtained on an object that is supposed to be modified or deleted, and thus cannot be modified or removed.

`ERROR_OBJECT_EXISTS`: This error code is a generic error indicator that an operation could not be performed because another object already exists in place, and is used as such by multiple Os components. AmigaDOS *file systems* use it, for example, when attempting to create a directory, but a file or a directory of the requested name is already present.

`ERROR_DIR_NOT_FOUND`: This error code indicates that the target directory is not found. Of the AmigaDOS ROM components, only the shell uses it on an attempt to change the working directory to a non-working target directory.

`ERROR_OBJECT_NOT_FOUND`: This is a generic error code that indicates that the object on which a particular operation is to be performed does not exist. It is for example generated on an attempt to open a non-existing file or to lock a file or directory that could not be found.

ERROR_BAD_STREAM_NAME: This error code is currently not in use by AmigaDOS ROM components. Its purpose is unclear.

ERROR_OBJECT_TOO_LARGE: This error could be used to indicate that an object is beyond the size a *handler* or *file system* is able to handle. Note that a full disk (or full storage medium) is indicated by ERROR_DISK_FULL, and not this error. However, currently no AmigaDOS component uses this error, even though the FFS should probably return it on an attempt to create or access files larger than 2GB.

ERROR_ACTION_NOT_KNOWN: This is a generic error code that is returned by many *handlers* or *file systems* when an action (in the form of a *packet*) is requested the handler does not support or understand. For example, this error is created when attempting to create a directory on a console handler.

ERROR_INVALID_COMPONENT_NAME: This is an error that is raised by file systems when providing an invalid path, or a path that contains components that are syntactically incorrect. For example, the colon (“:”) shall only appear one in a path as separator between the device name and the path within the device. A colon within a component is therefore a syntactical error. Also, all Amiga ROM file systems do not accept code points below 0x20, i.e. ASCII control characters.

ERROR_INVALID_LOCK: This error is raised if a value is passed in as a *lock* that is, in fact, not a valid lock of the target *file system*. For example, an attempt to use a *file handle* as a lock will result in such an error condition. Note, however, that *file systems* can, but do not need to check locks for validity. Passing incorrect objects to *file systems* can raise multiple error conditions of which this error code is probably the most harmless.

ERROR_OBJECT_WRONG_TYPE: This error code indicates that a particular operation is not applicable to a target object, even though the target object is valid and existing. For example, an attempt to open an existing directory for reading as a file will raise this error.

ERROR_DISK_NOT_VALIDATED: This error indicates that the inserted medium is currently not validated, i.e. not checked for consistency. Such a consistency check (or validation) may be currently ongoing. This error is for example generated if a write operation is attempted on an FFS volume whose validation is still ongoing. In such a case, retrying the operation later may solve the problem already.

ERROR_DISK_WRITE_PROTECTED: This indicates that an attempt was made to write to a medium, e.g. a disk, that is write-protected, or that cannot be written to, such as an attempt to write to a CD-ROM.

ERROR_RENAME_ACROSS_DEVICES: Generated if an attempt is made to move an object to a target directory that is located on a different medium or different *file system* than the source directory. This cannot succeed, instead the object (and its subobjects) need to be copied manually.

ERROR_DIRECTORY_NOT_EMPTY: Indicates that an attempt was made to delete a directory that is not empty. First, all the files within a directory must be deleted before the directory itself may be deleted.

ERROR_TOO_MANY_LEVELS: This error code is generated if too many softlinks refer iteratively to other softlinks. In order to avoid an endless indirection of softlinks referring to each other, the *dos.library* aborts following softlinks after 15 passes; application programs attempting to resolve softlinks themselves through ReadLink() should implement a similar mechanism, see also section 6.4.2.

ERROR_DEVICE_NOT_MOUNTED: This error indicates that an access was attempted to either a *handler*, *file system* or *assign* that is not known to the system, or to a volume that is currently not inserted in any known drive.

ERROR_SEEK_ERROR: This error is generated by an attempt to Seek() to a file position that is either negative, or behind the end of the file. It is also signalled if the mode of Seek() or SetFileSize() is none of the modes indicated in table 10. The FFS also sets this mode if it cannot read one of its administration blocks.

ERROR_COMMENT_TOO_BIG: This error is raised if the size of the comment is too large to be stored in in the metadata of the *file system*. Note that while *file systems* shall validate the size of the comment, it shall silently truncate file names to the maximal size possible.

ERROR_DISK_FULL: Generated by *file systems* when an attempt is made to write more data to a medium than it is possible to hold, i.e. when the target medium is full.

ERROR_DELETE_PROTECTED: This error is generated by *file systems* if an attempt is made to delete a file that is delete protected, i.e. whose FIBB_DELETE protection bit is set, see table 21 in section 6.1.

ERROR_WRITE_PROTECTED: This error is generated by *file systems* if a write is attempted to a file that is write protected, i.e. whose FIBB_WRITE bit is set.

ERROR_READ_PROTECTED: This error is generated on an attempt to read from a while whose FIBB_READ bit is set to indicate read protection.

ERROR_NOT_A_DOS_DISK: This error is generated by a *file system* on an attempt to read a disk that is not strutured according to the requirements of the *file system*, i.e. that is initialized by another incompatbile *file system* different from the mounted one. Unfortunately, AmigaDOS does not have a control instance that selects file systems according to the disk layout.

ERROR_NO_MORE_ENTRIES: This secondary result code does not really indicate an error condition, it just reports to the caller that the end of a directory has been reached when scanning it by ExNext() or ExAll().

ERROR_IS_SOFT_LINK: This error code is generated by *file systems* on an attempt to access a *soft link*. For many functions, the *dos.library* recognizes this error and then resolves the link through ReadLink() within the library, not requiring intervention of the caller. However, not all functions of the *dos.library* are aware of *soft links*, see section 6.4 for the list.

ERROR_OBJECT_LINKED: This error code is currently not used by AmigaDOS and its intended use is not known.

ERROR_BAD_HUNK: Generated by LoadSeg() and NewLoadSeg(), this error code indicates that the binary file includes a hunk type that is not supported or recognized by AmigaDOS. The hunk format for binary executables is documented in section **??**.

ERROR_NOT_IMPLEMENTED: This error code is not used by any ROM component, but several workbench components signal this error indicating that the requested function is not supported by this component. For example, the Format command generates it on an attempt to format a disk with long file names if the target file system does not support them.

ERROR_RECORD_NOT_LOCKED: Issued by *file systems* and their record-locking subsystem if an attempt is made to release a record that is, actually, not locked.

ERROR_LOCK_COLLISION: This error is also created by the record-locking subsystem of *file systems* if attempt is made to exclusively lock the same region within a file by two write locks.

ERROR_LOCK_TIMEOUT: Also generated by the record-locking mechanism of *file systems* if an attempt was made to exclusively lock a region of a file that is exclusively locked already, and the attempt failed because the region did not became available before the lock timed out.

ERROR_UNLOCK_ERROR: This error is currently not generated by any *file system*, though could be used to indicate that an attempt to unlock a record failed for an unknown reason.

ERROR_BUFFER_OVERFLOW: This error is raised by the pattern matcher and indicates that the buffer allocated in the AnchorPath structure is too small to keep the fully expanded matching file name, see also section **??**.

ERROR_BREAK: This error is also raised by the pattern matcher if it received an external signal for aborting a directory scan for objects. Such signals are raised, for example, by the user through the console by pressing Ctrl + C through Ctrl + F.

ERROR_NOT_EXECUTABLE: This error is generated by the workbench on an attempt to start an application icon from a file whose FIBB_EXECUTE is set, indicating that the file is not executable. Why the workbench does not use the same error code as the *Shell* remains unclear.

10.2.10 Setting IoErr

The `SetIoErr()` function sets the value returned by the next call to `IoErr()` and thus initializes or resets the next IO error.

```
oldcode = SetIoErr(code)
D0                  D1

LONG SetIoErr(LONG);
```

This function sets the next value returned by `IoErr()`; this can be necessary because some functions of the *dos.library* do not update this value in all cases. A particular example are the buffered I/O functions introduced in section **??** that do not touch `IoErr()` in case the input or output operation can be satisfied from the buffer. A good practise is to call `SetIoErr(0)` upfront to ensure that these functions leave a 0 in `IoErr()` on success.

This function returns the previous value of `IoErr()`, and thus the same value `IoErr()` would return.

10.2.11 Select the Console Handler

The `SetConsoleTask()` function selects the *handler* responsible for the "`*`" file name and `CONSOLE:` pseudo-device.

```
oldport = SetConsoleTask(port)
D0                         D1

struct MsgPort *SetConsoleTask(struct MsgPort *)
```

This function selects the *MsgPort* of the console handler. AmigaDOS will contact this handler for opening the "`*`" as file name, or a file relative to the `CONSOLE:` pseudo-device. Note that the argument is not a pointer to the *handler* process, but rather to a *MsgPort* through which this process can be contacted. It returns the previously used console handler *MsgPort*.

This function is the setter function corresponding to the `GetConsoleTask()` getter function introduced in section 8.2.4.

10.2.12 Select the Default File System

The `SetFileSysTask()` function selects the handler responsible for resolving paths relative to the `ZERO` lock.

```
oldport = SetFileSysTask(port)
D0                         D1

struct MsgPort *SetFileSysTask(struct MsgPort *)
```

This function selects the *MsgPort* of the default *file system*. AmigaDOS will contact this *file system* if a path relative to the `ZERO` lock is resolved, e.g. a relative path name if the current directory is `ZERO`. This *file system* should be identical to the *file system* of the `SYS:` assign, and should therefore not be relaced as otherwise resolving file names may be inconsistent between processes.

Note that the argument is not a pointer to the *handler* process, but rather to a *MsgPort* through which this process can be contacted. It returns the previously used default file system *MsgPort*. This function is the setter equivalent of `GetFileSysTask()` introduced in section 8.2.5.

10.2.13 Retrieve the Lock to the Program Directory

The GetProgramDir() returns a lock to the directory that contains the binary from which the caller executes, if such a directory exists. If the executable was made resident, this function returns ZERO.

```
lock = GetProgramDir()
D0

BPTR GetProgramDir(void)
```

The lock returned by this function corresponds to the PROGDIR: (pseudo)-assign and the pr_HomeDir member of the Process structure, with the only exception that ZERO does not correspond to the root directory of the boot volume, but rather indicates that no home directory exists.

10.2.14 Set the Program Directory

The SetProgramDir sets the directory within which the executing program is made to believe of getting started from, and the directory that corresponds to the PROGDIR: pseudo-assign.

```
oldlock = SetProgramDir(lock)
D0            D1

BPTR SetProgramDir(BPTR)
```

This function installs lock into pr_HomeDir of the Process structure. This lock is supposed to belong to the directory the currently executing program was loaded from and is used to resolve the PROGDIR: pseudo-assign. If ZERO is installed, the current process will be unable to resolve this pseudo-assign.

10.2.15 Retrieve Command Line Arguments

The GetArgStr() function returns the command line arguments, if any, of the calling process. If called from the workbench, this function returns NULL.

```
ptr = GetArgStr()
D0

STRPTR GetArgStr(void)
```

This function returns the command line arguments as NUL-terminated string. This is the same string the process finds in register a0 on startup, or that is placed into the file buffer of the Input() file handle. This function returns NULL if the program was run from the workbench; it is equivalent to reading the pr_Arguments member of the Process structure.

10.2.16 Set the Command Line Arguments

The SetArgStr() function sets the string returned by GetArgStr(). It cannot set the command line arguments as seen by ReadArgs().

```
oldptr = SetArgStr(ptr)
D0      D1

STRPTR SetArgStr(STRPTR)
```

This function requires a pointer to a NUL terminated string as ptr and installs it to pr_Arguments member of the Process structure. This is unfortunately of limited use as the ReadArgs() function takes the command line arguments from a different source, namely the input buffer of the Input() file handle.

Chapter 11

Binary File Structure

The AmigaDOS *Hunk* format represents executable and linkable object files. While both formats are related, they are not identical; executables can be loaded from the shell or the workbench from disk to RAM, and then either overload the shell process, or a new process is created from them. Object files are created as intermediate compiler outputs; typically, each translation unit is compiled into one object file which are then, in a final step, linked with a startup code and object code libraries to form an executable.

An object or executable file in this format consists of multiple *hunks* (thus, the name). Hunks define either payload data as indivisible *segments* of code or data that is initialized or loaded from disk, or additional meta-information interpreted by the AmigaDOS loader, the `LoadSeg()` function. The meta-information is used to relocate the payload to their final position in memory, to define the size of the sections, to select the memory type that is allocated for the segment, or to interrupt or terminate the loading process.

Loaded executables are represented as singly linked list of segments in memory, by a structure that looks as follows:

```
struct LoadedSegment {
    BPTR  NextSegment; /* BPTR to next segment or ZERO */
    ULONG Data[1];     /* Payload data */
};
```

The above structure is *not* documented and is not identical to the `Segment` in `dos/dosextens.h`. The latter describes a resident executable, see section **??**, but also contains a *BPTR* to a segment in the above sense. Each segment of a binary is allocated through `AllocVec()` which is sometimes helpful as it allows to retrieve size of the segment from the size of the allocated memory block.

The hunk format distinguishes three types of *segments*, each represented by a hunk: *code hunks* that should contain constant data, most notably executable machine code and constant data associated to this code, *data hunks* that contain (variable) data, and so called *BSS* hunks that contain data that is initialized to zero. Thus, the contents of *BSS* hunks is not represented on disk.

> *Const is not enforced* While *code hunks* should contain executable code and other constant data, and *data hunks* should contain variable data, nothing in AmigaDOS is able to enforce these conventions. In principle, *data hunks* may contain executable machine code, and *code hunks* may contain variable data. Note, however, that some third party tools may require programs to follow such conventions. Many commercial compilers structure their object code according to these conventions, or at least do so in their default configuration.

Additional *hunks* describe how to relocate the loaded code and data. Relocation means that data within the hunk is corrected according to the addresses this and other hunks are loaded to. The relocation process takes an offset into one hunk, and adds to the longword at this offset the absolute address of this or any other hunk. That is, hunks on disk are represented as if their first byte is placed at address 0, and relocation adjusts longwords within hunks to the final positions in memory.

An extension of the executable file format is the *overlay format* also supported by `LoadSeg()`. Here, only a part of the file is loaded into memory, while the remaining parts are only loaded on demand, potentially releasing other already loaded parts from memory. Overlaid executables thus take less main memory, though requires the volume containing the executable available all the time.

AmigaDOS also contains a simple run-time binder that is only used by compiled BCPL code, or by code that operates under such requirements. The purpose of this binder is to populate the BCPL *global vector* of the loaded program. While this runtime binder implements a legacy protocol, certain parts of AmigaDOS still expect. These are *handlers* or *file systems* that use the `dol_GlobVec` value of 0 or -2, or corresponding `GlobVec` entry in the mount list. While new handlers should not use this BCPL legacy protocol, the ROM file system (the FFS) and the port-handler currently still depend (or require) it, despite not being written in BCPL. A second application of this run-time binding procol is the shell which also depends on BCPL binding.

11.1 Executable File Format

The hunk format of executable files consists of 4-byte (longword) hunk identifiers and subsequent data that is interpreted by the AmigaDOS loader according to the introducing hunk identifier. The syntax of such a file, and its hunks, is here presented in a pseudo-code, in three-column tables.

The first column identifies the number of bits a syntax element takes. Bits within a byte are read from most significant to least significant bit, and bytes within a structure that extends over multiple bytes are read from most significant to least significant bit. That is, the binary file format follows the big-endian convention. If the first column contains a question mark ("?"), the structure is variably-sized, and the number of removed bits is defined by the second column, or the section it refers to. If the first column is empty, no bits are removed from the file.

The second column either identifies the member of a structure to which the value removed from the stream is assigned, or contains pseudo-code that describes how to process the values parsed from the stream. These syntax elements follow closely the convention of the C language. In particular `if (`*cond*`)` formulates a condition that is only executed if *cond* is true, `else` describes code that is executed following an `if` clause that is executed if *cond* is false, and `do` ... `while(`*cond*`)` indicates a loop that continues as long as `cond` is non-zero, and that may alternatively be terminated by a `break` within the body of the loop. The expression `i++` increments an internal state variable `i`, and the expression `--j` decrements an internal state variable. The value of `i++` is the value of i before the increment, and the value of `--j` is the value of j after decrementing it.

The following pseudo-code describes the top-level syntax of a binary executable file AmigaDOS is able to bring to memory:

Table 30: Regular Executable File

Size	Code	Syntax
?	`HUNK_HEADER`	Defines all segments, see section 11.1.1 for details
	$i = t_{\text{num}}$	Start with the first hunk, t_{num} is defined in the `HUNK_HEADER`
	`do {`	Repeat until all hunks done
2	$\hat{m}_t[i]$	These two bits are unused, but some utilities set it identical to $m_t[i]$, the memory type of the hunk, see 11.1.1
1	a_f	Advisory hunk flag.

29	`h`	This is the hunk type
	`if (EOF) break;`	Terminate loading on end of file
	`if (`a_f`) {`	Check for bit 29, these are advisory hunks
32	`l`	Read length of advisory hunk
$32 \times l$		l long words of hunk contents ignored
	`}`	
	`else if (h == HUNK_END) i++;`	Advance to next segment, see 11.1.11
	`else if (h == HUNK_BREAK) break;`	Terminate loading an overlay, see 11.3.5
?	`else if (h == HUNK_NAME) parse_NAME;`	See section 11.1.8
?	`else if (h == HUNK_CODE) parse_CODE;`	See section 11.1.2
?	`else if (h == HUNK_DATA) parse_DATA;`	See section 11.1.3
?	`else if (h == HUNK_BSS) parse_BSS;`	See section 11.1.4
?	`else if (h == HUNK_RELOC32) parse_RELOC32;`	See section 11.1.5
?	`else if (h == HUNK_SYMBOL) parse_SYMBOL;`	See section 11.1.9
?	`else if (h == HUNK_DEBUG) parse_DEBUG;`	See section 11.1.10
?	`else if (h == HUNK_OVERLAY) { parse_OVERLAY; break }`	See section 11.3.3
?	`else if (h == HUNK_DREL32) parse_RELOC32SHORT;`	This is a compatibility kludge for some older versions of the *dos.library*, new tools should use `HUNK_RELOC32SHORT` instead, see section 11.1.6
?	`else if (h == HUNK_RELOC32SHORT) parse_RELOC32SHORT;`	See section 11.1.6
?	`else if (h == HUNK_RELRELOC32) parse_RELRELOC32;`	See section 11.1.7
	`else ERROR_BAD_HUNK;`	Everything else is invalid
	`} while(true)`	repeat until all hunks done

In particular, every executable shall start with the `HUNK_HEADER` identifier, the big-endian long-word `0x3f3`. The following stream contains long-word identifiers of which the first 2 bits are ignored and masked out. Some tools (e.g. the `Atom` tool by CBM) places there memory requirements similar to what is indicated in the `HUNK_HEADER`. They have there, however, no effect as the segments are allocated within the `HUNK_HEADER` and not at times the hunk type is encountered.

Bit 29 (`HUNKB_ADVISORY`) has a special meaning. If this bit is set, then the hunk contents is ignored. The size of such an *advisory* hunk is defined by a long-word following the hunk type.

Loading a binary executable terminates on three conditions. Either, if an end of file is encountered. This closes the file handle and returns to the caller with the loaded segment list. Or, if a `HUNK_BREAK` or `HUNK_OVERLAY` are found. This mechanism is used for *overlaid* files. In the latter two cases, the file remains open, and for HUNK_OVERLAY, information on the loaded file is injected into the first hunk of the loaded data. More information on this mechanism is provided in section 11.3.

11.1.1 HUNK_HEADER

The HUNK_HEADER is the first hunk of every executable file. It identifies the number of segments in an executable, and the amount of memory to reserve for each segment.

Table 31: Hunk Header Syntax

Size	Code	Syntax
32	HUNK_HEADER [0x3f3]	Every executable file shall start with this hunk
32	0	Number of resident libraries, BCPL legacy, shall be zero
32	$t_{\texttt{size}} \in [1, 2^{31} - 1]$	Number of segments in binary
32	$t_{\texttt{num}} \in [0, t_{\texttt{size}} - 1]$	First segment to load
32	$t_{\texttt{max}} \in [t_{\texttt{num}}, t_{\texttt{size}} - 1]$	Last segment to load (inclusive)
	for(i=$t_{\texttt{num}}$; $i \leq t_{\texttt{max}}$; i++) {	Iterate over all hunks
2	$m_t[i]$	Read memory type of the segment as 2 bits
30	$m_s[i]$	Read memory size in long words as 30 bits
	if ($m[i]$ == 3) {	if the memory type is 3
32	$m_t[i]$	Memory type is explicitly provided
	}	End of special memory condition
	$m_a[i]$ = AllocVec(sizeof(BPTR) + $m_s[i] \times$ sizeof(LONG),$m_t[i]\vert$ MEMF_PUBLIC) + sizeof(BPTR)	Get memory for segment
	}	End of loop over segments

The first member of a HUNK_HEADER shall always be 0; it was used by a legacy mechanism which allowed run-time binding of the executable with dynamic libraries. While first versions of AmigaDOS inherited this mechanism from TRIPOS, it was not particularly useful as the calling conventions for such libraries did not follow the usual conventions of AmigaDOS, i.e. with the library base in register a6. Later versions of AmigaDOS, in particular its re-implementation as of Kickstart v37, removed support for such libraries. As this mechanism is no longer supported, it is not documented here. More information is found in [10].

The second entry t_{size} contains the number of segments the executable consists of. In case of overlays, it is the total number of segments that can be resident in memory at all times. See section 11.3 for more information. This value shall be consistent for all HUNK_HEADERS within an overlaid file. In regular executables, only a single HUNK_HEADER exists at the beginning of the file.

The members t_{num} and t_{max} define the 0-based index of the first and last segment to load within the branch of the overlay tree described by this HUNK_HEADER. For a regular (non-overlaid) file and for the root node of the overlay tree, t_{num} shall be 0, that is, the first segment to load is 0, the first index in the segment table.

For regular files, t_{max} shall be identical to $t_{\text{size}} - 1$, that is, the last segment to load is the last entry in the segment table described by this HUNK_HEADER. For overlaid files, the number may be smaller, i.e. not all segments may be populated initially and loading may continue later on when executing the binary.

11.1.2 HUNK_CODE

This hunk should contain executable machine code and constant data. As executables are started from the first byte of the first segment, the first hunk of an executable should be a HUNK_CODE, and it should start with a valid opcode.

Compilers use typically this hunk to represent the `text` segment, i.e. compiled code and constant data. The structure of this hunk is as follows:

Table 32: Hunk Code Syntax

Size	Code	Syntax
	`HUNK_CODE [0x3e9]`	A hunk describing a segment of code and constant data
32	$l \leq m_s[i]$	Size of the payload
1×32	`Code`	l long words of payload

Note that the size of the payload loaded from the file may be less than the size of the allocated segment as defined in `HUNK_HEADER`. In such a case, all bytes of the segment not included in the `HUNK_CODE` are zero-initialized. AmigaDOS versions earlier than v37 skipped this initialization. Due to a bug in the loader in later versions, the initialization is also skipped of the hunk length l is 0.

11.1.3 HUNK_DATA

This hunk should contain variable data, and it should not contain executable code. Compilers typically use this hunk to represent initialized data.

The structure of this hunk is otherwise identical to `HUNK_CODE`:

Table 33: Hunk Data Syntax

Size	Code	Syntax
	`HUNK_CODE [0x3ea]`	A hunk describing a segment of data
32	$l \leq m_s[i]$	Size of the payload
1×32	`Code`	l long words of payload

Similar to `HUNK_CODE`, the size of the payload defined by this hunk may be less than the size of the segment allocated by `HUNK_HEADER`. Excess bytes are zero-initialized in all AmigaDOS releases from v37 onwards. Due to a bug in the loader in later versions, the initialization is also skipped of the hunk length l is 0.

11.1.4 HUNK_BSS

This hunk contains zero-initialized data; it does not define actual payload.

The structure of this hunk is as follows:

Table 34: Hunk BSS Syntax

Size	Code	Syntax
	`HUNK_CODE [0x3eb]`	A hunk describing zero-initialized data
32	$l \leq m_s[i]$	Size of the segment in long-words

Note that this hunk does not contain any payload; the segment allocated from this hunk is always zero-initialized.

Due to a defect in AmigaDOS prior release v37, the BSS segment will not be completely initialized to zero if the segment size is larger than 256K, i.e. if $l > 2^{16}$. Also, these releases do not initialize long words beyond the l^{th} long-word to zero, i.e. the excess bytes included if $l < m_s[i]$.

11.1.5 HUNK_RELOC32

This hunk contains relocation information for the previously loaded segment; that is, it corrects addresses within this segment by adding the absolute address of this or other segments to long words at indicated offsets of the previous segments.

The structure of this hunk is as follows:

Table 35: Hunk Reloc32 Syntax

Size	Code	Syntax
	`HUNK_RELOC32 [0x3ec]`	A hunk containing relocation information
	`do {`	Loop over relocation entries
32	c	Number of relocation entries
	`if (`c` == 0) break;`	Terminate the hunk if the count is zero
32	$j \in [0, t_{\texttt{size}} - 1]$	Read the hunk to which the relocation is relative to
	`do {`	Loop over the relocation entries
32	$r_o \in [0, m_s[i] \times 4 - 4]$	Relocation offset into this hunk as byte address
	`(UBYTE **)(`$m_a[i]$ `+` r_o`) +=` $m_a[j]$	Fixup this hunk by the start address of the selected hunk
	`} while(--c);`	until all entries are used
	`} while(true);`	until a zero-count is read.

That is, the hunk consists first of a counter that indicates the number of relocation entries, followed by the hunk index relative to which an address should be relocated. Then relocation entries follow; each long-word defines an offset into the previously loaded segment to relocate, that is, to fix up the address.

For AmigaDOS versions 37 and up (Kickstart 2.0 and later), the number of relocation entries c shall not be larger than 2^{16}. This is a known defect of the loader that has currently not yet fixed. If more relocation entries are needed, they shall be split into multiple chunks.

11.1.6 HUNK_RELOC32SHORT

This hunk contains relocation information for the previously loaded segment, and is almost similar to `HUNK_RELOC32`, except that hunk indices, counts and offsets are only 16 bits in size. To ensure that all hunks start at long-word boundaries, the hunk contains an optional padding field at its end to align the next hunk appropriately.

The structure of this hunk is as follows:

Table 36: Hunk Reloc32Short Syntax

Size	Code	Syntax
	`HUNK_RELOC32SHORT [0x3fc]`	A hunk containing relocation information
	p=1	Padding count
	`do {`	Loop over relocation entries
16	c	Number of relocation entries
	`if (`c` == 0) break;`	Terminate the hunk if the count is zero
16	$j \in [0, t_{\texttt{size}} - 1]$	Read the hunk to which the relocation is relative to
	p `+=` c	Update padding count
	`do {`	Loop over the relocation entries
16	$r_o \in [0, m_s[i] \times 4 - 4]$	Relocation offset into this hunk as byte address

	(UBYTE **)($m_a[i]$ + r_o) += $m_a[j]$	Fixup this hunk by the start address of the selected hunk
	} while(--c);	until all entries are used
	} while(true);	until a zero-count is read.
	if (p & 1) {	check whether padding is required.
16		dummy for long-word alignment
	}	

Due to an oversight, some versions of AmigaDOS do not understand the hunk type `0x3fc` properly and use instead `0x3f7`. This alternative (but incorrect) hunk type for the short version of the relocation hunk is still supported currently.

11.1.7 HUNK_RELRELOC32

This hunk contains relocation information for 32-bit relative displacements the `68020` and later processors offer. Its purpose is to adjust the offsets of a 32-bit wide PC-relative branches between segments.

The structure of this hunk is as follows:

Table 37: Hunk RelReloc32 Syntax

Size	Code	Syntax
	HUNK_RELRELOC32 [0x3fd]	A hunk containing relocation information
	do {	Loop over relocation entries
32	c	Number of relocation entries
	if (c == 0) break;	Terminate the hunk if the count is zero
32	$j \in [0, t_{\texttt{size}} - 1]$	Read the hunk to which the relocation is relative to
	do {	Loop over the relocation entries
32	$r_o \in [0, m_s[i] \times 4 - 4]$	Relocation offset into this hunk as byte address
	(UBYTE **)($m_a[i]$ + r_o) += $m_a[j] - m_a[i] - r_o$	Fixup this hunk by the start address of the selected hunk
	} while(--c);	until all entries are used
	} while(true);	until a zero-count is read.

For AmigaDOS versions 37 and up (Kickstart 2.0 and later), the number of relocation entries c shall not be larger than 2^{16}. This is a known defect of the loader that has currently not yet fixed. If more relocation entries are needed, they shall be split into multiple chunks.

Due to another defect, all elements of this hunk, namely c, r_o, j and r_o are only 16 bit wide, which limits the usefulness of this hunk. It is therefore recommended not to depend on this hunk type at all and avoid 32-bit wide branches between segments. Luckely, the support for this hunk type is very limited.

11.1.8 HUNK_NAME

This hunk defines a name for the current segment. The AmigaDOS loader completely ignores this name, and it does not serve a particular purpose for the executable file format. However, linkers that bind object files together use the name to decide which segments to merge together to a single segment.

The structure of this hunk is as follows:

Table 38: Hunk Name Syntax

Size	Code	Syntax
	`HUNK_NAME [0x3e8]`	A hunk assigning a name to the current segment
32	`l`	Size of the name in long-words
$32 \times l$	h_n	Hunk name

The size of the name is not given in characters, but in 32-bit units. The name is possibly zero-padded to the next 32-bit boundary to fill an integer number of long-words. If the name fills an entire number of long-words already, it is *not* zero-terminated.

While the specification does not define a maximum size of the name, the AmigaDOS loader fails on names longer than 124 character, i.e. 31 long-words.

11.1.9 HUNK_SYMBOL

This hunk defines symbol names and corresponding symbol offsets or values within the currently loaded segment. Again, the AmigaDOS loader ignores this hunk, but the linker uses it to resolve symbols with external linkage to bind multiple object files together. If the symbol information is retained in the executable file, it may be used for debugging purposes.

The syntax of this hunk reads as follows:

Table 39: Hunk Symbol Syntax

Size	Code	Syntax
	`HUNK_SYMBOL [0x3f0]`	A hunk assigning symbols to positions within a segment
	`do {`	Repeat . . .
8	s_t	Symbol type
24	s_l	Symbol length in long-words
	`if (`s_l` == 0) break`	Terminate the hunk
$32 \times s_l$	s_n	Symbol name, potentially zero-padded
32	s_v	Symbol value
	`} while(true)`	until zero-sized symbol

The length of the symbol name is encoded in long-words, not in characters. If it does not fill an integer number of long-words, it is zero-padded; the name is not zero-terminated if it does fill an integer number of long-words, though. The AmigaDOS loader is currently limiting the maximum size of the symbol name to 124 characters, i.e. $s_i < 32$.

The symbol type s_t defines the nature of the symbol. The symbol types are defined in `dos/doshunks.h` and shared with the `HUNK_EXT` hunk; the latter hunk type shall not appear in an executable file, but may only appear in an object file, see section 11.5.7.

The symbol type can be roughly classified into two classes: If bit 7 of the type is clear, a symbol is *defined* that may be referenced by another object file. If bit 7 is set, the symbol is *referenced* and requires resolution by a symbol definition with bit 7 cleared upon linking. Executable files, and thus symbols within `HUNK_SYMBOL`, may only contain symbol definitions as references had been resolved by the linker before.

The following table contains the symbol types for definitions and those may therefore may appear in both `HUNK_SYMBOL` as part of executables and `HUNK_EXT` as part of object files; actually, `HUNK_SYMBOL` will typically only include the first type of entry, i.e. `EXT_SYMB`:

Table 40: Symbol types in HUNK_SYMBOL and HUNK_EXT

`EXT_SYMB`	[0x00]	Definition of a symbol, $s_v + m_a[i]$ is the address of the symbol
`EXT_DEF`	[0x01]	Relocation definition, $s_v + m_a[i]$ is the address of the symbol. References to this symbol are converted into a relocation information to the offset s_v in hunk i.
`EXT_ABS`	[0x02]	Absolute value, s_v is the value of the symbol which is substituted into the executable by the linker. No relocation information is created, the absolute value is just substituted.
`EXT_RES`	[0x03]	Not longer supported as it is part of the obsolete dynamic library runtime binding interface, see [10] for more details.

Additional symbol types representing references used within `HUNK_EXT` are documented in section 11.5.7.

11.1.10 HUNK_DEBUG

This hunk contains debug information such as function names and line number information. Generally, the contents of this hunk is compiler or assembler specific, and the AmigaDOS loader does not interpret the contents of this hunk at all, it is just skipped over.

However, the debug information emitted by the SAS/C compiler for the "line-debug" option is also shared by other development tools such as the DevPac assembler and will be documented here. In this format, the debug hunk contains for each line of the source file an offset into the hunk to the code that was compiled from this line.

The syntax of this hunk is as follows:

Table 41: Hunk Debug Syntax

Size	Code	Syntax
	HUNK_DEBUG [0x3f1]	Hunk including debug information
32	l > 3	Size of the hunk in long-words
Compiler- and configuration specific data for line-debug data:		
32	h_o	Offset of symbols into the hunk
32	`'LINE'`	These four bytes shall contain the ASCII characters `'L'`,`'I'`,`'N'`,`'E'` identifying the type of the debug information
32	l_n	Size of the source file name in long-words
32 $\times l_n$	n_f	source file name that compiled to the current segment in l_n long-words
	$l -= 3 + l_n$	Remove long-words read so far
	`while(`l `> 0) {`	Repeat for all entries
8		Dummy byte
24	l_l	Line number within the source file
8		Dummy byte
24	l_v	Offset into the source file. The source file at line l_l is compiled or assembled to the code at at address $m_a[i]+l_v$ and following.
	$l -= 2$	Remove the read data
	`};`	Loop over the hunk.

The file name n_f is encoded in l_n long-words, and potentially padded with 0-bytes to fill an integer number of long-words. If it already is an integer number of long-words sized, it is *not* zero-terminated.

The hunk offset h_o is added to all offsets l_v into the hunk to determine the position of a symbol in the hunk.

While [1] documents the entire hunk contents except the hunk length l to be compiler dependent, it is is recommended for custom debug hunks to always include the hunk offset h_o and the ID field — 'LINE' in this case — to simplify linker designs.

11.1.11 HUNK_END

This hunk terminates the current segment and advances to the next segment, if any. It does not contain any data.

Table 42: Hunk End Syntax

Size	Code	Syntax
	HUNK_END [0x3f2]	Terminate a segment

11.2 The AmigaDOS Loader

The *dos.library* provides service functions for loading and releasing binary executables in the *Hunk* format introduced in section 11. The functions discussed in this section load such binaries into memory, constructing a segment list from the hunks found in the files, or release such files. Overlay files are discussed separately in section 11.3 due to their additional complexity.

A segment list is a linearly linked list as defined in section 11, i.e. the first four bytes of every segment form a *BPTR* to the following segment of the loaded binary, or ZERO for the last segment.

The seglist returned from the loader functions may be, for example, passed into CreateNewProc() as argument to the NP_Seglist tag for starting a new process.

11.2.1 Loading an Executable

The LoadSeg() function loads an executable binary in the Hunk format and returns a *BPTR* to the first segment:

```
seglist = LoadSeg( name )
D0                 D1

BPTR LoadSeg(STRPTR)
```

This function loads the binary executable named name and returns a *BPTR* to its first segment in case of success, or ZERO in case of failure. The name is passed into the Open() function and follows the conventions of this function for locating the file.

The segment list shall be removed from memory via UnLoadSeg().

This function sets IoErr() to an error code in case of failure, or 0 in case of success.

11.2.2 Loading an Executable with Additional Parameters

The NewLoadSeg() function loads an executable providing additional data for loading.

```
seglist = NewLoadSeg(file, tags)
D0                   D1    D2

BPTR NewLoadSeg(STRPTR, struct TagItem *)

seglist = NewLoadSegTagList(file, tags)
D0                          D1    D2
```

```
BPTR NewLoadSegTagList(STRPTR, struct TagItem *)

seglist = NewLoadSegTags(file, ...)

BPTR NewLoadSegTags(STRPTR, ...)
```

This function loads a binary executable from `file` and returns a *BPTR* to its first segment, similar to `LoadSeg()`.

Additional parameters may be provided in the form of a TagList, passed in as `tags`. The first two functions are identical and differ only by their naming convention; the last function prototype also refers to the same entry within the *dos.library*, though uses a different calling convention where the second and all following arguments form the TagList itself. This TagList is build on the stack, and the pointer to this stack-based TagList is passed in.

While this function looks quite useful, AmigaDOS does currently not define any tags for this function, and thus no additional functionality over `LoadSeg()` is provided.

The segment list returned by this function shall be removed from memory via `UnLoadSeg()`, a specialized unloader function is not required for this call.

11.2.3 Loading an Executable through Call-Back Functions

The `InternalLoadSeg()` function loads a binary executable, retrieving data and memory through call-back functions. While `LoadSeg()` always goes through the *dos.library* and the *exec.library* for reading data and allocating memory, this function instead calls through user-provided functions.

```
seglist = InternalLoadSeg(fh,table,funcs)
D0                        D0  A0    A1

BPTR InternalLoadSeg(BPTR,BPTR,struct LoadSegFuncs *)
```

This function loads a binary executable in the hunk format from an opaque file handle `fh` through functions in the `funcs`. The `table` argument shall be `ZERO` when loading regular binaries or the root node of an overlay file, and shall be a *BPTR* to the array containing pointers to all segments when loading a non-root overlay node, see section 11.3.

The `LSFuncs` structure contains function pointers through which this function loads data or retrieves memory. It looks as follows:

```
struct LoadSegFuncs {
    LONG __asm ReadFunc(register __d1 BPTR fh,
                        register __a0 APTR buffer,
                        register __d0 ULONG size,
                        register __a6 struct DosLibrary *DOSBase);
    APTR __asm AllocMem(register __d0 ULONG size,
                        register __d1 ULONG flags,
                        register __a6 struct ExecBase *SysBase);
    void __asm FreeMem (register __a1 APTR mem,
                        register __d0 ULONG size,
                        register __a6 struct ExecBase *SysBase);
}
```

The `ReadFunc()` function retrieves `d0` bytes from an opaque file handle passed into register `d1` and places the read bytes into the buffer pointed to by register `a0`, it shall return the number of bytes read in register `d0`, or a negative value in case of error. Note that the file handle `d1` need not to be a file handle as returned by the `Open()` function, it is only a copy of the `fh` argument provided to `InternalLoadSeg()`. Register `a6` is loaded by a pointer to the *dos.library*.

The `AllocMem()` function allocates `d0` bytes of memory, using requirement flags from `exec/memory.h` such as `MEMF_CHIP` to require chip memory or `MEMF_FAST` for fast memory. This function shall return a pointer to the allocated memory in register `d0`, or `NULL` in case of failure. Register `a6` is loaded with a pointer to the *exec.library*.

The `FreeMem()` function releases a block of `d0` bytes pointed to by `a0`. Register `a6` is loaded with a pointer to the *exec.library*.

The purpose of this function is to load a segment or a binary without having access to a file or a *file system*; for example, this function could load binaries from ROM-space, or from the Rigit Disk Block of a boot partition. In particular, the `fh` argument does not need to be a regular *file handle*; it is rather an opaque value identifying the source. The `InternalLoadSeg()` function does not interpret this argument, but rather passes it into `funcs->ReadFunc()` in register `d1`.

When allocating memory, the `InternalLoadSeg()` function follows the conventions of the `AllocVec()` and `FreeVec()` functions and stores the number of allocated bytes in the first four bytes of the allocated memory block. In specific, the memory allocator and memory releaser functions provided in the `LoadSegFuncs` structure *do not need* to store the memory sizes, and the exec `AllocMem()` and `FreeMem()` functions satisfy the interfaces for `InternalLoadSeg()` function already.

This function does not set `IoErr()` consistently, unless the functions within `LoadSegFuncs` do. Callers should also call `SetIoErr(0)` upfront this function to identify all errors.

11.2.4 Unloading a Binary

The `UnLoadSeg()` function releases a linked list of segments as returned by `LoadSeg()` or `NewLoadSeg()`.

```
success = UnLoadSeg( seglist )
D0                   D1

BOOL UnLoadSeg(BPTR)
```

This function releases all segments chained together by `LoadSeg()` and `NewLoadSeg()` and returns their memory back into the system pool. This function *also* accepts overlaid segments, see section 11.3, and releases additional resources acquired for them.

Segment lists loaded through `InternalLoadSeg()` require in general a more generic unloader. They shall be be released through `InternalUnLoadSeg()` instead, see 11.2.5.

This function returns a non-zero result in case of success, or 0 in case of error. Currently, the only source of error is passing in `ZERO` as segment list, all other cases will indicate success. In particular, this function does not attempt to check return codes of the function calls required to release resources associated to overlaid files.

11.2.5 UnLoading a Binary through Call-Back Functions

The `InternalUnLoadSeg()` function releases a segment list loaded through `InternalLoadSeg()`.

```
success = InternalUnLoadSeg(seglist,FreeFunc)
D0                          D1      A1

BOOL InternalUnLoadSeg(BPTR,
                       void __asm (*)(register __a1 APTR,
```

```
                                    register __d0 ULONG,
                                    register __a6 struct ExecBase
                                                  *SysBase))
```

This function releases a segment list created by `InternalLoadSeg()` passed in as `seglist`. To release memory, it uses a function pointed to by `a1`. This function expects the memory block to release in register `a1` and its size in register `d0`. Additionally, register `a6` will be populated by a function to the *exec.library*.

This function pointer should be identical to the `FreeMem` function pointer in the `LoadSegFuncs` structure provided to `InternalAllocMem()`, or at least shall be able to release memory allocated by the `AllocMem` function pointer in this structure. Note that the `InternalLoadSeg()` stores the sizes of the allocated memory blocks itself and that `FreeFunc` does not need to retrieve them.

This function is also able to release overlaid binaries, but then closes the file stored in the root node of the overlay tree (see section 11.3) through the `Close()` function of the *dos.library*. It therefore can only release overlaid files that were loaded from regular *file handles* obtained through `Open()`.

This function returns a non-negative result code in case of success, or 0 in case of failure. Currently, the only cause of failure is to pass in a `ZERO` segment list, the function does not check of the result code of `Close()` on the file handle of overlaid files. It therefore neither sets `IoErr()` consistently in case of failure.

11.3 Overlays

While regular binary executables are first brought to memory in entity and then brought to execution, overlaid binaries only keep a fraction of the executable code in memory and then load additional code parts as required, potentially releasing other currently unused code parts and thus making more memory available.

Overlays are an extension of the AmigaDOS hunk format that splits the executable into a root node that is loaded initially and stays resident for the lifetime of the program, and one or multiple extension or overlay nodes that are loaded and unloaded on demand. Locating the overlay nodes, loading them to memory and releasing unused nodes is performed by the *overlay manager*, a short piece of program.

AmigaDOS does not provide a ROM-resident overlay manager itself, i.e. the *dos.library* does not provide an overlay manager itself, though it provides services overlay managers may use. Instead, the overlay manager is part of the root node of an overlaid binary, and thus overlay management is fully under control of the application.

However, the Amiga linker *ALink*, the Software Distillery linker *BLink* and the SAS/C linker *SLink* include a standard overlay manager, and this manager and its properties are discussed in greater detail in this section.

11.3.1 The Overlay File Format

A binary file making use of overlays consists of several nodes, one root node and several overlaid nodes. Nodes contain multiple segments, defined through `HUNK_CODE`, `HUNK_DATA` or `HUNK_BSS` as in regular (non-overlaid) binary files.

Each node, the root node and all overlaid nodes start with a `HUNK_HEADER` identifying which segments are contained in the node. The root node is terminated by a `HUNK_OVERLAY` on which loading stops; this hunk contains additional data for the purpose of the overlay manager, and therefore the data within this hunk depends on the overlay manager.

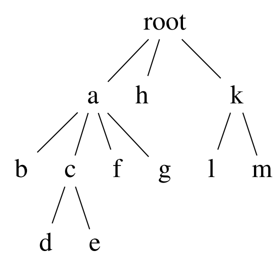
Every other overlay node terminates with a `HUNK_BREAK`, and loading stops there as well. This hunk does not contain any data. The overall structure of an overlaid binary therefore looks as follows:

Table 43: Overlay File Format

Hunk Type	Description
`HUNK_HEADER`	Defines segments for the root node
`HUNK_CODE`	Contains the overlay manager and other resident code
`...`	Other hunks, such as relocation information
`HUNK_END`	Terminates the previous segment
`HUNK_OVERLAY`	Metadata for the overlay manager, see 11.3.3
`do {`	Repeats over all overlay nodes
`HUNK_HEADER`	Defines the segments in this overlay node
`HUNK_CODE` or `HUNK_DATA`	First segment of the overlay node
`...`	Other hunks of this overlay node
`HUNK_END`	Terminates the last segment
`HUNK_BREAK`	Terminates the first overlay node, see 11.3.5
`} while(!end of file);`	This pattern repeats until end of file

11.3.2 The Hierarchical Overlay Manager

The overlay manager that comes with the standard Amiga linkers *ALink*, *BLink* and *SLink* structures overlay nodes into a tree such as the following:



Only those nodes that form a path from the root to one of the nodes of the tree can be in memory at a time. Thus, for the above example, the root node and nodes a, c and e can be in memory simultaneously, or the root node, and nodes k and m can be loaded at the same time, but not the nodes a, g and h because they do not form a path from the root to one of the nodes.

Thus, in the above example, if nodes a and f are in memory, and node l is required, the nodes a and f will be removed from memory, and nodes k and l are loaded. Even though k is not explicitly requested, it needs to be loaded as it is the parent of l.

Every node in the overlay tree is identified by two numbers: The depth of the node, which identifies the level within the tree where a node is located. The root node is at level 0, the nodes a, h and k forms level 1 in the above example, nodes b, c, f, g and l and m form level 2, and nodes d and e are level 3.

The second number is the ordinate number of a node. The ordinate enumerates nodes from left to right within a level, and it starts from 1 in the standard overlay manager. In the above example, a is at ordinate 1, h at ordinate 2, and k at ordinate 3. At level 2, node b has ordinate 1, node c ordinate 2 and so on.

11.3.3 HUNK_OVERLAY

This hunk terminates the loading process and indicates the end of the main (first) segments. The `HUNK_OVERLAY` contains meta-data — the overlay table — for the overlay manager. This table contains information where symbols within the overlaid segments are located. Section **??** provides more information on overlays. The format of the data within this hunk depends on the overlay manager which shall be included in the first segment of the executable itself as AmigaDOS does not contain a resident overlay manager.

The standard AmigaDOS linkers, `ALink` and `BLink` both include an overlay manager. Each entry in its overlay table describes a symbol that is located in one of the overlay nodes. The format of `HUNK_OVERLAY` reads as follows:

Table 44: MANX Hunk Overlay Syntax

Size	Code	Syntax
	`HUNK_OVERLAY [0x3f5]`	Overlay table definition
32	l	Size of the overlay table, it is $l+1$ long-words large.
Format for the standard overlay manager, $l+1$ long-words.		
32	o_d	Number of levels in the overlay tree, including the root node
	`for(`i `= 1;`i `<` o_d`;i++) {`	For all nodes, excluding the root node
32	0	Currently loaded ordinate, shall be zero
	`}`	That is, $o_d - 1$ zeros
	$l -= o_d$	Count removed long-words
	$s = 0$	Start with symbol 0
	`while(`$l \geq 0$`) {`	Repeat over the overlay table
32	$o_p[s]$	Absolute file offset of the `HUNK_HEADER` of the overlay node containing the symbol.
64		Two reserved long-words.
32	$o_l[s]$	Level of the overlay node containing the symbol, the root level containing the overlay manager is level 0.
32	$o_n[s]$	Ordinate of the overlay node, enumerating overlay nodes of the same depth.
32	$o_h[s]$	Hunk index of the first hunk within the overlay node.
32	$o_s[s]$	Hunk index of the hunk containing the symbol described by this entry in the overlay node.
32	$o_o[s]$	Symbol offset within hunk o_s
	l `-=8`	Remove 8 long words.
	$s{+}{+}$	Advance to next symbol.
	`}`	End of loop over table

Note that the overlay table is $l+1$ and not l long-words large, i.e. a table only defining a single symbol would be indicated by a value of $l = 7$. While the payload data of `HUNK_OVERLAY` is always $l+1$ long-words large, with l indicated in the first long-word of the hunk, the format of the subsequent data is specific to the overlay manager used.

Irrespective of the overlay manager used, the AmigaDOS loader injects overlay-specific data into the first segment loaded from disk, that is, into the root-node. The data placed there is also required to release all resources associated to overlays and is expected there by `UnLoadSeg()` and `InternalUnLoadSeg()`.

The first bytes of the root node shall therefore form the following structure:

```
struct OverlayHeader {
    UWORD         oh_Jump[2];   /* Forms a branch to the startup code */
    LONG          oh_Magic;     /* Shall be 0x0000abcd                */
    BPTR          oh_FileHandle;/* Filled by the loader with the fh   */
    struct OVTab *oh_OVTab;     /* Overlay table from HUNK_OVERLAY    */
```

```
    BPTR          oh_Segments;  /* Array of segment BPTRs             */
    BPTR          oh_GV;        /* standard Global Vector             */
};
```

As said earlier, this structure is expected to be present at the start of the first hunk of the root node. The members `oh_FileHandle` to `oh_GV` are filled in by the AmigaDOS loader, i.e. `LoadSeg()` and related functions, but `oh_Jump` and `oh_Magic` shall be part of the segment itself.

`oh_Jump` form valid `68K` opcodes, and shall contain a jump or branch branch around this structure. This is because loaded binaries are executed from the first byte of the first segment loaded. Otherwise, the CPU would run into the data of the structure which likely forms invalid or illegal opcodes. The AmigaDOS Loader itself does not interpret the values here, just expects them to be present.

`oh_Magic` shall contain the "magic" long-word `0xabcd`. This value is neither filled or interpreted by the loader, but nevertheless shall be present. It is, however, checked by `UnLoadSeg()` and used there as an identifier for the `OverlayHeader` structure. If this identifier is not present, `UnLoadSeg()` will not be able to release resources associated to overlays.

`oh_FileHandle` will be filled by the AmigaDOS loader with a *BPTR* to the *FileHandle* from which the root node has been loaded, or with the first argument of `InternalLoadSeg()`. This handle is used by the overload manager to load all subsequent overlay nodes. Also, `UnLoadSeg()` and related functions call `Close()` on the handle stored here as the file needs to stay open for the life time of the loaded program.

`oh_OVTab` is filled by the AmigaDOS loader to a pointer to the payload data of `HUNK_OVERLAY`. The standard overlay manager stores here for every externally referenced symbol in an overlay node a structure that records for each tree level the ordinate of the currently loaded overlay node, and for all externally referenced symbols the position of the symbol within the overlay tree:

```
struct OVTab {
    ULONG ot_TreeDepth;   /* Depth of the tree, including the root    */
    ULONG ot_LoadedOrd[]; /* The loaded ordinate, indexed by level-1  */
}
struct SymTab {
    ULONG ot_FilePosition;/* File position of HUNK_HEADER of the node */
    ULONG ot_Reserved[2]; /* Not in use                               */
    ULONG ot_Level;       /* Level of the overlay node                */
    ULONG ot_Ordinate;    /* Ordinate of the overlay node             */
    ULONG ot_FirstHunk;   /* First segment of the overlay node        */
    ULONG ot_SymbolHunk;  /* Segment containing the referenced symbol */
    ULONG ot_SymbolOffset;/* Offset of the segment within the segment */
} []                      /* Repeats for each symbol */
```

That is, the overlay table starts with the tree depth o_d and an array of $o_d - 1$ elements where each element stores the ordinate of the currently loaded overlay node. If an entry in this array is 0, no overlay node at this tree level is loaded, otherwise it is the 1-based ordinate of the node.

The ordinate table is followed by the symbol table. The purpose of this structure is that it allows the overlay manager on a reference to such an external symbol to find and load the overlay node containing the symbol, and then resolve references to it. How exactly it does so is explained in more detail in section **??**. The elements of this structure are already briefly introduced in table 44.

`oh_Segments` is filled by the AmigaDOS loader to a *BPTR* to the segment table of the loaded binary. The size of this table is taken from t_{size} in the `HUNK_HEADER` of the root node, see table 31. Each element in this array contains a *BPTR* to a segment of the loaded binary, and it is indexed by the segment number, counting from 0 for the first segment of the root node.

When parsing a `HUNK_HEADER`, the array entries t_{num} to t_{max} will be populated with the *BPTR*s to the segments allocated of the node described by this hunk, and when unloading an overlay node, the corresponding segments will be unlinked, released and then cleared out.

oh_GV is, finally, filled with the *Global Vector* of the *dos.library* containing all regular functions in the library, as required by BCPL code. Overlay managers implemented in C or assembler will not make use of it and instead call vectors of the *dos.library* through the *dos.library* base address loaded in register a6.

11.3.4 The MANX Overlay Manager

The Aztec C compiler from MANX offers an alternative overlay manager that is related to the Resource Manager from MacOs. It does not organize overlay notes in a hierarchy, but only in a single level; however, all nodes of this single level can be loaded and unloaded independently from each other, either on demand through the function segload() provided by the MANX compiler library, or whenever a function of an overlaid node is called. The corresponding freeseg() function unloads a node again. A node consists of one or more hunks that are loaded and unloaded jointly. Unfortunately, this overlay manager depends on self-modifying code and ignores the instruction cache present in later members of the Motorola 68K family, and is therefore no longer safe to use.

The MANX overlay manager organizes its nodes through the data in the HUNK_OVERLAY hunk, which, however, is in a different format than the one documented in section 11.3.3, and trampolines that direct the code flow for non-resident functions to the overlay manager. The contents of the HUNK_OVERLAY hunk contains offsets within the file, to the trampoline functions and to the symbol table that provides information in which hunks the overlaid functions reside. The trampolines are not part of HUNK_OVERLAY but reside at the beginning of the HUNK_DATA hunk, relative to the __H1_org symbol.

Even though the structure of the HUNK_OVERLAY differs from the one in section 11.3.3, the AmigaDOS LoadSeg() function does not care about the contents of this hunk as long as its first LONG word indicates its size. It provides the data within to the program as-is through oh_OVTab of the OverlayHeader which shall be present at the beginning of the first segment of the binary; this structure, of course, does not change from its definition in section 11.3.3 except that data within the overlay hunk is organized differently:

```
struct ManxOverlayHeader {
    UWORD          oh_Jump[2];    /* Forms a branch to the startup code */
    LONG           oh_Magic;      /* Shall be 0x0000abcd                */
    BPTR           oh_FileHandle;/* Filled by the loader with the fh   */
    struct MANXOv *oh_OVTab;      /* Overlay table from HUNK_OVERLAY    */
    BPTR           oh_Segments;   /* Array of segment BPTRs             */
    BPTR           oh_GV;         /* standard Global Vector             */
};
```

The overlay structure for the MANX compiler reads on disk as follows:

Table 45: Hunk Overlay Syntax

Size	Code	Syntax
	HUNK_OVERLAY [0x3f5]	Overlay table definition for MANX
32	l	Size of the overlay table, it is $l+1$ long-words large.
Format for the MANX overlay manager, $l+1$ long-words.		
32	o_d	Number of nodes in the overlay, excluding the root node
	for(i = 1;i < o_d;i++) {	For all nodes, excluding the root node
32	$o_p[i]$	Absolute file offset of the HUNK_HEADER of the overlay node
16	$o_t[i]$	Offset of the first trampoline relative to the data hunk of the root node
16	$o_s[i]$	Offset to the symbol table relative to $o_p[0]$

	}	
	$l- = o_d \times 2$	Count removed long-words
	$s = 0$	Start with symbol 0
	while ($l \geq 0$) {	Repeat over the symbol table
16	$o_h[s]$	Hunk within which the symbols reside, or 0 for end of symbols for this hunk
16	$o_c[s]$	Symbol count for hunk $o_h[s]$
	l -=1	Remove one long words.
	$s++$	Advance to next entry.
	}	End of loop over table

In memory, it is approximately described by the following pseuo-structure, noting that some elements are variably sized and are thus hard to represent in the C syntax:

```
struct MANXOv {
    ULONG ot_NodeCount;          /* Number of overlay nodes             */
    struct OvNode {              /* One per overlay node                */
        ULONG ot_FilePosition;   /* Position of HUNK_HEADER             */
        UWORD ot_TrampolineOff;  /* Offset of the first trampoline      */
        UWORD ot_SymbolOffset;   /* Relative to &ot_NodeCount+1         */
    }     ot_Nodes[];
}
struct SymTab {
    UWORD ot_Hunk;         /* Hunk containting symbols or 0 for end    */
    UWORD ot_Count;        /* Number of trampolines to patch           */
} []                       /* Repeats multiple times */
```

The element o_d representing `ot_NodeCount` defines the number overlay nodes that can all be loaded or unloaded individually. The element $o_p[i]$ providing `ot_FilePosition` is the offset relative to the start of the binary file at which the `HUNK_HEADER` of the overlay node i is found. The offset $o_t[i]$ giving `ot_TrampolineOff` is the offset of the first trampoline to a symbol within overlay node i; the offset is relative to the second hunk of the root node, or more precisely, relative to `__H1_org`.

Finally, $o_s[i]$, or in memory `ot_SymbolOffset`, is used by the MANX overlay manager to find the first symbol descriptor within the second part of the `HUNK_OVERLAY`, i.e. a `SymTab` structure. The offset is relative to the third long word within this hunk, or as l is not part of the internal memory representation, relative to `&ot_NodeCount+1`. The target of this offset is a sequence of $o_h[s]$,$o_c[s]$ pairs. The first member of this pair, $o_h[s]$, or `ot_Hunk` in memory, is the hunk number containing the overlaid symbol; this clearly cannot be 0 as this would be within root node. The second member of the pair, $o_c[s]$ or `ot_Count` is the number of symbols within this hunk. The symbols for the loaded node terminate with an $o_h[s]$ entry being 0.

The `HUNK_OVERLAY` hunk does not contain the symbol offsets itself. Rather, symbol offsets are part of the trampoline which is included in the second hunk of the root node. The offset to the first trampoline of an overlay node relative to the start the second hunk is provided by $o_t[i]$, that is, by `ot_TrampolineOff`.

Each trampoline looks as follows on disk:

Table 46: MANX Overlay Trampoline

Size	Code	Syntax
16	0x6100	68K Opcode of `bsr.w`
16	t_j	Branch offset to overlay manager
8	t_n	Overlay node number

24	t_o	Offset of the overlay symbol within the loaded hunk

In memory, this is equivalent to the following structure:

```
struct MANXTrampoline {
    UWORD mt_BSR;                /* filled with 0x6100          */
    WORD  mt_OvMngrOffset;       /* Offset to overlay manager   */
    UBYTE mt_OverlayNode;        /* Overlay node, counts from 0 */
    UBYTE mt_SymbolOffset[3];    /* Big-endian 24-bit offset    */
};
```

The start of the trampoline is a word-sized relative subroutine jump to the overlay manager itself. As the trampoline is typically in the second hunk of the root node, but the code of the overlay manager is in its first hunk, this branch goes to a long absolute jump to the overlay manager. The element t_j, or `mt_OvMngrOffset` is the branch distance to this jump. When building an overlaid binary, the MANX linker resolves all references to overlaid symbols to a trampoline as indicated above, and when the code of the loaded binary calls through them, the overlay manager fetches from the return stack of the 68K processor the address of the trampoline.

From t_n, or `mt_OverlayNode` in memory, it finds the entry in the first part of the `HUNK_OVERLAY`, namely a triple $o_p[i]$, $o_t[i]$, $o_s[i]$ of file offset, trampoline offset and symbol offset, that is, a `OvNode` structure. This overlay node index is zero-indexed, i.e. the first overlay node is node 0, corresponding to the first element of the `ot_Nodes` array. The t_o offset, or `mt_SymbolOffset` in memory, is finally the offset of the symbol within its hunk.

When an overlay node is loaded, the overlay manager uses the symbol table consisting of `SymTab` structures and relocates from them the trampolines to the symbols; that is, the opcode of the relative branch in the first word of the trampoline is replaced by an absolute jump[1], opcode `0x4ef9`. The subsequent long is filled by the address of the symbol, computed from the start of the hunk $o_h[s]$ in `HUNK_OVERLAY` plus the offset t_o stored in the trampoline. The branch offset t_j is moved to the last 16 bits of the trampoline to enable the overlay manager to restore it back when the overlay node is unloaded.

Such a patched symbol then looks as follows:

```
struct MANXPatchedTrampoline {
    UWORD mt_JMP;                /* filled with 0x4ef9          */
    APTR  mt_OVSymbol;           /* absolute symbol address     */
    WORD  mt_OvMngrOffset;       /* Offset to overlay manager   */
};
```

When unloading an overlay node, the original trampolines have to be restored such that a call to an overlay symbol triggers again loading the hunks containing the symbol from disk. For that, `mt_JMP` is again replaced by a `bsr.w` instruction, `mt_OvMngrOffset` is moved to the next word, and the hunk offset is re-injected by counting the hunks within the singly linked list of loaded segments. Finally, `mt_SymbolOffset` is re-computed by subtracting the base address of the segment from the absolute symbol address.

11.3.5 HUNK_BREAK

This hunk terminates the loading process and indicates the end of an overlay node. The hunk itself does not contain any data.

Table 47: Hunk Break Syntax

Size	Code	Syntax
	`HUNK_BREAK [0x3f6]`	Terminate a segment

[1] Here the MANX overlay manager fails to clear the instruction cache, causing failure on later members of the 68K family.

11.3.6 Loading an Overload Node

The `LoadSeg()` function is not only able to load the root segments of an overlaid binary, it can also be used for loading an overlaid node and all segments within it. For that, the file pointer shall first be placed with `Seek()` to the file offset of the `HUNK_HEADER` of the overlaid node. This file offset may, for the standard hierarchical overlay manager, be taken from the `ot_FilePosition` of the overlay table.

```
seglist = LoadSeg( name ,table, fh)
D0                 D1    D2     D3

BPTR LoadSeg(STRPTR ,BPTR, BPTR)
```

For overlaid node loading, the first argument `name` shall be `NULL`, which is used as an indicator to this function to interpret two additional (usually hidden) arguments.

`table` is a *BPTR* to the segment table, and may be taken from `oh_Segments`. It contains *BPTRs* to all allocated segments, see section 11.3.3.

`fh` is a *BPTR* to the *FileHandle* from which the overlay node is to be loaded. This handle may be taken from `oh_FileHandle`, see section 11.3.3.

While this function allocates and loads the segments in the overlaid node, it does not attempt to release already allocated segments populating the same entries in the segment table; it is instead up to the overlay manager to clean up the segment table upfront, see 11.3.8. The information which segments will be populated by an overlay node may be taken from the `ot_FirstHunk` member of the overlay table. Due to the tree structure imposed by the hierarhical overlay manager, it has to release all segments from `ot_FirstHunk` onwards up to the end of the table, unlink the segments contained therein, and then load another overlay node through `LoadSeg()`.

Note that this function populates the same offset in the *dos.library* as the regular `LoadSeg()` function; the function distinguishes loading regular binaries through a file name from loading overlay nodes by the first argument.

As the regular `LoadSeg()` call, this function returns the *BPTR* to the first segment loaded on success, links all loaded segments together, populates the segment table, and then sets `IoErr()` to 0. On error, it returns `ZERO` and installs an error code in `IoErr()`.

11.3.7 Loading an Overlay Node through Call-Back Functions

The `InternalLoadSeg()` function can also load an overlay node.

```
seglist = InternalLoadSeg(fh,table,funcs)
D0                        D0  A0   A1

BPTR InternalLoadSeg(BPTR,BPTR,struct LoadSegFuncs *)
```

The `fh` argument is an opaque file handle that is suitable for the `ReadFunc()` provided by the `funcs` structure. The corresponding file pointer shall first be placed to the file offset of the `HUNK_HEADER` of the overlaid node, e.g. by a functionality similar to `Seek()` for regular *FileHandles*. This file offset may, for the standard hierarchical overlay manager, be taken from the `ot_FilePosition` within the overlay table.

The `table` shall be the *BPTR* to the segment table; this may be taken from `oh_Segments`. This argument determines whether a regular binary load is requested, or an overlay node is to be loaded. In the latter case, this argument is non-`ZERO`.

Like `LoadSeg()`, this function does not release segments in populated entries in the segment list, it is up to the overlay manager to unload these segments. The information which entries of the segment table will be populated by an overlay node may be taken from the `ot_FirstHunk` member of the overlay table, see also 11.3.6.

The `funcs` argument points to a `LoadSegFuncs` structure as defined in section 11.2.3 and contains functions for reading data and allocating and releasing memory.

This function does not set `IoErr()` consistently, unless the functions in the `LoadSegFuncs` structure do. The function returns the segment of the first segment of the overlay node on success, or `ZERO` on error.

11.3.8 Unloading Overlay Nodes

Unloading overlay nodes (and *not* the root node) of an overlaid binary requires some manipulation of the segment table as the *dos.library* does not provide a function for such operation. This algorithm is part of the overlay manager, but its implementation within the standard hierarchical overlay manager documented here for completeness. Other custom overlay managers perform potentially different algorithms.

First, it finds the previous segment upfront the segment to be unloaded, and cleans there the `NextSegment` pointer to unlink all following segments. Then these following segments are released through `FreeVec()` or, in case a custom allocator was provided for `InternalLoadSeg()`, whatever memory release function is appropriate.

The following sample code releases the overlay node starting at segment $i > 0$ from a segment table of an overlay header:

```
void UnloadOverlayNode(struct OverlayHeader *oh,ULONG i)
{
  BPTR *segtbl  = (BPTR *)BADDR(oh->oh_Segments);
  BPTR *segment = (BPTR *)BADDR(segtbl[i - 1]);
  BPTR  next;

  /* Release the linkage from the last loaded to
  ** the first segment to release */
  *segment = NULL;

  do {
    /* Get the segment to release */
    if (segment = (BPTR *)BADDR(segtbl[i++])) {
      next      = *segment;
      FreeVec(segment);
    } else break;
    /* Repeat until the last segment */
  } while(next);
}
```

Note that a previous segment always exists because the root node populates at least entry 0 of the segment table. The above loop makes use of the fact that the first long-word of a segment is a ***BPTR*** to the next segment, and this linkage is `ZERO` for the final node.

If a custom memory allocator has been used for loading overlay nodes through `InternalLoadSeg()`, the `FreeVec()` in the above function is replaced by the corresponding memory release function.

11.3.9 Unloading Overlay Binaries

To unload the root node, and thus unload the entire program including all overlay nodes, `UnLoadSeg()` on the first segment of the root node is sufficient if neither custom I/O nor a custom memory allocator has been used to load the binary, independent on which overlay manager has been used. `UnLoadSeg()` will detect the overlay manager from the magic value in `oh_Magic` and will then not only release the segments, but also close the overlay file handle and release the segment table.

If `InternalLoadSeg()` has been used for loading the root node through custom I/O functions or with a custom memory allocator, `InternalUnLoadSeg()` shall be used instead to release the root node. Unfortunately, it *always* uses `Close()` on `oh_FileHandle`, even if `oh_FileHandle` does not correspond to a *FileHandle* as returned by `Open()`, e.g. because `ReadFunc()` upon loading the overlay program pointed to a custom I/O function. The best strategy in this case is probably to close `oh_FileHandle` manually upfront with whatever method is appropriate, then zero it out manually and then finally call into `InternalUnLoadSeg()` to perform all the necessary cleanup steps. This strategy works because `Close()` on a `ZERO` file handle performs no operation and is legit.

11.3.10 Internal Working of the Overlay Manager

Several versions of the hierarchical overlay manager exist. The version described here stems from the SAS/C `SLink` utility and is designed for the *registerized parameters* configuration within which some function arguments are passed in CPU registers. Earlier versions require stack-based parameter passing.

When binding objects together to an overlay binary together, the linker checks whether a reference to a symbol crosses a boundary of overlay nodes. References that go to a parent node or the node itself can be resolved by the linker by creating a relocation entry in a `HUNK_RELOC32` hunk as it can assume that the corresponding segment is already loaded.

References to symbols within child nodes receive each a unique integer identifier, and an entry in the overlay table in `HUNK_OVERLAY` at the index given by the identifier. The actual call to a function in a child node is then replaced to call into a trampoline function that looks as follows:

```
@symX:
    jsr @ovlyMgr
    dc.w symbX
```

where `@ovlyMgr` is the entry point of the overlay manager and `symbX` is the identifier of the referenced symbol. The overlay manager reads the return PC which points to the identifier, and from the identifier finds the entry in the symbol table.

The symbol table contains both the ordinate and the level of the symbol with which the overlay manager is able to check whether the node containing the symbol is currently loaded. If this is not the case, it needs to unload the currently loaded node at this level and all its children, and then progresses to loading the required node from the file offset in the symbol table, and then progresses to updating the overlay table.

If the overlay node containing the symbol is already loaded, or just has been loaded, the symbol address is computed from the offset in the symbol table and the address of the segment containing the symbol from the segment table, and injected into the return address that contained a pointer to the symbol identifier. Thus, when returning from the overlay manager, the code will continue to execute from the target symbol. Other versions of the overlay manager use a trampoline function that loads register `d0` with the symbol identifier and thus require stack-based function calls.

Regardless of the version of the overlay manager, only symbols corresponding to function can be resolved as the overlay manager must be called to resolve a symbol. In particular, data cannot be referenced across overlay nodes — instead, an accessor function may be used that returns the object to be accessed.

The following code provides an overlay manager for register-based calls:

```
        xdef    @ovlyMgr
;************************************************
;** Offsets in the overlay-table              **
;************************************************
```

```
        rsreset
ot_FilePosition:        rs.l 1          ;File position
ot_reserved:            rs.l 2          ;for whatever
ot_OverlayLevel:        rs.l 1          ;Overlay-Level
ot_Ordinate:            rs.l 1          ;Overlay-Ordinate
ot_InitialHunk:         rs.l 1          ;Initial hunk for loading
ot_SymbolHunk:          rs.l 1          ;Hunk containing symbol
ot_SymbolOffset:        rs.l 1          ;Offset of symbol
ot_len:                 rs.b 0

;**************************************************
;** Other stuff                                  **
;**************************************************
MajikLibWord    =       23456

       section NTRYHUNK,CODE
;**************************************************
;** Manager starts here                          **
;**************************************************
Start:
        bra.w NextModule                ;Jump to the next segment...

;* This next word serves to identify the overlay
;* supervisor to 'unloader', i.e. UnLoadSeg()

        dc.l       $ABCD                ;Magic longword for UnLoadSeg

;* The next four LWs are filled by the loader (LoadSeg())
ol_FileHandle:  dc.l 0                  ;Overlay file handle (points to me)
ol_OverlayTab:  dc.l 0                  ;Overlay table as found in the overlay hunk
ol_HunkTable:   dc.l 0                  ;BPTR to Overlay hunk table
ol_GlobVec:     dc.l 0                  ;BPTR to global vector (what for ?)

                dc.l MajikLibWord       ;Majik library word as identifier
                dc.b 7,"Overlay"        ;Majik identifier

;* the following data is specific to this manger

ol_SysBase:     dc.l 0                  ;additional pointer
ol_DOSBase:     dc.l 0                  ;to libraries

                dc.b "THOR Overlay Manager 1.0",0      ;another ID

@ovlyMgr:                               ;Entry-points
        saveregs d0-d3/a0-a4/a6         ;Saveback register

        moveq #0,d0
        move.l 10*4(a7),a0
        move.w (a0),d0                  ;get the overlay reference ID

        move.l ol_OverlayTab(pc),a3     ;get pointer to overlay table
```

```
        move.l a3,a4                    ;to a4
        add.l (a3),d0                   ;add length
        lsl.l #2,d0                     ;get offset
        add.l d0,a3                     ;address of overlay entry
        move.l ot_OverlayLevel(a3),d0   ;get overlay
        lsl.l #2,d0
        adda.l d0,a4
        move.l ot_Ordinate(a3),d0       ;get required ordinate level
        cmp.l (a4),d0                   ;compare with current ordinate level
        beq.s .gotsegment
                                        ;not correct level
                                        ;clear all other entries behind this
        move.l d0,(a4)+                 ;fill with new overlay entries

        moveq #0,d1
        do                              ;macros in action! ;-)
         tst.l (a4)                     ;terminate, if end of table found
         break.s eq
         move.l d1,(a4)+                ;clear this
        loop.s

        move.l ot_InitialHunk(a3),d0    ;first hunk number to load
        add.l ol_HunkTable(pc),d0       ;plus BPTR of hunk table
        lsl.l #2,d0                     ;address of entry in hunk table
        move.l d0,a4
        move.l -4(a4),d0                ;get previous hunk
        beq.s .noprevious
        lsl.l #2,d0
        move.l d0,a2
        move.l d1,(a2)                  ;unlink fields before loading

                                        ;now free all hunks
        move.l ol_SysBase(pc),a6

        do
         move.l (a4)+,d0                ;next hunk ?
         break.s eq
         lsl.l #2,d0
         move.l d0,a1                   ;->a1
         move.l -(a1),d0                ;get length
         jsr FreeMem(a6)                ;free this hunk
        loop.s                          ;and now the next
.retry:
        move.l ol_DOSBase(pc),a6
        move.l ol_FileHandle(pc),d1     ;get our stream
        move.l ot_FilePosition(a3),d2   ;get file position
        moveq #-1,d3                    ;relative to beginning of file
        jsr Seek(a6)                    ;seek to this position
        tst.l d0                        ;found something ?
        bmi.s .loaderror                ;what to do on failure ?
```

```
                                        ;now call the loader
        move.l ol_HunkTable(pc),d2      ;hunk table
        moveq #0,d1                     ;no file (is overlay)
        move.l ol_FileHandle(pc),d3     ;filehandle
        jsr LoadSeg(a6)                 ;load this stuff
        tst.l d0                        ;found
        beq.s .loaderror
        move.l d0,(a2)                  ;add new chain

                                        ;found this stuff
.gotsegment:
        move.l ot_SymbolHunk(a3),d0     ;get hunk # containing symbol
        add.l ol_HunkTable(pc),d0
        lsl.l #2,d0                     ;get APTR to hunk
        move.l d0,a4
        move.l (a4),d0                  ;BPTR to hunk
        lsl.l #2,d0
        add.l ot_SymbolOffset(a3),d0    ;Offset

        move.l d0,10*4(a7)              ;Set RETURN-Address

        loadregs
        rts

;**************************************************
;** Go here if we find an error                 **
;**************************************************
.loaderror:
        saveregs d7/a5
        move.l ol_SysBase(pc),a6
        move.l #$0700000C,d7
        move.l $114(a6),a5
        jsr Alert(a6)                   ;Post alert
        loadregs
        bra.s .retry                    ;Retry or die

.noprevious:
        move.l ol_SysBase(pc),a6
        move.l #$8700000C,d7            ;dead end !
        move.l $114(a6),a5
        jsr Alert(a6)                   ;Post alert
        bra.s .noprevious


;**************************************************
;** NextModule                                  **
;** Open stuff absolutely necessary and         **
;** continue with main program code             **
;**************************************************
NextModule:
                                        ;why safe registers ?
```

```
        move.l a0,a2
        move.l d0,d2                    ;keep arguments
        lea ol_SysBase(pc),a3
        move.l ExecBase,a6
        move.l a6,(a3)                  ;fill in Sysbase
        lea DOSName(pc),a1              ;get name of DOS
        moveq #33,d0                    ;at least 1.2 MUST be used
        jsr OpenLibrary(a6)
        move.l d0,4(a3)                 ;Save back DOS base for loader
        beq.s .nodosexit                ;exit if no DOS here

        move.l d0,a6
        move.l Start-4(pc),a0           ;Get BPTR of next hunk
        adda.l a0,a0
        adda.l a0,a0
        exg.l a0,a2                     ;move to a2
        move.l d2,d0                    ;restore argument
        jsr 4(a2)                       ;jump in
        move.l d0,d2                    ;Save return code

        move.l ol_SysBase(pc),a6
        move.l ol_DOSBase(pc),a1
        jsr CloseLibrary(a6)            ;Close the lib

        move.l d2,d0                    ;Returncode in d0
        rts
.nodosexit:
        move.l #$07038007,d7            ;DOS didn't open
        move.l $114(a6),a5
        jsr Alert(a6)
        moveq #30,d0                    ;Something went really wrong !
        rts

DOSName:        dc.b "dos.library",0
```

11.4 Structures within Hunks

While the AmigaDOS loader, i.e. `LoadSeg()` and related functions, do not care about the contents of the segments it loaded, some other components of AmigaDOS do actually analyze their contents.

11.4.1 The Version Cookie

The `Version` command scans a ROM-resident modules or all segments of a binary for the character sequence `$VER:` and if such a sequence is found, the string following is scanned. The syntax of the string consists of the following elements:

- The version cookie `$VER:`
- one or multiple blank spaces
- a program name, which is output by the `Version` command

- a decimal number, representing the *version* of the program
- a single dot ("`.`")
- a decimal number, representing the *revision* of the program
- one or multiple blank spaces
- an opening bracket ("`(`")
- a decimal number, representing the day of the month of the revision
- a single dot ("`.`")
- a decimal number, representing the month of the revision
- a single dot ("`.`")
- a decimal number, representing the year of the revision
- a closing bracket ("`)`")
- an optional comment that is only output if the `FULL` option of the `Version` is given.

If the number representing the year is below 1900, the `Version` command assumes a two-digit year and either adds 200 if the year is below 78, or 1900 otherwise. The command then re-formats the date according to the currently active locale and prints it to the console, along with the program name and, optionally, the comment string.

An example for the version cookie is

```
const char version[] = "$VER: RKRM-Dos 45.3 (12.9.2023) (c) THOR";
```

Note that the date follows the convention date of the month, month and year, here September 12, 2023. The version in this example is 45, the version is 3. The string behind the date is a comment and usually not printed by the `Version` command.

11.4.2 The Stack Cookie

The workbench, the shell, and also `GetDeviceProc()` when loading *handlers* scan the loaded binary for the string sequence `$STACK:`. If this string sequence is found, AmigaDOS attempts to read a following decimal number, and interprets this as stack size in bytes.

The stack of the program is then, potentially increased to the provided size. Note that AmigaDOS also scans alternative sources for a stack size: The `Stack` setting in the icon information window of the workbench, the `Stack` command of the shell, or the `STACKSIZE` entry in the mount list. The stack size indicated by the above stack cookie does not override these settings, it can only *increase* the stack size. This allows program authors to ensure that the stack of their program has a necessary minimal size, though still allows users to increase it if necessary.

An example for the stack cookie is

```
const char stack[] = "$STACK: 8192";
```

This ensures that the stack size of the program is at least 8192 bytes.

The *dos.library* provides with the `ScanStackToken()` an optimized function to quickly scan segments for the stack cookie and potentially adjust a default stacksize upwards to the value found in the stack cookie.

```
stack = ScanStackToken(segment, defaultstack)
D0                     D1       D2

LONG ScanStackToken(BPTR segment, LONG defaultstack)
```

This function scans the segment list starting at `segment` for a stack cookie, potentially adjusting the `defaultstack` size in bytes passed in. If a stack cookie is found, and the minimal stack size it finds is larger than the default stack, the stack size found in the stack cookie is returned in `stack`. If no stack cookie is found, or the value in the stack cookie is smaller than the `defaultstack` size, the default size is returned.

The `segment` is a *BPTR* to a singly linked list of segments, e.g. as returned by `LoadSeg()` function.

11.4.3 Runtime binding of BCPL programs

BPCL programs depend on a *Global Vector* that includes function entries and data available to all its modules. AmigaDOS includes a runtime binder functionality that creates the *Global Vector* from data found in the segments of the loaded binary and the *dos.library Global Vector*.

Even though this mechanism is deprecated and AmigaDOS has long been ported to C and assembler, some components still depend on this legacy mechanism, namely all *handlers* and *file systems* mounted with the `GLOBVEC = 0` or `GLOBVEC = -2` entry in the mount list. While newer *handlers* should not depend on this mechanism anymore, the `Port-Handler` mount entry is created in the Kickstart ROM as BCPL handler, beyond control of the user. The same goes for the `Shell`, which is also initiated as BCPL process.

If the above components — the `Port-Handler` or the *Shell* — are attempted to be customized, implementors need to be aware that these processes are not started from the first byte of the first segment, but from the *Global Vector* entry `#1`, which contains the address of the `START` function from which the process is run. All other entries of the vector are of no concern, and should not be used anymore.

The *Runtime Binder* of AmigaOs, initiated only for BCPL handlers and BCPL processes such as the *Shell*, now scans the segments of such programs for information on how to populate the *Global Vector*.

The *first long-word* of the segment, usually the entry point of the process, contains the long-word offset from the start of the process to the start of the *Global Vector* initialization data. This initialization data is *scanned backwards* from the given offset towards lower addresses, starting with the long-word before the offset.

The first long-word of the initialization data is the required size of the *Global Vector* the program requires. This value is only used to check the following initializers for validity. The standard system global vector currently requires 150 entries, which is a safe choice.

All following entries consist of pairs of long-words, scanned again towards smaller addresses, where each pair defines one entry in the global vector. The first (higher address) long-word is the offset of the function which will populate the *Global Vector*, the second (lower) address is the index of the *Global Vector* entry. An offset of 0 terminates the list.

The following assembler stub may be used as initial segment of an (otherwise C-based) handler that instructs the *Runtime Binder* to populate the `START` vector, and then calls into the `@main` function. BCPL unfortunately also uses a custom call syntax, register `a6` is the address of the BCPL return code which cleans up the BCPL stack frame and returns to the caller.

```
                SECTION text,code

                XREF    _main           ; handler or shell main

G_GLOBMAX       EQU     150             ; size of GV
```

```
G_START         EQU     1               ; BCPL START functions
G_CLISTART      EQU     133             ; shell startup

CodeHeader:     DC.L    (CodeEnd-CodeHeader)/4

*               C Startup function, called for GlobVec=-1 or -3
*               see text below why this works
CStart:         sub.l   a0,a0           ; no startup message
                bsr.w   _main           ; need to GetMsg() in main
                rts

                CNOP    0,4

*               BCPL startup function, called for GlobVec=0 or -2
BCPLStart:      movem.l a0-a6,-(a7)     ; save for BCPL use
                lsl.l   #2,d1           ; get startup packet
                move.l  d1,a0           ; move to a0
                bsr.w   _main           ; get the ball rolling
                movem.l (a7)+,a0-a6     ; restore everyone
                jmp     (a6)            ; BCPL-style return

BCPLTable:      CNOP    0,4

                DC.L    0               ; End of global list
                DC.L    G_CLISTART,BCPLStart-CodeHeader ;for the shell
                DC.L    G_START,BCPLStart-CodeHeader
                DC.L    G_GLOBMAX       ; max global used (default)
CodeEnd:
```

Note that there are other differences for BCPL handlers the `main()` function of the handler needs to take care of, see also section **??**. BCPL handlers do not receive their startup message in the process *MsgPort*, but rather receive it as first BCPL argument in register `d1`. It is here converted to a C-style pointer and provided as first argument to the main function, assuming the SAS/C registerized parameters ABI.

The `CStart` label is not called at all if the handler is mounted with `GLOBVEC=0` or `GLOBVEC=-2`, and thus would be, in this example, not required. It is included here to demonstrate another technique, namely *dual use* handlers that can be mounted both as C and as BCPL handlers.

The above startup code also allows `GLOBVEC=-1` in the mount list. In this case, the code *is* started from the first byte, which is, actually, the long-word offset to the BCPL initializer. In this particular case, it also assembles to a harmless `ORI` instruction, provided the offset to the end of the code is short enough, i.e. below 64K. It is therefore harmless. As the calling syntax is different, the main function is now called with a `NULL` argument, and then needs to wait for the startup package itself, see again section **??**.

For the *Shell*, in particular, a second entry in the *Global Vector* shall be populated, namely the entry `G_CLISTART` at offset `#133`. It may point to the same entry code, more on this in section **??**. As this entry is not used for handler startup, it does not hurt to include it in the BCPL initializer in either case, and thus the above code may be used as universal "BCPL kludge" for both the shell and legacy handlers that depend on BCPL startup.

11.5 Object File Format

Object files are intermediate output files of a compiler or assembler, generated from one translation unit, i.e. typically one source code file. Such files can still contain references to symbols that could not be resolved within the translation unit because the corresponding symbol is defined in another unit. The linker then combines multiple object codes, resolving all unreferenced symbol, and generates an executable binary file as output.

The overall structure of an object file is depicted in table 48:

Table 48: Object File Format

Size	Code	Syntax
?	`HUNK_UNIT`	Defines the start of a translation unit, see 11.5.1
	`do {`	Multiple segments follow
?	`HUNK_NAME`	Name of the hunk, defines hunks to merge, see 11.1.8
2	m_t	Read the memory type of the next hunk
30	h_t	Read the next hunk type
	`if (`h_t` == HUNK_CODE) parse_CODE`	Code and constant data, see 11.1.2
	`else if (`h_t` == HUNK_DATA) parse_DATA`	Data, see 11.1.3
	`else if (`h_t` == HUNK_BSS) parse_BSS`	Zero-initialized data, see 11.1.4
	`else if (`m_t` != 0) ERROR_BAD_HUNK`	Upper bits shall be 0 for all other hunks
	`else do {`	Loop over auxiliary information
	`if (`h_t` == HUNK_RELOC32) parse_RELOC32`	32-bit relocation, see 11.1.5
	`else if (`h_t` == HUNK_RELOC32SHORT) parse_RELOC32SHORT`	32-bit relocation, see 11.1.6
	`else if (`h_t` == HUNK_RELRELOC32) parse_RELRELOC32`	32-bit PC-relative relocation, see 11.1.7
	`else if (`h_t` == HUNK_RELOC16) parse_RELOC16`	16-bit PC-relative relocation, see 11.5.2
	`else if (`h_t` == HUNK_RELOC8) parse_RELOC8`	8-bit PC-relative relocation, see 11.5.2
	`else if (`h_t` == HUNK_DRELOC32) parse_RELOC32`	32-bit base-relative relocation, see 11.5.4
	`else if (`h_t` == HUNK_DRELOC16) parse_RELOC16`	16-bit base-relative relocation, see 11.5.5
	`else if (`h_t` == HUNK_DRELOC8) parse_RELOC8`	8-bit base-relative relocation, see 11.5.6
	`else if (`h_t` == HUNK_EXT) parse_EXT`	External symbol definition, see 11.5.7
	`else if (`h_t` == HUNK_SYMBOL) parse_SYMBOL`	Symbol definition, see 11.1.9

	`else if (`h_t` == HUNK_DEBUG) parse_DEBUG`	Debug information, see 11.1.10
	`else if (`h_t` == HUNK_END) break`	abort this segment
	`else ERROR_INVALID_HUNK`	an error
32	h_t	Read next hunk type
	`} while(true)`	Repeated until `HUNK_END`
	`} while(!EOF)`	Repeated with the next hunk until the file ends

Since there is no `HUNK_HEADER` in object files, the memory attributes for the hunk are instead stored in the topmost two bits of the hunk type itself. Unlike in `HUNK_HEADER`, there is no documented way how to indicate a memory type beyond `MEMF_CHIP` and `MEMF_FAST`. As the interpretation of object files is up to the linker, a suggested implementation strategy is to set the topmost two bits and store the memory type in the following long-word, similar to how `HUNK_HEADER` expects it.

11.5.1 HUNK_UNIT

This hunk identifies a translation unit and provides it a unique name. This hunk shall be the first hunk of an object file. A translation unit typically refers to one source code file that has been processed by the compiler or assembler. Typically, the name of the unit is ignored by linkers.

The structure of this hunk is as follows:

Table 49: Hunk Unit Syntax

Size	Code	Syntax
	`HUNK_UNIT [0x3e7]`	A hunk identifying a translation unit
32	`l`	Size of the name in long-words
32×1	h_n	Unit name

The size of the name is not given in characters, but in 32-bit units. The name is possibly zero-padded to the next 32-bit boundary to fill an integer number of long-words. If the name fills an entire number of long-words already, it is *not* zero-terminated.

Even though not enforced by the format, linkers can limit the size of the unit.

11.5.2 HUNK_RELOC16

This hunk defines relocation information of one hunk into another hunk, and its format is identical to `HUNK_RELRELOC32`, see section 11.1.7 and table 37.. Relocation offsets are therefore 32 bits long, though the elements to relocate at offset r_o within the segment are only 16 bits in size, and refer to PC-relative addressing modes, including PC-relative 16-bit wide branches.

Table 50: Hunk Reloc16 Syntax

Size	Code	Syntax
	`HUNK_RELOC16 [0x3ed]`	16-bit PC-relative relocation information
	`...`	See table 37

This restricts possible displacements to 16 bits, and thus the segment containing the 16-bit value to be relocated and the segment the hunk is relative to shall be linked together to form a single segment in the final output. In the notation of section 37, the segments i and j shall thus be merged. To make this happen, their names as provided by `HUNK_NAME` shall be identical; alternatively the linker shall be configured to the small data or small code model that forcefully merges hunks of the same type.

However, it may still happen that the joined segment generated by merging two or more segments together is too long to allow 16-bit displacements. In such a case, the relocation can obviously not performed. Then linkers either abort with a failure, or generate an *automatic link vector*. The PC-relative branch or jump to an out-of-range target symbol is then replaced by the linker with a branch or jump to an intermediate "automatic" vector that performs a 32-bit absolute jump to the intended target.

While such *automatic link vectors* or short *ALV*s solve the problem of changing the program flow by 16-bit displacements over distances exceeding 16-bit, *ALV*s do not work correctly for data that is addressed by 16-bit PC relative modes. Instead of referencing the intended data, the executing code would then see the *ALV* as data.

Thus, authors of compilers or assemblers should disallow data references across translation unit boundaries with 16-bit PC-relative addressing modes as those can trigger linkers to incorrectly generate *ALV*s. Linkers should also generate a warning when creating *ALV*s.

11.5.3 HUNK_RELOC8

This hunk defines relocation information of one hunk into another hunk, and its format is identical to `HUNK_RELRELOC32`, see section 11.1.7 and table 37.. Relocation offsets are therefore 32 bits long, though the elements to relocate at offset r_o within the current segment are only 8 bits in size, and thus refer to short branches.

The same restrictions as for `HUNK_RELOC16` applies, i.e. the hunk within which the relocation offset is to be adjusted and the target hunk shall be merged to a single hunk as the AmigaDOS loader cannot resolve 8-bit relocations. This can be either arranged by giving the two hunks the same name, or by configuring the linker to the small code or small data model, depending on the type of the hunk. This will instruct the linker to merge hunks of the same type.

Table 51: Hunk Reloc8 Syntax

Size	Code	Syntax
	`HUNK_RELOC8 [0x3ee]`	8-bit PC-relative relocation information
	`...`	See table 37

As for `HUNK_RELOC16`, the linker can generate *ALV*s in case the target offset is not reachable with an 8-bit offset. However, as the possible range for displacement is quite short, it is quite likely that the generated *ALV* itself is not reachable, and thus relocation during the linking phase is not possible at all. Thus, short branches between translation units should be avoided.

Otherwise, the same precautions as for `HUNK_RELOC16` should be taken, i.e. short displacements to data over translation unit boundaries should be avoided as proper linkage cannot be ensured.

11.5.4 HUNK_DRELOC32

This hunk defines relocation of 32-bit data elements within a hunk that is addressed relative to a base register. The name of this hunk shall be `__MERGED`, indicating that the hunk contains data and zero-initialized elements in the *small data model*.

The format of this hunk is identical to `HUNK_RELOC32`, see section 11.1.5 and table 35, where each 32-bit wide relocation offset r_o points to a long-word within the preceding data or BSS hunk. The long-word at this offset is then adjusted by the position of the first byte of this hunk relative to the start of the target `__MERGED` hunk into which this hunk is merged; in some cases, linkers can include an additional adjustment, see the next paragraph for details.

Table 52: Hunk DReloc32 Syntax

Size	Code	Syntax
	`HUNK_DRELOC32 [0x3f7]`	32-bit base-relative relocation information
	`...`	See table 35

The hunks named `__MERGED` are typically generated by compilers or assemblers when implementing the *small data model* within which all non-static objects are addressed relative to a base register. Typically, register `a4` is used for this purpose, and it is loaded by the compiler startup code to point either to the start of the `__MERGED` hunk, or 32K into the hunk such that both negative and positive offsets relative to `a4` can be used. In the latter case, linkers need to subtract an additional 32K displacement from the r_o offsets when performing relocation. The name *small data model* stems for the limitation to 64K of data as the 68000 uses only 16-bit for base-relative addressing.

11.5.5 HUNK_DRELOC16

This hunk defines relocation of 16-bit data elements within a hunk that is addressed relative to a base register, i.e. `__MERGED` hunks in the *small data* memory model.

The format of this hunk is identical to `HUNK_RELOC32`, see section 11.1.5 and table 35, where each 32-bit wide relocation offset r_o points to an unsigned 16-bit word within the preceding data or BSS segment. The word at this offset is then adjusted by the position of the first byte of this hunk relative to the start of the `__MERGED` hunk into which this hunk is merged.

Table 53: Hunk DReloc16 Syntax

Size	Code	Syntax
	`HUNK_DRELOC16 [0x3f8]`	16-bit base-relative relocation information
	`...`	See table 35

Similar to the comments made in section 11.5.4, this hunk is typically used to resolve symbols that are reached relative through a base register, e.g `a4`. As base-relative addressing is restricted to 16-bit displacements for the 68000, linkers typically adjust the base register to point 32K into the __MERGED hunk if this hunk exceeds 32K in size. In such a case, they need to include an additional negative offset of -32K in r_0 when performing relocation.

11.5.6 HUNK_DRELOC8

This hunk defines relocation of 8-bit data elements within a hunk that is addressed relative to a base register, i.e. `__MERGED` hunks in the *small data* memory model.

The format of this hunk is identical to `HUNK_RELOC32`, see section 11.1.5 and table 35, where each 32-bit wide relocation offset r_o points to a byte within the preceding data or BSS hunk. The byte at this offset is then adjusted by the position of the first byte of this hunk relative to the start of the `__MERGED` hunk into which this hunk is merged.

Table 54: Hunk DReloc8 Syntax

Size	Code	Syntax
	`HUNK_DRELOC8 [0x3f9]`	8-bit base-relative relocation information
	`...`	See table 35

11.5.7 HUNK_EXT

This hunk defines symbol names and corresponding symbol offsets or values within the currently loaded segment. It is quite similar to `HUNK_SYMBOL` except that it not only includes symbol definitions, but also symbol references. The linker uses this hunk to resolve symbols with external linkage.

The syntax of this hunk reads as follows:

Table 55: Hunk EXT Syntax

Size	Code	Syntax
	`HUNK_EXT [0x3ef]`	A hunk assigning symbols to positions within a segment
	`do {`	Repeat . . .
8	s_t	Symbol type
24	s_l	Symbol length in long-words
	`if (`s_l` == 0) break`	Terminate the hunk
$32 \times s_l$	s_n	Symbol name, potentially zero-padded
	`if (`s_t` < 0x80) {`	Symbol definition?
32	s_v	Symbol value
	`} else {`	Symbol reference
	`if (`s_t` == 0x82 || `s_t` == 0x89)`	A common block?
32	s_c	Size of the common block in bytes
	`}`	End of common block
32	s_n	Number of references of this symbol
	`while(`$--s_n \geq 0$`) {`	Repeat over the references
32	$s_o[s_n]$	Offset into the hunk of the reference
	`}`	End of loop over symbols
	`} while(true)`	until zero-sized symbol

The length of the symbol name is encoded in long-words, not in characters. If it does not fill an integer number of long-words, it is zero-padded; the name is not zero-terminated if it does fill an integer number of long-words, though.

The symbol type s_t defines the nature of the symbol. The symbol types are defined in `dos/doshunks.h` and shared with the `HUNK_SYMBOL` hunk, see section 11.1.9.

Entries of a symbol type with s_t `< 0x80` are symbol definitions, the symbol value is defined by s_v. See table 56 for possible types of symbol definitions.

The next table includes symbol types that identify symbol references, i.e. they are referenced within a segment of an object file, though not defined there. These types can clearly not be contained within a executable binary, but they may appear within an object file and are then resolved by corresponding symbol definitions from the above table by the linker:

Table 56: Symbol types in HUNK_EXT

`EXT_REF32`	[0x81]	Reference to a 32-bit symbol that is resolved by a corresponding `EXT_ABS` to an absolute value or by a `EXT_DEF` definition to a relocation information to this or another segment.
`EXT_COMMON`	[0x82]	Reference to a 32-bit symbol that may be resolved by a `EXT_ABS` or `EXT_DEF` definition, but if no such definition is found, a BSS hunk of the maximal size of all references to the symbol is created by the linker. Thus, this type generates a zero-initialized object if no definition is found.
`EXT_REF16`	[0x83]	Reference to a 16-bit PC relative offset within the same segment.
`EXT_REF8`	[0x84]	Reference to a 8-bit PC relative offset within the same segment.
`EXT_DREF32`	[0x85]	32-bit reference relative to a base register (typically `a4`), resolved by the linker through an entry in a `HUNK_DRELOC32` hunk.
`EXT_DREF16`	[0x86]	16-bit reference relative to a base register, resolved by the linker through an entry in a `HUNK_DRELOC16` hunk.

`EXT_DREF8`	[0x87]	8-bit reference relative to a base register, resolved by the linker through an entry in a `HUNK_DRELOC8` hunk .
`EXT_RELREF32`	[0x88]	32-bit PC-relative reference for 32-bit address, this will be resolved by an `EXT_DEF` definition into an entry into a `HUNK_RELRELOC32` hunk by the linker.
`EXT_RELCOMMON`	[0x89]	32-bit PC relative common reference for a 32-bit address. Similar to a `EXT_COMMON` definition, this will be resolved into an `HUNK_RELRELOC32` entry where potentially space for the symbol will be allocated in a BSS segment if no corresponding definition is found.
`EXT_ABSREF16`	[0x8a]	16-bit absolute reference, resolved by the linker to a 16-bit value by an `EXT_ABS` definition.
`EXT_ABSREF8`	[0x8b]	8-bit absolute reference, resolved by the linker to an 8-bit value through an `EXT_ABS` definition.

For references, s_n identifies the number of times the symbol is referenced, while s_o defines the offsets into the current segment where the symbol is used and into which the symbol value will be resolved during linking. This value comes from an s_v entry in a `HUNK_EXT` hunk from another translation unit.

Common symbols are symbols that are defined in multiple translation units. The size of the symbol required by the translation s_c. If no corresponding symbol definition is found, the linker then allocates space of a size that is determined by the maximum of all s_c values found for the same symbol in all translation units. The symbol will then be created within a BSS segment by the linker without an explicit symbol definition. This mechanism is mostly used by FORTRAN and is therefore rarely used. SAS/C can also be configured to emit common symbols as well.

11.6 Link Library File Format

Link Library files are collections of small compiled or assembled program sections that provide multiple commonly used symbols or functions. Unliky AmigaOs libraries, which are loaded dynamically at run time, link libraries resolve undefined symbols at link time; functions or symbols within them become a permanent part of the generated executable.

The *amiga.lib* is a typical example for a link library. It contains functions such as `CreateExtIO()`. While newer versions of the *exec.library* contains with `CreateIORequest()` a similar function, some manual work was required for creating an `IORequest` structure in exec versions prior v37. To ease development, it was made available in a (static) library whose functions are merged with the compiled code.

Link libraries come in two forms: Old-style non-indexed libraries, and indexed libraries that are faster to process. Old-style or non-indexed link libraries are simply a concatenation of object files in the form presented in section 11.5 and table 48. Then, of course, one translation unit as introduced by `HUNK_UNIT` **??** is not necessarily terminated by an `EOF` as specified in table 48, but possibly by the subsequent program unit, starting with another `HUNK_UNIT`.

Non-indexed link libraries do not require any tools beyond a compiler or assembler for building them. The AmigaDOS `JOIN` command is sufficient to build them. The drawback of such libraries is that they are slow to process as the linker needs to scan the entire library to find a specific symbol.

Indexed libraries are faster to parse as they contain a compressed index of all symbols defined in the library. It consists at its topmost level of two hunks: one containing the program units, and a symbol table with an index that are repeated until the end of the file.

The overall format of indexed libraries is depicted in table 57.

Table 57: Indexed Library

Size	Code	Syntax
	`do {`	Multiple repetitions of the following
?	`HUNK_LIB [0x3fa]`	Object code modules, see section 11.6.1
?	`HUNK_INDEX [0x3fb]`	Indices into `HUNK_LIB`, see section **??**
	`} while(!EOF)`	Until the end of the file

11.6.1 HUNK_LIB

The `HUNK_LIB` hunk contains the actual playload in the form of multiple code, data or BSS hunks along with their relocation, symbol and debug information. It looks almost like the contents of a `HUNK_UNIT` hunk, with a couple of changes noted below.

Table 58 depicts the syntax of this hunk.

Table 58: Hunk LIB Format

Size	Code	Syntax
?	`HUNK_LIB [0x3fa]`	Identifies the start of an indexed library
32	l	Length of this hunk in long-words not including the header and this length field
	`do {`	Multiple segments follow
2	m_t	Read the memory type of the next hunk
30	h_t	Read the next hunk type
	`if (`h_t `== HUNK_CODE) parse_CODE`	Code and constant data, see 11.1.2
	`else if (`h_t `== HUNK_DATA) parse_DATA`	Data, see 11.1.3
	`else if (`h_t `== HUNK_BSS) parse_BSS`	Zero-initialized data, see 11.1.4
	`else if (`m_t `!= 0) ERROR_BAD_HUNK`	Upper bits shall be 0 for all other hunks
	`else do {`	Loop over auxiliary information
	`if (`h_t `== HUNK_RELOC32) parse_RELOC32`	32-bit relocation, see 11.1.5
	`else if (`h_t `== HUNK_RELOC32SHORT) parse_RELOC32SHORT`	32-bit relocation, see 11.1.6
	`else if (`h_t `== HUNK_RELRELOC32) parse_RELRELOC32`	32-bit PC-relative relocation, see 11.1.7
	`else if (`h_t `== HUNK_RELOC16) parse_RELOC16`	16-bit PC-relative relocation, see 11.5.2
	`else if (`h_t `== HUNK_RELOC8) parse_RELOC8`	8-bit PC-relative relocation, see 11.5.2
	`else if (`h_t `== HUNK_DRELOC32) parse_RELOC32`	32-bit base-relative relocation, see 11.5.4
	`else if (`h_t `== HUNK_DRELOC16) parse_RELOC16`	16-bit base-relative relocation, see 11.5.5
	`else if (`h_t `== HUNK_DRELOC8) parse_RELOC8`	8-bit base-relative relocation, see 11.5.6

	`else if (`h_t` == HUNK_EXT) parse_EXT`	External symbol definition, see 11.5.7
	`else if (`h_t` == HUNK_SYMBOL) parse_SYMBOL`	Symbol definition, see 11.1.9
	`else if (`h_t` == HUNK_DEBUG) parse_DEBUG`	Debug information, see 11.1.10
	`else if (`h_t` == HUNK_END) break`	abort this segment
	`else ERROR_INVALID_HUNK`	an error
32	h_t	Read next hunk type
	`} while(true)`	Repeated until `HUNK_END`
	`} while(!EOF)`	Repeated with the next hunk until the file ends

Additional restrictions arise for the `HUNK_EXT` hunk; as symbol definitions are included in the `HUNK_INDEX` hunk, they shall be removed from this hunk; the corresponding symbol typtes to be removed are listed in table 40. Unlike symbol definitions, symbol references as given by table 56 shall be retained as only the reference, but not the type of the reference is included in `HUNK_INDEX`.

The translation unit name and the hunk names shall also stripped, i.e. neither `HUNK_UNIT` nor `HUNK_NAME` shall be included in `HUNK_LIB`. The corresponding names are also defined in `HUNK_INDEX` by means of the string table included there.

Due to restrictions of `HUNK_INDEX`, the size of a `HUNK_LIB` shall not exceed 2^{16} long-words and shall be split over multiple `HUNK_LIB`, `HUNK_INDEX` pairs otherwise.

11.6.2 HUNK_INDEX

The `HUNK_INDEX` hunk contains a string table and indices into the preceding `HUNK_LIB`.

Table 59 depicts the syntax of this hunk.

Table 59: Hunk Index Format

Size	Code	Syntax
32	`HUNK_INDEX [0x3fb]`	Defines symbols and references into the library
32	l	Length of this hunk in long-words
16	s_l	Length of the string table in **bytes**
	`do {`	Repeat over the strings
?	$s_y[i]$	A `NUL`-terminated (C-style) string
	s_l `-= strlen(`$s_y[i]$`)+1`	Remove from the length of the symbol table
	`} while(`$s_l > 0$`)`	Repeat until all s_l bytes are parsed
	`do {`	Loop over translation units
16	u_o	Byte offset of the unit name into the string table
16	h_o	Long-word offset of the first hunk of the unit within `HUNK_LIB`
16	h_c	Number of hunks within the unit
	`for(`j`=0;`j`<`h_c`;`j`++) {`	Loop over all hunks
16	h_n	Byte offset of the hunk name into the string table

2	m_t	Memory type of the hunk
14	h_t	(Shortened) hunk type
16	x_c	Number of references in the hunk
	`for(`k`=0;`k`<`x_c`;`k`++) {`	Loop over references
16	x_n	Byte offset of the reference name into the string table
	`}`	
16	d_c	Number of definitions in the hunk
	`for(`k`=0;`k`<`d_c`;`k`++) {`	Loop over definitions
16	d_n	Byte offset of the defined name into the string table
16	d_o	Byte offset into the hunk or absolute value
8	a_u	Bits 23-16 of `EXT_ABS` definition
1	`0`	This bit shall be 0 to identify a definition
1	a_s	Sign bit and bits 30 to 24 of an `EXT_ABS` definition
6	d_t	Type of the definition from table 40
	`}`	
	`}`	
	`} while(!end)`	Repeated until the end of hunk is found

The initial part, the string table, contains all strings that can be used by the rest of the hunk. Strings within this table are indexed as byte offset from the start of the string, i.e. the first string has offset 0. To enable unnamed hunks, the first entry in a string table shall be the empty string, that is, an isolated 0-byte.

The rest of `HUNK_INDEX` contains the offsets into the hunks along with symbols referenced and defined within them. The memory type of the hunk is again expressed in two bits. The current specification does not define the meaning of both bits set. The hunk type itself is abbreviated, i.e. only the lower 14 bits of the hunk type are stored.

The first part of the subsequent data defines references, that is, symbols that are used but not defined within the hunk. The x_n values define the names of these symbols as offsets from the start of the string table. These names correspond to symbol types defined in table 56. The precise reference type of the symbols is then found in an `HUNK_EXT` hunk as part of the preceding `HUNK_LIB` hunk.

Unlike symbol references, symbol definitions are stored directly in the `HUNK_INDEX` hunk. While d_n identifies the name of the symbol as offset into the string table, the d_o value is either the offset of the defined symbol within the hunk, or the least significant 16 bits of an `EXT_ABS` definition. As some absolute values can exceed 16 bits, a_o stores bits 23 to 16 of the symbol value, and bit a_s is copied into bits 31 to 24 of the symbol to enable negative values. The type of the symbol definition is d_t, which shall be a value from table 40.

As seen from this definition, symbols can only be defined within the first 64K of a hunk. This is typically not a problem as link libraries typically contain short service functions. For absolute values, larger values are required, e.g. for the base address of the custom chips, and thus split into a_s, a_o and d_o.

Chapter 12

Handlers, Devices and File Systems

Handlers are AmigaDOS processes that provide all the services to implement many functions of the *dos.library*. Operations on files, such as opening files, reading data or seeking in files are implemented in the corresponding handler and not the *dos.library* itself. *File systems* are special handlers that organize data streams on volumes such as hard disks in files, and also provide locks to reserve access rights to files. Most file systems also support directories and thus a hierarchical organization of files.

Handlers are recognized by an entry in the *device list* whose `dol_Task` element provides a pointer to a message port through which the *dos.library* communicates with the handler, section 8 provides further details on this structure.

To ease communication, the `FileHandle` structure representing a file also includes with its `fh_Type` element a pointer to such a port that is typically a copy of `dol_Task` when a file is opened, see section 4.9.1 for this structure. It is created by the *dos.library* when opening files.

Similarly, the `fh_Type` element of the `FileLock` structure includes the port through which communication with the file system concerning the lock is routed. Unlike `FileHandles`, the `FileLock` structure is created by the *file system* itself which initializes its `fh_Type`. This is again in many cases identical to the `dol_Task` message port within the *device list*.

12.1 The DosPacket Structure

While it is in many cases more practical to interact with handlers through the functions of the *dos.library*, it is also possible to communicate with the handler directly through this port. This communication is based on *packets*, represented by a `DosPacket` structure documented in `dos/dosextens.h`:

```
struct DosPacket {
   struct Message *dp_Link;
   struct MsgPort *dp_Port;
   LONG dp_Type;
   LONG dp_Res1;
   LONG dp_Res2;
   LONG dp_Arg1;
   LONG dp_Arg2;
   LONG dp_Arg3;
   LONG dp_Arg4;
   LONG dp_Arg5;
   LONG dp_Arg6;
   LONG dp_Arg7;
```

```
};
```

Packets ride on top of exec messages, see `exec/ports.h`, but they do not extend the `Message` structure as it would be usually the case. Instead, `mn_Node.ln_Name` of the exec message is (mis-)used to point to the `DosPacket`. The reply port of the message in `mn_ReplyPort` is *not* used; instead, the message carrying the packet is send back to `dp_Port`.

Members of the `DosPacket` structure shall be initialized as follows:

`dp_Link` shall point to the message which is used for transmitting the `DosPacket`. The message node name in `mn_Node.ln_Name` shall be initialized to point to the `DosPacket` itself.

`dp_Port` shall point to the `MsgPort` structure to which the packet shall be send back after the handler has completed the requested activity. This is typically, but not necessary `pr_MsgPort` of the process sending the packet. See section 10 for the definition of the `Process` structure.

`dp_Type` identifies the action requested from the handler. It shall be filled by the process requesting an activity from a handler and is interpreted by the handler. Section **??** lists the currently documented packet types.

`dp_Res1` is the primary result code of the activity performed by the handler. For many, but not for all packet types, this is a boolean result code that is 0 for failure and non-zero for success. Many functions of the *dos.library* return `dp_Res1` as their return code.

`dp_Res2` is the secondary result code installed by the handler and is typically is 0 for success, or an error code on failure. Many functions of the *dos.library* install this error code into `IoErr()`. Section 10.2.9 lists the error codes defined by the *dos.library*.

`dp_Arg1` to `dp_Arg7` provide additional arguments to the handler. They shall be filled by the process submitting a packet to a handler. Most packet types do not require all 7 possible arguments; in such a case, only the necessary arguments may be initialized.

12.1.1 Send a Packet to a Handler and Wait for Reply

The `DoPkt()` function creates from its arguments a `DosPacket` structure along with an exec `Message` carrying it on the fly, transmits the packet to a target port and waits for the packet to return.

```
result1 = DoPkt(port,action,arg1,arg2,arg3,arg4,arg5)
D0                 D1     D2     D3    D4    D5    D6    D7

LONG DoPkt(struct MsgPort *,LONG,LONG,LONG,LONG,LONG,LONG)
```

This function performs low-level packet IO to a target message port belonging to a handler. The `port` is the `MsgPort` of the handler to contact. Depending on the context, this port should be taken from various sources. If low-level file I/O is to be performed, the best source for the port is the `fh_Type` pointer in the `FileHandle` structure. If the communication is related to a *Lock*, the `fl_Task` member of the `FileLock` is the right source. For activities unrelated to locks or files, the `dol_Task` member of the *device list* is another source.

`action` identifies the activity to be performed by the handler or file system. Section **??** lists the packet types and how they relate to the functions of the *dos.library*.

`arg1` through `arg5` are arguments to the packet and filled into their `dp_Arg1` through `dp_Arg5` elements. If more arguments are required, the packet needs to be created and transmitted manually.

This function returns the primary result code of the handler from `dp_Res1` in `result1`, and `dp_Res2` in `IoErr()`.

If the caller is a process and the `pr_PktWait` pointer in the `Process` structure is set, `DoPkt()` calls through it to wait for the packet (or rather the message carrying it) to return, see section 10. Otherwise, DoPkt() waits on pr_MsgPort with WaitPort() and removes the message through GetMsg(). If the caller is a task, the function even builds an exec MsgPort on the fly and waits on this temporary port — thus unlike many other functions of the *dos.library*, this function is even callable from tasks.

If the return MsgPort contains a message different from the one carrying the issued packet, this function aborts with a deadend alert of type AN_QPktFail, defined in exec/alerts.h. Note that this is quite different from exec-style communications with exec devices through DoIO(); this function is able to extract the send IORequest from the port without creating a conflict if another message is still pending in the port. This problem of packet communication manifests itself typically when attempting to perform I/O operations through the *dos.library* while the workbench startup message is still queued in the process message port.

Because packets typically require less than 5 arguments, additional prototypes are supplied that do not take all arguments. They all access the same entry within the *dos.library*, the only difference is that the function prototypes do not enforce initialization of the data registers carrying the unneeded arguments. These functions are named DoPkt0() to DoPkt5() and carry 2 to 7 arguments: The target port, the type of the packet action and 0 to 5 additional arguments which are filled into dp_Arg1 upwards.

12.1.2 Send a Packet to a Handler Asynchronously

The SendPkt() function transmits a packet to a target message port of a handler without waiting for it to return. Instead, a reply port is provided to which the packet will be returned once the handler acted upon it.

```
SendPkt(packet, port, replyport)
 D1     D2 D3

void SendPkt(struct DosPacket *,struct MsgPort *,struct MsgPort *)
```

This function transmits packet to the handler port, requesting to return it to replyport. The function returns immediately without waiting for the packet to return.

The packet shall be partially initialized; in particular, dp_Link shall point to an exec Message whose mn_Node.ln_Name field points back to packet. This function *does not* supply or initialize a suitable message, this is up to the caller.

dp_Type shall be filled with the type of the packet, i.e. an identifier specifying the type of activity requested from the handler, see section **??**. Depending on this type, dp_Arg1 through dp_Arg7 shall be initialized with additional arguments.

DosPackets can be constructed in multiple ways; the AllocDosObject() function may be called to construct a StandardPacket. This is a structure that contains both the Message and the DosPacket. It is defined in dos/dosextens.h:

```
struct StandardPacket {
   struct Message   sp_Msg;
   struct DosPacket sp_Pkt;
};
```

AllocDosObject() ensures that the linkage between Message and DosPackete are properly initialized.

Another option is to use AllocMem() to allocate sufficient storage to hold a StandardPacket and initialize the structure appropriately:

```
struct StandardPacket *sp;

sp->sp_Msg.mn_Node.ln_Name = (UBYTE *)&(sp->sp_Pkt);
sp->sp_Pkt.dp_Link         = &(sp->sp_Msg);
```

12.1.3 Waiting for a Packet to Return

The `WaitPkt()` function waits on the message port of the calling process for a packet to return.

```
packet = WaitPkt()
D0

struct DosPacket *WaitPkt(void);
```

This function performs all activities to receive a message returning from a handler; it is also implicitly called by `DoPkt()` after sending the messages to the handler.

If the `pr_PktWait` pointer in the `Process` structure is set, `WaitPkt()` calls through this function to wait for the arrival of a message. Otherwise, the `WaitPkt()` calls `WaitPort()` to wait for a arrival of a message on `pr_MsgPort` of the calling process, and then calls `GetMsg()` to remove it from the port. The function then returns `mn_Node.ln_Name` of the received message, i.e. the packet corresponding to the message.

This function does not test whether the received message does, actually, belong to a packet. The caller shall ensure that only `Messages` corresponding to `DosPackets` can arrive at the process message port.

12.1.4 Aborting a Packet

The purpose of the `AbortPkt()` funcktion is to attempt to abort a packet already send to a handler. However, as of the current Os release, it does nothing and is not functional.

```
AbortPkt(port, pkt)
  D1    D2

void AbortPkt(struct MsgPort *, struct DosPacket *)
```

What this function should do is to scan `port`, presumably the `MsgPort` of the handler to which `pkt` was send, and dequeue it there if the handler is not yet working on it. Then, it would be placed back into the port of its initiator. As of V747, this function does nothing.

12.1.5 Reply a Packet to its Caller

The `ReplyPkt()` function returns a packet to its initiator, filling the primary and secondary result codes. This function is intended to be used by handlers.

```
ReplyPkt(packet, result1, result2)
   D1      D2       D3

void ReplyPkt(struct DosPacket *, LONG, LONG)
```

This function fills `dp_Res1` and `dp_Res2` of the `packet` with `result1` and `result2`, and sends the packet to `dp_Port`, the initiating port. Note that `mn_ReplyPort` of the message pointed to by `dp_Link` is ignored, i.e. packets do *not* follow the exec protocol for replying messages.

The `result1` argument is the primary result code and identical to the return code of many *dos.library* functions. `dp_Res2` is the secondary result code and typically accessible through `IoErr()` if the packet is replied to a *dos.library* function.

12.2 Implementing a Handler

A *handler* or a *file system* is an Amiga process that retrieves commands in the form of `DosPackets`. The main loop of a handler is conceptionally similar to a program implementing a graphical user interface, except that the latter retrieves messages via the *intuition* IDCMP system and works them off, whereas the handlers receive commands from the port in the `pr_MsgPort` of its process, or any other port it may provide to its clients.

12.2.1 Handler Startup

When a user of the *dos.library* attempts to access an absolute path, i.e. a path including a device name, the *dos.library* walks the *device list* (see section 8) to find the handler responsible for it by comparing the device name in the path with the `dol_Name` element of the *device list*. Once a suitable entry has been found, the *dos.library* checks whether a handler is already running by checking the `dol_Task` field of the `DosList`. If so, a packet corresponding to the called *dos.library* function is send to the port pointed to by `dol_Task`. The relation between library functions and packet types is further explained in subsequent sections.

If `dol_Task` is `NULL`, the *dos.library* checks next whether `dol_SegList` is `ZERO`. If it is, the handler code is not yet present and will be loaded from the file name indicated in `dol_Handler` through `LoadSeg()`, and its return code is used to initialize `dol_SegList`. Once the handler is present, a new process is created from the segment, and a startup packet is delivered to `pr_MsgPort` of the created handler process. The *dos.library* will not continue processing the initiating call until the handler replies to this packet.

How the startup packet is delivered depends on the `dol_GlobVec` element of the *device list* entry, see Table 27. For C or assembler handlers with a `dol_GlobVec` value of -1 or -2, the startup packet is delivered to the `pr_MsgPort` of the handler process. For all other values of `dol_GlobVec`, the startup packet becomes the first argument of the `START` entry at offset 4 of the global vector of the process.

If the “fake” BCPL startup code from section 11.4.3 is used, this packet is delivered in register `a0` of the main function. The following code demonstrates this:

```
LONG __asm __saveds main(register __a0 struct DosPacket *pkt)
{
    SysBase = *((struct ExecBase **)(4L));
    struct Process *proc = (struct Process *)FindTask(NULL);
    struct Message *msg;
    const UBYTE *path;
    ULONG startup;
    struct DosList *dlist;
    LONG error = 0;

    /* if NULL, this was a C startup, retrieve
    ** the packet manually
    */
    if (pkt == NULL) {
      /* Wait and retrieve the startup message
      */
      WaitPort(&proc->pr_MsgPort);
      msg = GetMsg(&proc->pr_MsgPort);
      pkt = (struct DosPacket *)msg->mn_Node.ln_Name;
    }

    path    = (const UBYTE *)BADDR(pkt->dp_Arg1);
```

```
    startup = pkt->dp_Arg2;
    dlist   = (struct DosList *)BADDR(pkt->dp_Arg3);
    ... /* Handler initialization */

    if (error) {
      ReplyPkt(pkt,DOSFALSE,error);
      ... /* shutdown, terminate */
      return;
    } else {
      BOOL run = TRUE;
      ReplyPkt(pkt,DOSTRUE,0);
      /* main program loop */
      do {
       LONG res1 = DOSFALSE;
       LONG res2 = ERROR_ACTION_NOT_KNOWN;
       WaitPort(&proc->pr_MsgPort);
       msg = GetMsg(&proc->pr_MsgPort);
       pkt = (struct DosPacket *)(msg->mn_Node.ln_Name);
       switch(pkt->dp_Type) {
         case ACTION_....
         ....
       }
       ReplyPkt(pkt,res1,res2);
      } while(run);
    }
}
```

The startup packet is populated as follows:

Table 60: Handler Startup Packet

DosPacket Element	Value
`dp_Type`	`ACTION_STARTUP (0)`
`dp_Arg1`	BPTR to BSTR of path
`dp_Arg2`	Copy of `dol_Startup`
`dp_Arg3`	BPTR to `DosList`
`dp_Res1`	`DOSTRUE`
`dp_Res2`	0

`dp_Type` is set to `ACTION_STARTUP`, which is defined to be 0. As the startup packet is always received first, there is no need to test for this particular type. However, as its type is identical to `ACTION_NIL`, the startup packet may also be processed within the main handler loop.

`dp_Arg1` is set to a BPTR to a BSTR representing the path name under which the client of the *dos.library* attempted to access the handler. Note that this is not a `NUL`-terminated C string, but a BSTR whose first element is the size of the string.

This argument is for example taken from the first argument to `Open()`, just that it has been converted to a *BSTR* by the *dos.library*. For the `Console-Handler` for example, this is the window specification that instructs the handler on the position, size and title of the console.

`dp_Arg2` is a copy of the `dol_Startup` element of the `DosList` structure, see section 8. It is used to configure the properties of the handler. The type that is placed here is depends on the mount list. While its use is handler, it is typically, but not necessarily, a BPTR to a `FileSysStartupMsg` structure. Other possibilities for dol_Startup are a BPTR to a BSTR or an integer. What exactly the handler will receive depends on the Mountlist and is discussed in more detail in section 8.1.1 and section 8.1.2.

dp_Arg3 is a *BPTR* to the DosList structure that triggered starting this handler.

Multiple strategies exist how handlers make use of this information. A *file system* process would typically handle multiple files at once through the same process. To ensure that the *dos.library* sends requests for the file system to the process just started, the *file system* shall place a pointer to the MsgPort incoming packets are supposed to be send to in dol_Task of the DosList structure received in dp_Art3. This is typically, but not necessarily, the pr_MsgPort of the handler process.

Whenever a client program opens a file on this *file system* or attempts to lock an object, the handler process will be contacted by sending a packet to the port listed in dol_Task.

A *handler* such as the CON handler requires a separate process for each window it manages. In such a case, dol_Task remains NULL. Thus, handlers can decide whether they require a new process for each file opened from the handler.

While the *dos.library* will also send a packet to open the file for which the handler was launched, the path of this second packet or any subsequent packet to open a file on the same process is not relevant to the Console-Handler anymore as the window will be opened during startup, and not during opening a file. Even though the handler is started once for the initial open and does not fill in its port in dol_Task, multiple requests to open a file may arrive at the handler, e.g. when opening the "*" file indicating the current console.

Once the *handler* or *file system* initiated itself from the startup packet, the packet shall be replied. If startup failed, the primary result code shall be DOSFALSE and the secondary result code shall be an error code suitable for reporting through IoErr(), see section 10.2.9 for a list of common error codes. Then, the handler shall release all resources acquired so far and terminate.

12.2.2 Handler Main Processing Loop

If startup succeeded, the primary result code for the packet shall be DOSTRUE, and the secondary result code shall be 0. Handler operations then proceed by waiting for incoming packets, and processing them one by another.

The *dos.library* keeps the *device list* locked while the handler is starting up. This means in particular that an attempt to gain access to the *device list* with LockDosList(), see section 8.3.1, can deadlock. Even if such a call is not made explicitly, *dos.library* functions can require implicitly such a lock, and thus attempting to access files or lock objects within handlers should be avoided, not only during startup.

If dol_GlobVec is -2 or -3, the *dos.library* will only acquire a shared lock, and thus will allow the handler to retrieve a shared lock on the *device list* as well.

Once started up, handlers or file systems should wait for incoming packets. Depending on how a handler is contacted, the *dos.library* uses multiple sources to identify a suitable port:

If the handler is contacted through the special path "*" or a path starting with "CONSOLE:", the port in pr_ConsoleTask is used to send packets to.

If the handler is contacted through a path starting with "PROGDIR:" and the pr_HomeDir element of the calling process is non-NULL, the fl_Task element of the lock stored there is used to contact the handler.

If the handler is contacted through an absolute path, the *dos.library* scans the *device list* to locate a DosList structure whose dol_Name element matches the device name in the path. The dol_Task field, if non-NULL, is then used as destination of a packet. If it is NULL, a new process of the handler is created. From this follows that a handler or file system can customize the port through which it expects packets. File systems will typically place the pr_MsgPort of their process there.

If a handler is contacted through a relative path, and pr_CurrentDir of the calling process is non-ZERO, the fl_Task element of the current directory of the process attempting to resolve a path is used as target port. If pr_CurrentDir is ZERO, the pr_FileSystemTask is used as target port.

If the handler is contacted through a *File Handle*, for example to read or write bytes from a file, the fh_Type element of the handle is used as destination port. A file system may place a custom port in this element on opening files through ACTION_FINDINPUT, ACTION_FINDOUTPUT or ACTION_FINDUPDATE in the fh_Type element of the handle to receive all packets associated to this particular file on an alternative port. The *dos.library* places by default there the port it found through the path, see above.

If the handler is contacted through a lock, the fl_Task element of the FileLock structure is used to send out packets. A file system thus may customize a port through which all packets related to a particular lock are transmitted by placing this port in fl_Task when creating a lock.

The special path "NIL:" does not correspond to any handler but sets the fh_Type element to ZERO. Any attempt to write out data through such a handle ignores all bytes written, and any attempt to read bytes will return zero bytes. This is a special case in which the *dos.library* does not go through a handler at all.

The main loop of a handler then checks its own process port, or all ports it provided through the above mechanisms for incoming packets and tests their dp_Type field, identifying the requested action to be performed. Subsequent sections will provide information on all packets documented within AmigaDOS, though third-party handlers may implement additional packet types.

A handler or file system receiving a packet it does not implement shall set its dp_Res2 element to ERROR_ACTION_NOT_KNOWN. dp_Res1 shall be set for non-implemented packets according to the packet type as shown in the following table:

Table 61: Primary Result Code for Unimplemented Packets

dp_Type	dp_Res1
ACTION_READ	-1
ACTION_WRITE	-1
ACTION_SEEK	-1
ACTION_SET_FILE_SIZE	-1
ACTION_STACK	-1
ACTION_QUEUE	-1
ACTION_FORCE	-1
all others	0

This ensures that clients of the handler or file system will receive a result that is an indication of an error.

12.2.3 Handler Shutdown

A *handler* that does not initialize the dol_Task element of its DosList structure should keep a counter that is incremented for each object it creates, and decremented for each object deleted or disposed. For example, if the handler supports opening files, then the initialization of each file handle should increment the counter, and each file handle closed through ACTION_END should decrement the counter. Once the use counter reaches zero, the handler process should die by releasing all of its resources and falling off its main function. This ensures that the system is not congested by creating more and more processes of the same handler that, effectively, cannot be contacted anymore because its process part is not referenced in any object passed out of the *dos.library*.

A typical example of a handler is the Con-Handler of the system that opens its window from its startup message but any file opened to it will interact with the same window. The window will be closed when each of these files had been closed[1].

[1]This is a simplification, ignoring AUTO and WAIT parameters, see section 12.13 for details

File systems such as the FFS, however, typically do initialize dol_Task and thus can be reached even if all files or locks on the volume they manage have been released. Thus, in addition to such resource tracking, file systems should check for incoming packets of the type ACTION_DIE and then attempt to shutdown, see section 12.11.5. This is, of course, only possible if all open files have been closed and all locked objects have been unlocked.

The MsgPort or ports of such a handler may still contain packets that have not yet been worked on after ACTION_DIE has been received. In order to avoid a deadlock, the packets pending in the input queue still need to be replied, for example using the default return codes from table 61.

12.3 Packets for File Interactions

The packet types listed in this section are used to implement file-specific functions, such as those listed in chapter 4. The arguments of the packets typically follow the calling conventions of the *dos.library* functions closely, though are typically represented in their BCPL equivalents, i.e. *BPTR*s instead of regular pointers or *BSTR*s instead of NUL-terminated C strings.

12.3.1 Opening a File for Shared Access

The packet ACTION_FINDINPUT initializes a FileHandle structure for shared access to a file.

Table 62: ACTION_FINDINPUT

DosPacket Element	Value
dp_Type	ACTION_FINDINPUT (1005)
dp_Arg1	BPTR to *FileHandle*
dp_Arg2	BPTR to *FileLock*
dp_Arg3	BPTR to BSTR of the file name
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is used by the Open() function of the *dos.library* where the packet type is taken copied from the second argument, i.e. the packet type is identical to the accessMode argument of Open(), and thus ACTION_FINDINPUT is identical to MODE_OLDFILE.

dp_Arg1 is initialized to BPTR to a FileHandle structure whose fh_Arg1 handle should be initialized to a value the handler or file system may use later on to identify the file it operates on. This is particularly important to *file systems* that handle multiple files by a single process. In a typical implementation, this opaque value may be the (internal) lock to the opened file.

A handler or file system may also replace the fh_Type element of the FileHandle structure request that packets concerning this particular file shall be delivered to an alternative port. This element otherwise defaults to the process port of the handler.

dp_Arg2 is initialized to the BPTR to a FileLock structure describing the directory within which the file to be opened is located. Typically, this corresponds to the current directory of the caller of Open(). If this lock is ZERO, then the *file system* shall assume that the provided path is relative to the root directory of the currently inserted volume. Flat file systems or handlers may ignore this argument.

dp_Arg3 is initialized to a BPTR to a BSTR providing the path of the file relative to the directory provided by dp_Arg1.

All other arguments of the packet shall be ignored. The handler should locate the file indicated by dp_Arg3 relative to dp_Arg2, and fill in a boolean success code in dp_Res1. It shall be set to DOSTRUE for success or DOSFALSE for error. dp_Res2 shall be set to an error code from dos/dos.h or 0 for success.

The purpose of this packet is to prepare a *FileHandle* for shared access, either for reading or for writing. If the file cannot be located, this packet *shall not* create it but rather fail with `ERROR_OBJECT_NOT_FOUND`. This packet is used by the `Open()` function if its second argument is set to `MODE_OLDFILE`.

Handlers such that the `Port-Handler` or the `Console-Handler` may already open its resources as part of the startup-packet handling and thus may not perform a lot of activities here. Note that both handlers do not initialize `dol_Task` of the `DosList` structure and thus each opened file will launch a new process. The FFS, however, runs on a single process and thus distinguishes its files through fh_Arg1 in the `FileHandle` structure.

Note that both the Lock provided by `dp_Arg2` and the path `dp_Arg3` are required for locating a file on a hierarchical file system. The path from `dp_Arg3` is logically "appended" to the path implied by `dp_Arg2`, i.e. the file system starts interpreting the former by scanning the directory hierarchy at the position given by `dp_Arg2`, or the root directory if `dp_Arg2` is `ZERO`.

A special case arises if `dp_Arg3` is the empty string; in such a case, `dp_Arg2` shall be already a Lock to the file to open. This is implied by the above algorithm to locate a file that ends walking the directory tree whenever `dp_Arg3` ends.

The type of this packet, `ACTION_FINDINPUT`, is intentionally identical to `MODE_OLDFILE` as the `Open()` function currently initializes the packet type from its second argument.

12.3.2 Opening a File for Exclusive Access

The packet `ACTION_FINDOUTPUT` initializes a `FileHandle` structure for exclusive access to a file and potentially creates the file if it does not yet exist.

Table 63: `ACTION_FINDOUTPUT`

DosPacket Element	Value
`dp_Type`	`ACTION_FINDOUTPUT (1006)`
`dp_Arg1`	BPTR to *FileHandle*
`dp_Arg2`	BPTR to *FileLock*
`dp_Arg3`	BPTR to BSTR of file name
`dp_Res1`	Boolean result code
`dp_Res2`	Error code

This packet is used by the `Open()` function of the *dos.library* where the packet type is taken copied from the second argument, i.e. the packet type is identical to the `accessMode` argument of `Open()`, and thus `ACTION_FINDOUTPUT` is identical to `MODE_NEWFILE`.

The arguments of the packet are initialized as for `ACTION_FINDINPUT`, see section 12.3.1.

12.3.3 Opening or Creating a File for Shared Access

The packet `ACTION_FINDUPDATE` initializes a `FileHandle` structure for shared access to a file, potentially creating the file if it does not yet exist.

Table 64: `ACTION_FINDUPDATE`

DosPacket Element	Value
`dp_Type`	`ACTION_FINDUPDATE (1004)`
`dp_Arg1`	BPTR to *FileHandle*
`dp_Arg2`	BPTR to *FileLock*
`dp_Arg3`	BPTR to BSTR of file name
`dp_Res1`	Boolean result code
`dp_Res2`	Error code

This packet is used by the `Open()` function of the *dos.library* where the packet type is taken copied from the second argument, i.e. the packet type is identical to the `accessMode` argument of `Open()`, and thus `ACTION_FINDUPDATE` is identical to `MODE_READWRITE`.

The arguments of the packet are initialized as for `ACTION_FINDINPUT`, see section 12.3.1.

12.3.4 Opening a File from a Lock

The packet `ACTION_FH_FROM_LOCK` initializes a `FileHandle` structure from a lock on an existing file. Whether this access is shared or exclusive depends on the type of the lock. Upon success, the lock is absorbed into the *FileHandle*.

Table 65: `ACTION_FH_FROM_LOCK`

DosPacket Element	Value
`dp_Type`	`ACTION_FH_FROM_LOCK (1026)`
`dp_Arg1`	BPTR to *FileHandle*
`dp_Arg2`	BPTR to *FileLock*
`dp_Res1`	Boolean result code
`dp_Res2`	Error code

This packet type implements the `OpenFromLock()` function of the *dos.library*, see section 5.2.3. It opens a file from a lock. On a hierarchical file system, this is equivalent to an `ACTION_FINDINPUT` packet with `dp_Arg3` set to an empty string.

To uniquely identify the file handle and resources associated to it later on, the handler may place an identifier or a handle or pointer to internal resources in the `fh_Arg1` element of the *FileHandle* provided by `dp_Arg1`. Before replying the packet, `dp_Res1` shall be set by the handler to `DOSTRUE` on success, or `DOSFALSE` on error. On success, `dp_Res2` shall be set to 0, and to an error code from `dos/dos.h` otherwise.

12.3.5 Closing a File

The packet `ACTION_END` releases all *file system* internal resources of a file handle.

Table 66: `ACTION_END`

DosPacket Element	Value
`dp_Type`	`ACTION_END (1007)`
`dp_Arg1`	`fh_Arg1` of the *FileHandle*
`dp_Res1`	Boolean result code
`dp_Res2`	Error code

`dp_Arg1` is initialized to the `fh_Arg1` element of the `FileHandle` structure corresponding to the file that is supposed to be closed. This value may be used by the *File System* or *Handler* to uniquely identify the resources associated to the file, for example any implicit lock on the file system object.

Before repyling to the packet, `dp_Res1` shall be set to `DOSTRUE` on success or `DOSFALSE` on failure. On success, `dp_Res2` shall be set to 0, or to an error code otherwise.

The *dos.library* uses this packet to implement the `Close()` function. If it receives an error code, the library will not release the memory of the `FileHandle` structure, and as such, it remains available to the caller of `Close()` to perform other activities on the file.

12.3.6 Reading from a File

The packet ACTION_READ reads data from a *file system* or *handler* and advances the file pointer accordingly.

Table 67: ACTION_READ

DosPacket Element	Value
dp_Type	ACTION_READ (82)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	Pointer to the buffer
dp_Arg3	Number of bytes to read
dp_Res1	Bytes read or -1
dp_Res2	Error code

This packet implements the Read() function of the *dos.library*. The elements of the packet are initialized as follows:

dp_Arg1 is a copy from fh_Arg1 of the *FileHandle* structure and may be used by the *file system* or *handler* to identify the file. Note that it is *not* the *FileHandle* itself; instead, the *handler* may create and insert such an identifier into the *FileHandle* when opening a file.

dp_Arg2 is a pointer (not a BPTR) to the buffer to be filled.

dp_Arg3 is the number of bytes to read.

Before replying this packet, the *handler* shall fill dp_Res1 with the number of bytes that could be transferred into the buffer, or -1 for an error condition. This number may also be 0 if no data could be transferred, either because the end of file has been reached, or because currently no data is available on an interactive file, such as the console or the serial port. In case of an error, i.e. for the primary result code -1, dp_Res2 shall be filled with an error code, otherwise it shall be set to 0.

Note that there are no separate packet types corresponding to the buffered IO functions from section 4.8. Instead, the *dos.library* functions at the caller side manage the buffer, monitor its fill state and potentially call into Read() which then generates this packet.

12.3.7 Writing to a File

The packet ACTION_WRITE writes data to a *file system* or *handler* and advances the file pointer accordingly.

Table 68: ACTION_WRITE

DosPacket Element	Value
dp_Type	ACTION_WRITE (87)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	Pointer to the buffer
dp_Arg3	Number of bytes to write
dp_Res1	Bytes written or -1
dp_Res2	Error code

This packet implements the Write() function of the *dos.library*. The elements of the packet are initialized as follows:

dp_Arg1 is a copy from fh_Arg1 of the *FileHandle* structure and may be used by the *file system* or *handler* to identify the file.

dp_Arg2 is a pointer (not a BPTR) to the buffer containing the data to be transferred.

dp_Arg3 is the number of bytes to write.

Before replying this packet, the *handler* shall fill dp_Res1 with the number of bytes that could be transferred from the buffer, or -1 for an error condition. In case of an error, i.e. for the primary result code -1, dp_Res2 shall be filled with an error code, otherwise it shall be set to 0.

Note that there are no separate packet types corresponding to the buffered IO functions from section 4.8. Instead, the *dos.library* functions at the caller side manage the buffer, monitor its fill state and potentially call into Write() which then generates this packet.

12.3.8 Adjusting the File Pointer

The packet ACTION_SEEK sets the file pointer relative to a base location.

Table 69: ACTION_SEEK

DosPacket Element	Value
dp_Type	ACTION_SEEK (1008)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	File pointer offset
dp_Arg3	Seek mode from Table 10
dp_Res1	Previous file position
dp_Res2	Error code

This packet implements, to a major degree, the Seek() function of the *dos.library*. The elements of the packet are initialized as follows:

dp_Arg1 is a copy from fh_Arg1 of the *FileHandle* structure and may be used by the *file system* or *handler* to identify the file.

dp_Arg2 defines the new location of the file pointer relative to a position identified by dp_Arg3.

dp_Arg3 defines the position to which dp_Arg2 is relative. It is one of the modes in table 10 and is therefore identical to the third argument of Seek().

Before replying this packet, the *handler* shall fill dp_Res1 with the previous value of the file pointer, i.e. before making the requested adjustment, or to -1 in case an error occurred. In the latter case, dp_Res2 shall be filled with an error code, otherwise it shall be set to 0.

While this packet type mostly implement the Seek() function, the latter is also aware of the (caller-side) buffer of the *FileHandle* and performs a flush of this buffer. The packet cannot, of course, perform a flush.

12.3.9 Setting the File Size

The packet ACTION_SET_FILE_SIZE adjusts the size of a file, either truncating or extends it beyond its current end of file.

Table 70: ACTION_SET_FILE_SIZE

DosPacket Element	Value
dp_Type	ACTION_SET_FILE_SIZE (1022)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	File size adjustment
dp_Arg3	Mode from Table 10
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetFileSize() function of the *dos.library*. The elements of the packet are initialized as follows:

dp_Arg1 is a copy from fh_Arg1 of the *FileHandle* structure and may be used by the *file system* or *handler* to identify the file.

dp_Arg2 defines the new size of the file or equivalently the new position of the end of file, relative to a position identified by dp_Arg3.

dp_Arg3 defines the position to which dp_Arg2 is relative. It is one of the modes in table 10 and is therefore identical to the third argument of SetFileSize(). The new end-of-file position of the file can therefore be set relative to the start of the file, i.e. dp_Arg2 is the new size of the file, relative to the current file pointer, or relative to the current end-of-file.

Before replying this packet, the *handler* shall fill dp_Res1 with a boolean success indicator, DOSTRUE in case it could extend or truncate the file as requested, or DOSFALSE in case of error. In case of success, dp_Res2 shall be set to 0, otherwise it shall be set to an error code.

Additional information on this packet is found in section 4.7.5 which describes the *dos.library* function that is based on it.

12.3.10 Locking a Record of a File

The packet ACTION_LOCK_RECORD locks a record of a file. Such a record lock neither provides reading nor writing to the locked region, it just prevents locking the same region with an exclusive lock, see section 4.11 for details how the protocol is supposed to use.

Table 71: ACTION_LOCK_RECORD

DosPacket Element	Value
dp_Type	ACTION_LOCK_RECORD (2008)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	Start offset of record
dp_Arg3	Length of record
dp_Arg4	Type of lock from table 13
dp_Arg5	Timeout (if applicable) in ticks
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the LockRecord() function of the *dos.library* and attempts to lock a record of a file, given as start offset from the beginning of the file and a byte size. The file is identified by dp_Arg1 which is a copy from fh_Arg1 of the FileHandle structure[2]. There is no packet corresponding to LockRecords(). Instead, the latter locks records sequentially.

The record to lock is identified by dp_Arg2 and dp_Arg3 which correspond to the offset and length arguments of the LockRecord() function.

The mode by which the record is supposed to be locked is given by dp_Arg4, it identifies whether the access is shared or exclusive, and whether a timeout is applied or not. The mode is a value from table 13, and more information on the modes is found in section 4.11.1.

If the mode from dp_Arg4 includes a timeout the *file system* should wait for the record to become available, it is provided by dp_Arg5. Otherwise, this argument is ignored, see table 13.

If locking the record is possible, or possible within the timeout, then dp_Res1 shall be set to DOSTRUE when replying this packet. In such a case, dp_Res2 shall be set to 0. On failure to obtain the record lock, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

[2]The information on dp_Arg1 in [1] is incorrect.

12.3.11 Release a Record of a File

The packet ACTION_FREE_RECORD releases a record lock on a portion of a file.

Table 72: ACTION_FREE_RECORD

DosPacket Element	Value
dp_Type	ACTION_FREE_RECORD (2009)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Arg2	Start offset of record
dp_Arg3	Length of record
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the UnLockRecord() function of the *dos.library* and releases a lock on a subset of a file, identified by start position and length. There is no packet corresponding to UnLockRecords(); instead, the *dos.library* sequentially calls UnLockRecord() for each record.

The file itself is identified by dp_Arg1 which is a copy from the fh_Arg1 element of the FileHandle structure. The record to release is given by the start offset within the file provided by dp_Arg2 and the byte size of the record in dp_Arg3.

On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.4 Packets for Interacting with Locks

The packets listed in this section implement the *dos.library* functions listed in section ; they create, release or duplicate locks or create directories.

12.4.1 Obtaining a Lock

The ACTION_LOCATE_OBJECT packet locates an object — a file or a directory — on a *file system* and creates from it a *Lock* identifying the object uniquely. The object can later be used as active directory, to open a file from it or to retrieve metadata such as comments or protection bits associated to the identified object.

Table 73: ACTION_LOCATE_OBJECT

DosPacket Element	Value
dp_Type	ACTION_LOCATE_OBJECT (8)
dp_Arg1	BPTR to *FileLock*
dp_Arg2	Mode of the Lock
dp_Arg3	BPTR to BSTR of the object name
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet creates a lock from a path and a directory to which this path is relative, also represented as a lock. As such, it implements the Lock() function of the *dos.library*.

dp_Arg1 is a BPTR to a *FileLock* structure that represents the object to which the path given in dp_Arg3 is relative. This is usually a directory, and the Lock() function fills it from the current directory of the calling process. This argument can be ZERO in which case the *file system* shall assume that dp_Arg3 is relative to the root of the currently inserted volume handled by the file system.

dp_Arg2 is the type of the lock to be created as defined in table 14. The value SHARED_LOCK requests a non-exclusive lock on an object; multiple of such locks can be held on the same object. The value EXCLUSIVE_LOCK requests an exclusive an object; only a single exclusive lock can be held on an object at once, and no other locks, including shared locks, are permissible. Attempting to exclusively lock an object that is already locked shall fail, and attempting to lock an object that is already exclusively locked shall as well. Unfortunately, some programs call Lock() with an invalid argument for the mode, and thus *file systems* should be prepared to handle invalid values for dp_Arg2. Such values should be considered equivalent to SHARED_LOCK.

dp_Arg3 is a BPTR to a BSTR of an absolute or relative path of the object to be locked. Relative paths are relative to the lock in dp_Arg1, and if this argument is ZERO, relative to the root — the topmost directory — of the volume currently managed by this file system. If this string is empty, the identified object to be locked is identical to the one identified by dp_Arg1.

On success, dp_Res1 shall be a BPTR to a FileLock structure. These objects are created and maintained by the *file system*. This structure shall be initialized as indicated in section 5.2.5:

fl_Task shall point to a MsgPort through which the maintaining *file system* can be contacted, which is typically, but not necessarily the process message port pr_Port of the *file system* itself.

fl_Volume shall be a BPTR to the DosList structure representing the volume on which the locked object is located, see section 8.

fl_Access shall be filled by dp_Arg2, identifying the type of the lock.

fl_Link may be used to queue up locks on a volume that is currently not inserted. When a volume with locked objects is removed from the drive, the *file system* may store all these locks in a singly linked list starting at dol_LockList and chained by fl_Link. If the same volume is then re-inserted into another drive, another instance of the same file system is able to pick up these locks and manage them instead. Thus, for example, a lock on an object in drive df0: will remain valid even if the volume is removed and re-inserted into df1:.

fl_Key, finally, may be used for the purpose of the *file system* for uniquely identifying the locked object. It is an opaque value as far as the *dos.library* is concerned.

On success, the BPTR to the created FileLock shall be stored in dp_Res1 and dp_Res2 shall be set to 0. On error, dp_Res1 shall be set to ZERO and dp_Res2 to an error code from dos/dos.h identifying the source of the problem, see also section 10.2.9.

12.4.2 Duplicating a Lock

Despite its misguiding name, the packet ACTION_COPY_DIR makes a copy of a (shared) lock.

Table 74: ACTION_COPY_DIR

DosPacket Element	Value
dp_Type	ACTION_COPY_DIR (19)
dp_Arg1	BPTR to *FileLock*
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet implements the DupLock() function of the *dos.library* and attempts to replicate the lock passed in dp_Arg1. If this argument is ZERO, the packet is supposed to create a lock on the root directory of the currently mounted volume.

On success, dp_Res1 is filled with the BPTR to a copy of the FileLock passed in, and dp_Res2 is set to 0. On error, dp_Res1 is set to ZERO and dp_Res2 to an error code. While [1] indicates that dp_Res1 may be ZERO on an attempt to replicate the ZERO lock, this is not advisable as most users of this packet may misinterpret this result as failure case.

This packet is identical to ACTION_LOCATE_OBJECT with dp_Arg2 set to SHARED_LOCK and dp_Arg3 set to an empty string.

12.4.3 Finding the Parent of a Lock

The packet ACTION_PARENT obtains a shared lock on the directory containing a locked object.

Table 75: ACTION_PARENT

DosPacket Element	Value
dp_Type	ACTION_PARENT (29)
dp_Arg1	BPTR to *FileLock*
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet implements the ParentDir() function of the *dos.library* and attempts to create a lock on the directory containing the object identified by dp_Arg1. If no parent exists because dp_Arg1 is a lock on the root directory or the ZERO lock, the *file system* shall set dp_Res1 to ZERO and dp_Res2 to 0, indicating that this is not a failure case.

Otherwise, this function returns on success a BPTR to the FileLock representing the parent directory in dp_Arg1 and sets dp_Arg2 to 0. On error, dp_Res1 is set to ZERO and dp_Arg2 to an error code.

12.4.4 Duplicating a Lock from a File Handle

The packet ACTION_COPY_DIR_FH creates a shared lock from an object opened by a *file handle*; that is, it copies the implicit lock of the handle.

Table 76: ACTION_COPY_DIR_FH

DosPacket Element	Value
dp_Type	ACTION_COPY_DIR_FH (1030)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet implements the DupLockFromFH() function of the *dos.library*, and thus creates a copy of the lock that is implicit to an open file handle. This works only if the file is open in a non-exclusive mode, i.e. either MODE_READWRITE or MODE_OLDFILE.

dp_Arg1 is a copy of the fh_Arg1 element of the FileHandle structure and thus serves to identify the opened file.

On success, dp_Res1 is filled by the BPTR to the FileLock created, namely a lock to the object opened by the file handle. In such a case, dp_Res2 is set to 0. On error, dp_Res1 is set to ZERO and dp_Res2 to an error code.

12.4.5 Finding the Parent Directory of a File Handle

The packet ACTION_PARENT_FH creates a lock on the directory containing a file identified by a file handle.

Table 77: ACTION_PARENT_FH

DosPacket Element	Value
dp_Type	ACTION_PARENT_FH (1031)
dp_Arg1	fh_Arg1 of the *FileHandle*
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet implements the ParentOfFH() function of the *dos.library* and as such creates a lock on the directory that contains a given *file handle*. dp_Arg1 is a copy of the fh_Arg1 element of the FileHandle structure and thus identifies the handle.

On success, dp_Res1 is filled with a BPTR to the FileLock created, and dp_Res2 is set to 0. On error, dp_Res1 is set to ZERO and dp_Res2 to an error code.

12.4.6 Creating a new Directory

The packet ACTION_CREATE_DIR creates a new directory and represents it by an exclusive lock on the directory created.

Table 78: ACTION_CREATE_DIR

DosPacket Element	Value
dp_Type	ACTION_CREATE_DIR (22)
dp_Arg1	BPTR to *FileLock*
dp_Arg2	BPTR to BSTR of the directory name
dp_Res1	BPTR to *FileLock*
dp_Res2	Error code

This packet implements the CreateDir() function of the *dos.library* and creates a new directory of the name dp_Arg2 within the directory identified by the lock dp_Arg1.

On success, it creates a new exclusive lock which is returned in dp_Res1, and dp_Res2 is set to 0. On error, dp_Res1 is set to ZERO and dp_Res2 is set to an error code.

12.4.7 Comparing two Locks

The packet ACTION_SAME_LOCK compares two locks on the same file system and checks whether the two locks are on the same object.

Table 79: ACTION_SAME_LOCK

DosPacket Element	Value
dp_Type	ACTION_SAME_LOCK (40)
dp_Arg1	BPTR to *FileLock*
dp_Arg2	BPTR to *FileLock*
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is the core of the SameLock() function of the *dos.library*, which, however, first checks whether the two locks to compare are on the same file system. Only if so, the file system corresponding the two locks is contacted with the above packet to compare the two locks. For this, dp_Arg1 and dp_Arg2 are BPTRs to the two FileLocks to compare.

Upon reply, dp_Res1 shall be set to DOSTRUE if the two locks are on the same object, and in that case, dp_Res2 shall be set to 0. If the two locks are on two different objects, then dp_Res1 shall be set to DOSFALSE and dp_Res2 shall also be set to 0. On error, dp_Res1 is set to 0 and dp_Res2 to an error code[3].

[3] The documentation in [1] on dp_Res1 is incorrect.

12.4.8 Changing the Mode of a Lock or a File Handle

The packet ACTION_CHANGE_MODE changes the access mode of a lock or a file handle, thus potentially granting exclusive access — if possible — or lowering the rights to shared access.

Table 80: ACTION_CHANGE_MODE

DosPacket Element	Value
dp_Type	ACTION_CHANGE_MODE (1028)
dp_Arg1	Object type from table 15
dp_Arg2	BPTR to *FileLock* or *FileHandle*
dp_Arg3	Target mode
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the ChangeMode() function of the *dos.library* and thus changes the access mode of files or locks to exclusive or shared access mode.

dp_Arg1 identifies the object whose mode is to be changed. This is a value from table 15, i.e. either CHANGE_LOCK to adjust the type of the lock, or CHANGE_FH to change the access mode of a file handle.

dp_Arg2 is the BPTR to the object whose mode is to be changed. If dp_Arg1 is CHANGE_LOCK, this is a BPTR to a FileLock structure, if dp_Arg1 is CHANGE_FH, it is a BPTR to a FileHandle structure. Note that this is unusual as files are typically identified by their fh_Arg1 element and not by the handle itself. This packet is an exception.

dp_Arg3 is the target mode. This is either SHARED_LOCK for shared access to the file or the lock, or EXCLUSIVE_LOCK for exclusive access to the file or the lock[4]. However, as information on this packet is sparse and application programs can call the corresponding ChangeMode() function with incorrect target modes, *file handlers* should also accept ACTION_FINDINPUT and ACTION_FINDUPDATE for shared access and ACTION_FINDOUTPUT for exclusive access.

Note that it is not always possible to change the mode of a lock or a file to exclusive access, namely if it is accessed by a second file handle or locked a second time. This packet shall then fail.

Upon reply, dp_Res1 shall include a boolean success indicator, DOSTRUE for success or DOSFALSE for failure. In the former case, dp_Res2 shall be 0, in the latter case, it shall contain an error code.

12.4.9 Releasing a Lock

The packet ACTION_FREE_LOCK releases a lock on a file system.

Table 81: ACTION_FREE_LOCK

DosPacket Element	Value
dp_Type	ACTION_FREE_LOCK (15)
dp_Arg1	BPTR to *FileLock*
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the *dos.library* function UnLock() and releases a FileLock. A BPTR to the lock to release is provided in dp_Arg1. If this argument is ZERO, the *file system* shall ignore the request and return success.

When replying this packet, dp_Res1 shall be set to DOSTRUE on success and DOSFALSE on error. On success, dp_Res2 shall be set to 0, otherwise it shall be set to an error code. There are actually few reasons

[4] The information in [1] is incorrect on this subject matter.

why this packet could fail, probably because the passed in BPTR is invalid and does not point to a valid FileLock. The UnLock() function does not return this result code, but adjusts IoErr() according to dp_Res2.

12.5 Packets for Examining Objects

The packets in this section implement the functions of section 6.1 on packet level, i.e. they retrieve information from the file system on the metadata of objects and allow to scan all objects of a directory. Unfortunately, the packets in this section are the hardest to implement in a robust way as the directory contents can change while a directory scan is active, e.g. because files or directories are created or deleted.

12.5.1 Examining a Locked Object

The ACTION_EXAMINE_OBJECT packet retrieves metadata such as file name, comment and protection bits from a lock on an object on a file system and fills a FileInfoBlock with this data.

Table 82: ACTION_EXAMINE_OBJECT

DosPacket Element	Value
dp_Type	ACTION_EXAMINE_OBJECT (23)
dp_Arg1	BPTR to FileLock
dp_Arg2	BPTR to a FileInfoBlock structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Examine() function of the *dos.library* and retrieves metainformation on the object represented by the lock in dp_Arg1. This information is provided in a FileInfoBlock structure that is documented in section 6.1.

However, as the AmigaDOS handler design is due to historic reasons based on BCPL, small differences exist between how this packet operates and how the Examine() function provides its results to the caller. In specific, the fib_FileName and fib_Comment elements shall be filled with a BSTRs, i.e. the first character is the length of the file name or the comment. The conversion to a NUL-terminated C string is performed by the *dos.library*.

The elements fib_DirEntryType and fib_EntryType shall be filled with the same value as some programs check one and others the other element. In particular, the value filled in shall be taken from table 20. The value 0 shall be avoided as some programs check for directories by testing against a positive value whereas some others check for a non-negative value, i.e. accept 0 as a directory.

The fields fib_OwnerUID and fib_OwnerGID shall be set to 0, unless the file system has an idea on user and group IDs — unfortunately AmigaDOS cannot make use of these values anyhow, and it is not documented how these fields shall be interpreted; they are probably an opaque value. fib_Reserved shall be left alone, in particular file systems *shall not* use it to store internal state information. Such information may *only* go into fib_DiskKey, which is an element application programs, i.e. callers of the *dos.library*, shall not interpret.

This packet is also used to start a scan over the contents of a directory. In such a case, the examined object is the directory itself, i.e. the lock in dp_Arg1 is on a directory. As such, the file system should prepare for a scan over this directory and potentially initialize an internal state machine.

This function returns a boolean success code in dp_Res1, it shall be either set to DOSTRUE in case information on the locked object could be retrieved and had been successfully deposited into the FileInfoBlock given by dp_Arg2, or shall be set to DOSFALSE in case of error. In the success case, dp_Res2 shall be set to 0, or to an error code otherwise.

12.5.2 Scanning Directory Contents

The ACTION_EXAMINE_NEXT continues a scan over the directory contents and delivers meta-information on the subsequent entry in a directory. Such a scan is started by an ACTION_EXAMINE_OBJECT on the directory to be scanned; the first ACTION_EXAMINE_NEXT then provides information on the first entry in this directory and each subsequent packet to the corresponding next entry.

Table 83: ACTION_EXAMINE_NEXT

DosPacket Element	Value
dp_Type	ACTION_EXAMINE_NEXT (24)
dp_Arg1	BPTR to FileLock
dp_Arg2	BPTR to a FileInfoBlock structure
dp_Res1	Boolean result code
dp_Res2	Error code

This function continues a directory scan by providing information on the next subsequent object in the directory identified by the lock in dp_Arg1. Meta-information on the object itself is copied into the FileInfoBlock structure pointed to by the BPTR in dp_Arg2. Similar to ACTION_EXAMINE_OBJECT discussed in 12.5.1, the file name and comment shall be provided as BSTRs and not as NUL-terminated C strings. Conversion to the latter format is performed within the *dos.library*.

Unlike Unixoid file systems, AmigaDOS does not keep entries in directories that correspond to the directory itself or its parent directory, i.e. AmigaDOS file systems do not carry "." or ".." directory entries. When parsing paths, the current directory is identified by the empty string, and the parent directory by the isolated slash ("/").

Unfortunately, this packet is one of the hardest to implement in a file system as the directory may change while the scan is active. In particular, file systems shall handle the situation gracefully in which the object from the previous iteration identified by fib_DiskKey has been deleted, moved or replaced by another object, or in which dp_Arg1 is a different lock than the lock that was used to start the scan by ACTION_EXAMINE_OJBECT. The file system may only assume that the lock in dp_Arg1 is a lock on the same directory on which the scan has been started. Similarly, dp_Arg2 may have changed from the last iteration, and the file system shall only depend on fib_DiskKey and fib_DirEntryType being identical compared to the last iteration, all other entries can be potentially trashed or inconsistent. Thus, the file system shall only use these two elements to store state information. Also, file systems shall not depend on application programs scanning directories up to the last entry; application programs can abort a directory scan at an arbitrary point, yet file system shall release all resources required for storing state information of the scan after at least the lock on the scanned directory is released.

A possible implementation strategy is to store full state information in the lock given by dp_Arg1, though keep sufficient information in fib_DiskKey to rebuild the full information in case the lock is released and replaced during the scan. In the simplest possible case, fib_DiskKey could be a counter that enumerates the elements in the directory, whereas the lock contains the full state information to access the element directly. In case the lock is replaced, ACTION_EXAMINE_NEXT would find the state information in the lock missing, and would then scan forward to the element enumerated by fib_DiskKey. While this is less efficient than using the (now missing) state information in the lock, it will at least provide information on a valid object in the directory. Also, if an object is removed or moved out of the scanned directory, the file system would update the state information kept within the lock to the directory, though loosing the lock would at least continue the scan within the directory, even though not necessary from the same object. Storing a block number (for disk-based file systems) or a pointer to an object (for RAM-based file systems) is, however, a bad strategy as the corresponding disk block or RAM location may have found other uses at the time the next object is examined. Unfortunately, such implementation defects are rather common and have been found in multiple file systems of AmigaDOS in the past.

This packet shall provide a boolean success code in dp_Res1. In case the next object in a directory could be successfully examined and information on it could be stored in FileInformationBlock, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0. In case of an error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code. In case the end of the directory has been reached and no further entries remain to be examined, this error code shall be ERROR_NO_MORE_ENTRIES.

12.5.3 Examining Multiple Entries at once

The ACTION_EXAMINE_ALL packet scans a directory supplying multiple entries at once, potentially filtering entries through a pattern or through a hook.

Table 84: ACTION_EXAMINE_ALL

DosPacket Element	Value
dp_Type	ACTION_EXAMINE_ALL (1033)
dp_Arg1	BPTR to FileLock
dp_Arg2	APTR to a buffer to fill
dp_Arg3	Size of the buffer
dp_Arg4	Type defining the requested entries
dp_Arg5	Pointer to struct ExAllControl
dp_Res1	Continuation flag
dp_Res2	Error code

This packet implements the ExAll() function of the *dos.library* and thus takes parameters similar to the above function. Note that unlike many other packets, dp_Arg2 and dp_Arg5 are regular pointers and not BPTRs[5]. If the *file system* does not implement this packet, i.e. returns ERROR_ACTION_NOT_KNOWN, then the *dos.library* emulates it using ACTION_EXAMINE_OBJECT and ACTION_EXAMINE_NEXT.

dp_Arg1 is a lock on the directory to be examined.

dp_Arg2 is a pointer to the buffer to be filled with information on the objects found in the directory, it is *not* a BPTR. This buffer is filled with a singly linked list of ExAllData structures, see section 6.1.4 for the definition of this structure. Only the elements requested by dp_Arg4 are filled, remaining entries are undefined.

dp_Arg3 is the size of the buffer provided in dp_Arg2 in bytes.

dp_Arg4 defines which elements of the ExAllData are filled. The encoding of this argument is given by table 22 in section 6.1.4.

dp_Arg5 is a pointer to a ExAllControl structure, also defined in section 6.1.4. A detailed description of this structure is also provided in section 6.1.4. Note that this is really a regular pointer, not a BPTR.

The *file system* shall provide in the eac_Entries element of this structure the number of ExAllData structures it could fit into the target buffer provided by dp_Arg2.

It may store internal state information of the directory scanner in eac_LastKey. This state information could, for example, correspond to the fib_DiskKey in the FileInfoBlock identifying an element in a directory. It is zero-initialized before the first packet, and thus the *file system* may assume that a value of 0 for the key identifies the start of the scan.

If non-NULL, eac_MatchString is a parsed pattern as generated by the ParsePatternNoCase() function, see section 9.2.2. If this pattern is present, only directory entries whose name matches the pattern shall be filled into the target buffer.

eac_MatchFunc provides even finer control of which elements are filled into the target buffer; it supplies a Hook structure whose h_Entry function is called for each candidate directory entry. If the hook

[5] The information on dp_Arg5 in [1] is incorrect, it is really a pointer and not a BPTR

returns non-zero, the ExAllData copied to the buffer shall be considered accepted and shall remain in the buffer; if it returns zero, this candidate entry is rejected and will be removed from the final output. Calling conventions of this hook are also described in section 6.1.4.

The same precautions as for ACTION_EXAMINE_NEXT hold for this packet, too. In particular, the *file system* shall be prepared for the directory to get modified between scans, by either adding, removing, renaming or moving objects out or into the directory. Using a disk block or a pointer to a structure representing a specific object as eac_LastKey is therefore discouraged. Similarly, dp_Arg1 will be a lock to the same directory, though may not necessarily be the identical lock as used in the previous iteration over the same directory, only the directory that is locked may assumed to be the same. In other words, eac_DiskKey shall hold sufficient state information to reconstruct the point from which the scan is to be continued. What is, however, is ensured is that the pointer to the ExAllControl structure stored in dp_Arg5 did not change and the *file system* may depend on the pointer having the same value as on a the previous iteration over a directory. Also, *file systems* may depend on the client sending a packet of type ACTION_EXAMINE_ALL_END to abort a scan before reaching the end of the directory.

This packet shall be replied with dp_Res1 set to DOSTRUE if not all entries could be fit into the buffer, i.e. if dp_Arg3 bytes were not sufficient to hold all matching directory entries and at least another iteration over the directory is necessary to supply (some of) the missing entries. In such a case, dp_Res2 shall also be set to 0. Such an incomplete scan is either continued with another ACTION_EXAMINE_ALL packet, or aborted by an ACTION_EXAMINE_ALL_END packet.

In case the end of the directory has reached and all directory entries could be supplied, dp_Res1 shall be set to 0, and dp_Res2 to ERROR_NO_MORE_ENTRIES. In case the directory scan had been aborted due to an error, dp_Res1 shall be set to 0 and dp_Res2 to an error code.

12.5.4 Aborting a Directory Scan

The packet ACTION_EXAMINE_ALL_END aborts a directory scan started with ACTION_EXAMINE_ALL that returned with dp_Res1 non-zero and thus indicated that the end of the directory has not yet been reached.

Table 85: ACTION_EXAMINE_ALL_END

DosPacket Element	Value
dp_Type	ACTION_EXAMINE_ALL_END (1035)
dp_Arg1	BPTR to FileLock
dp_Arg2	APTR to a buffer to fill
dp_Arg3	Size of the buffer
dp_Arg4	Type defining the requested entries
dp_Arg5	Pointer to struct ExAllControl
dp_Res1	Boolean success flag
dp_Res2	Error code

This packet implements the ExAllEnd() function of the *dos.library* and aborts a partial directory scan started with ExAll() but for which neither the end of the directory has been reached nor an error code has been received. This packet may be used by an implementing *file system* to release any temporary resources allocated for the purpose of the scan.

dp_Arg1 is the lock on the directory on which a partial directory scan has been started. It is not necessarily the original lock passed into ACTION_EXAMINE_ALL, but a lock on the same directory.

dp_Arg2 and dp_Arg3 are a pointer to a buffer and its size. This buffer, however, will not be touched and no data will be deposited there; as this buffer is not necessarily the same as the one for which the scan has been started, this information is likely not very useful, but it is provided here anyhow.

dp_Arg4 is a type information which would define the information that would go into the buffer provided by dp_Arg2; however, as this packet does not request to add any data to the buffer, it is probably not very helpful and *file systems* should probably ignore it as no useful decisions can be derived from what the requested information actually was.

dp_Arg5 is a pointer to a ExAllControl structure, and the pointer provided here is identical to the pointer provided to ACTION_EXAMINE_ALL. Thus, *file systems* may use this pointer value and specifically the eac_DiskKey element therein to release any resources related to this scan.

Before replying this packet, the *file system* shall set dp_Res1 to a boolean success code whether it could abort the scan. If dp_Res1 is set to DOSTRUE indicating that the scan was aborted successfully, then dp_Res2 shall also be set to 0.

If the *file system* does not implement this packet, it shall set dp_Res1 to DOSFALSE and dp_Res2 to ERROR_ACTION_NOT_KNOWN. The *dos.library* then (attempts to) emulates this packet by setting the match pattern in the ExAllControl structure to a pattern that matches no entry, and then continues the scan with a ACTION_EXAMINE_ALL packet. This would then clearly reach the end of the directory without overruning the buffer. However, due to a defect in the *dos.library* up to the latest release, the (non-matching) pattern is a literal pattern and not a pre-parsed pattern and thus, actually, could match an entry in the directory. Thus, it is advised to always implement ACTION_EXAMINE_ALL_END if ACTION_EXAMINE_ALL is implemented, even if it is just replied with success and no additional resources need to be released.

On any other error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code from dos/dos.h.

12.5.5 Examining from a File Handle

The ACTION_EXAMINE_FH packet provides meta data on an object identified by a *file handle* rather than a *lock*; that is, it uses the (implied) lock of the opened file to retrieve information.

Table 86: ACTION_EXAMINE_FH

DosPacket Element	Value
dp_Type	ACTION_EXAMINE_FH (1034)
dp_Arg1	fh_Arg1 of the FileHandle
dp_Arg2	BPTR to a FileInfoBlock structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the ExamineFH() function of the *dos.library* and retrieves information on an object from a *file handle* rather than a *lock*.

dp_Arg1 is a copy of the fh_Arg1 element of the FileHandle that is to be examined and thus serves to identify the object to be examined[6].

dp_Arg2 is a BPTR to a FileInfoBlock structure as documented in section 6.1, and which shall be filled by the *file system* with the information on the object identified by dp_Arg1. As for the packet type ACTION_EXAMINE_OBJECT specified in section 12.5.1, the FileInfoBlock passed out to the caller of the *dos.library* and what the packet shall deliver differ. In specific, fib_FileName and fib_Comment shall be BSTRs with the length of the string in the zeroth element, and not NUL-terminated C strings. The conversion to C strings happens within the *dos.library*.

Before replying this packet, the *file system* shall set dp_Res1 to a boolean result code. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

[6]Note, again, that the information in [1] on dp_Arg1 is incorrect.

12.6 Packets for Working with Links

The packets in this section interact with links; they create them, or in case of soft-links, resolve them and update a path given the link. Section 6.4 provides background information on links and on the interface within the *dos.library* for links.

12.6.1 Creating Links

The `ACTION_MAKE_LINK` packet creates a link in a file system.

Table 87: `ACTION_MAKE_LINK`

DosPacket Element	Value
`dp_Type`	`ACTION_MAKE_LINK (1021)`
`dp_Arg1`	BPTR to a `FileLock`
`dp_Arg2`	BPTR to BSTR of the link to create
`dp_Arg3`	BPTR to `FileLock` or APTR to C-string
`dp_Arg4`	Type of the link, from table 24
`dp_Res1`	Boolean result code
`dp_Res2`	Error code

This packet implements the `MakeLink()` function of the *dos.library* and as such creates soft- or hardlinks within the *file system*.

`dp_Arg1` is a BPTR to a `FileLock` structure that identifies the directory within which the object is to be created.

`dp_Arg2` is a BPTR to a BSTR that provides the name of the link to be created.

`dp_Arg3` identifies the target of the link, i.e. the object the link points to. If `dp_Arg4` is `LINK_HARD`, then this argument is a `BPTR` to a `FileLock` structure identifying the target. If this `FileLock` identifies an object on the same file system as `dp_Arg1`, then a hard link is created. If the object locked by `dp_Arg3` is a file, then the created link will represent a file, otherwise a directory.

Resolution of hard links is up to the *file system*. That is, if the link is accessed, it is up to the *file system* to locate the target of the link and access it instead of the link. Multiple implementation strategies exist for hard links: Either, each object includes a reference count that is incremented for each directory entry pointing to it, that is for each link created; likewise, this counter is decremented each time a directory entry is removed. If the counter reaches 0, the object itself is deleted.

Alternatively, each link is pointing to the linked object, and the object itself contains a list of links that reference it. If a link is deleted, it is removed from its directory and from the list of links within the target object. If the object itself is deleted, one of the links becomes the object itself and the list of links is copied from the deleted object to this link. The FFS follows (mostly for backwards compatibility) this latter approach.

If `dp_Arg4` is `LINK_HARD` and the `FileLock` pointed to by `dp_Arg3` is on a different file system, then an external link shall be created. That is, the *file system* addressed by the packet shall create a file or directory within its own file system in the directory identified by `dp_Arg1`, and this file or directory shall mirror the contents of the link target given by `dp_Arg4` whenever the link or an object within the link is accessed; the file system shall thus implement a "copy on read" for the linked object and all objects within the linked object if this object is a directory.

If the target of such a link is deleted or an object within the linked target, the copy within the *file system* containing the link remains accessible as a regular file or directory. If no copy has been created so far, an attempt to access the linked object fails with `ERROR_OBJECT_NOT_FOUND`.

Currently, only the *RAM-Handler* implements this type of link, and it is there used to realize the ENV: assign containing all preferences settings. The external link pulls only those preferences settings into the RAM disk that are actually required, at the time they are required.

If dp_Arg4 is LINK_SOFT, then dp_Arg3 is a pointer to a NUL-terminated C string providing the target of the link. This string is interpreted as a path name relative to the location of the link source at the time the link is resolved[7].

Resolution of soft links is performed within the *dos.library* or within the client application as not all functions of the library implement soft link resolution. For a list of functions that *do* implement it, see table 23.

Upon accessing a soft link, or a path containing a soft link, the *file system* shall create an error code ERROR_IS_SOFT_LINK. If this error is returned, the sender of a packet accessing the link — thus typically the *dos.library* itself — shall read the target of the link with the ReadLink() function specified in section 6.4.2. This function then again contacts the file system containing the link with a ACTION_READ_LINK which will construct from the link an updated path to the object.

From this follows that a *file system* is not aware whether the target of a soft link actually exists as it can only provide the path to the object, but not necessarily the object itself; in particular, soft links may cross file system boundaries. If the target of a soft link is deleted, the soft link itself remains and becomes a "dangling" link. When accessing such a link, its resolution fails with an error ERROR_OBJECT_NOT_FOUND.

Upon replying the packet, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0 on success. On failure, dp_Res2 shall be set to DOSFALSE and dp_Res1 to an error code.

12.6.2 Resolving a Soft Link

The ACTION_READ_LINK packet constructs from a path containing a soft link an updated path by inserting the target of the link.

Table 88: ACTION_READ_LINK

DosPacket Element	Value
dp_Type	ACTION_READ_LINK (1024)
dp_Arg1	BPTR to a FileLock
dp_Arg2	APTR to C string
dp_Arg3	APTR to buffer
dp_Arg4	Buffer size
dp_Res1	Actual buffer size needed
dp_Res2	Error code

This packet implements the ReadLink() function of the *dos.library* and is used there to resolve soft links and obtain the link target. Implementing this packet correctly requires, however, some care as the soft link may be in the middle of the path provided by dp_Arg2 and not just its last component, and the soft link itself may be an absolute or relative path. This packet needs to provide from the original path an updated path that points to the intended location relative to the location of the soft link, and not relative to dp_Arg1.

dp_Arg1 is a lock to a directory in the *file system* to which this packet has been send and relative to which the path in dp_Arg2 shall be interpreted. This *need not* to be the directory containing the link.

dp_Arg2 is a pointer to a path name containing a soft link on this *file system*. This is, unlike in many other packets, not a BPTR to a BSTR but a pointer to a regular NUL-terminated C string.

The *file system* shall now proceed with soft link resolution as follows: Starting from the directory given by dp_Arg1, it shall interpret the path in dp_Arg2 component by component as explained in section 4.3,

[7]This is quite unusual as AmigaDOS otherwise depends on BSTR representation for packets.

until it finds a soft link. That is, colons (":") indicate that the scan should continue at the root directory of the volume, an isolated slash ("/") shall enter the parent directory, and all other components terminated by a slash shall be interpreted as names of directories that shall be recursively entered. This process continues until either the end of the path is found, or — and this is the purpose of this packet — a soft link is detected.

If a soft link is detected as part of the path, the target of the link as stored in the file system shall be read. Note that the link target may not only consist of an isolated file or directory name, but may well be an absolute or relative path that shall be merged with the path provided in `dp_Arg2`.

In particular, if the path stored in the soft link contains a colon (":"), and hence is an absolute path, the components parsed off from `dp_Arg2` up to the detection of the soft link shall be disregarded in order to start from the root directory. If no device or volume name is provided in the absolute link target, the *file system* shall insert the name of the current volume, and a colon, in order to provide an unambiguous anchor of the newly constructed path. The remaining of the path stored in the soft link is then concatenated to this device or volume specification. Finally, the rest of the components from `dp_Arg2` behind the component name of the soft link are concatenated to this intermediate path, forming the final link target.

If the path stored in the soft link is a relative path, then it shall be concatenated to the path from `dp_Arg2` up to the component name of the soft link at which iterating through `dp_Arg2` was interrupted. The remaining components from `dp_Arg2` behind the component name of the soft link is then attached to this intermediate path, forming the final result.

This procedure is tedious, but it ensures that the soft link is interpreted relative to the path from which the client application detected it, even if the soft link is the middle of the supplied path and not contained in the directory provided by `dp_Arg1`. Note that the above algorithm only resolves a single soft link in a path; this is intentional, the *dos.library* will send another `ACTION_READ_LINK` packet to the same or another file system if the remaining path contains additional soft links, or even in case the soft link points to another soft link. It is therefore important at the level of client application — or the *dos.library* — to detect endless loops of soft links pointing to each other. The *dos.library* aborts soft link resolution after 15 links.

`dp_Arg3` is the pointer (not a BPTR) to a target buffer into which the newly constructed path, with the soft link resolved, shall be provided as a `NUL`-terminated C string.

`dp_Arg4` is the size of this target buffer in bytes.

On an error, `dp_Res1` shall be set to -1[8] and `dp_Res2` to an error code. In particular, if the target buffer size `dp_Arg4` is too small to hold the resolved path, `dp_Res2` shall be set to `ERROR_LINE_TOO_LONG`.

If the source path in `dp_Arg2` does actually not contain a soft link and the scanning algorithm aborted without finding one, this also consistutes an error that shall be reported by setting `dp_Res1` to -1. This error is not handled consistently in AmigaDOS. The RAM-Handler reports `ERROR_OBJECT_WRONG_TYPE`, the FFS the error code `ERROR_OBJECT_NOT_FOUND`. The former error is probably more sensible.

On success, `dp_Res1` shall be set to the length of the constructed path, i.e. to the length of the string in `dp_Arg3` (not including the terminating `NUL`), and `dp_Res2` to 0.

The following example is a skeleton code implementing the above algorithm:

```
/*
** Skeleton of an implementation of the readlink function
** lock   is from dp_Arg1 and a BPTR to a filelock
** string is from dp_Arg2 and the path containing a link
** buffer is from dp_Arg3 and the target buffer
** size   is from dp_Arg4 and the size of the buffer.
*/
LONG readlink(BPTR lock, UBYTE *string,UBYTE *buffer, ULONG size)
{
```

[8] [1] recommends to set it to -2 on a target buffer overflow, though currently any negative value will do. Unfortunately, even the latest version of the FFS will *not* return a negative value but 0 in case of an error; this is a defect.

```
struct node *node,*linknode;
UBYTE *src  = string;
LONG is_dir = FALSE;
LONG path_before;
LONG path_pos;
LONG res,len;
/* Pointer to DosList of this handler, needed
** for the name of the volume.
*/
extern struct DosList *volumenode;

/*
** Find the object from lock and string. This is a file
** system internal function that need to be provided
** by the user.
** path_before is the offset of the last component
** of the path in the string that could be resolved
** successfully. If a softlink is found in the
** middle of the path, or some other error was found,
** NULL is returned.
** link_node is set to a pointer to a structure that
** represents the link.
** path_pos is set to the offset of the "/" behind
** the soft link if a soft link is in the middle.
** If the link is the last component of the path, then
** the node that represents the soft link is returned,
** Otherwise, the node is returned.
*/
node = locatenode(lock,string,&path_before,
                  &linknode,&path_pos);
if (!node) {
  if (IoErr() == ERROR_IS_SOFT_LINK) {
    is_dir = TRUE; /* remember... */
    node   = linknode;
  } else {
    /* Resolution did not work for some
    ** other error. Return an error.
    */
    return -1;
  }
}

/*
** Check whether the found object is a softlink
*/
if (node->type != ST_SOFTLINK) {
  res2 = ERROR_OBJECT_WRONG_TYPE;
  return -1;
}

/*
```

```
** Check whether the link is in the middle or the end of
** the path.
*/
if (is_dir) {
  /* must deal with '/' and ':' correctly in the soft link
  ** code below counts on these assigns!
  */
  string = string + path_pos;
  len    = strlen(string) + 1;       /* + 1 for slash */
} else {
  len    = 0; /* softlink is last part of string */
}

/*
** Check whether there is sufficient room in the
** target buffer.
*/
if (node->size + 1 + path_before + len >= size) {
  res2 = ERROR_LINE_TOO_LONG;
  return -2;
}

/*
** Copy the head of the link resolution path to the
** target buffer, ready to append the contents of
** the link.
*/
memcpy(buffer,src,path_before);

/*
** copy the target of the soft link into the buffer behind
** the path of the link as zero-terminated C string.
** This function also need to be provided by the
** implementation of the file system. It returns
** the size of the soft link as result, or -1 on error.
*/
res = readsoftlink(node,buffer + path_before,size - path_before);
if (res < 0)
  return res; /* Deliver the error */

/*
** If the link is absolute, i.e. contains a ':', then ignore the
** start of the string. 'res' is the length of the link location.
*/
src = strchr(buffer + path_before,':');
if (src) {
  /* Yes, is absolute. First check whether it is ":", thus
  ** whether it refers to this volume.
  */
  if (src == buffer + path_before) {
    /* Is relative to our root, but not necessarily
```

```
      ** to the root of the caller, so fix up.
      */
      char *volname = (char *)BADDR(volumenode->dl_Name);
      LONG len      = *volname; /* It's a BSTR */
      /* Check whether there is enough buffer */
      if (len + res >= size) {
        SetIoErr(ERROR_LINE_TOO_LONG);
        return -2;
      } else {
        /* Move soft link behind the volume name,
        ** note that the softlink is ":" here and
        ** the ":" becomes part of the volume name.
        */
        memmove(buffer + len ,buffer + path_before,res + 1);
        /* Prepend the volume name */
        memcpy(buffer,volname + 1,len);
        res += len;
      }
    } else {
      /* Here the link is absolute to a given volume
      ** so move the soft link behind the volume name
      */
      memmove(buffer,buffer + path_before,res + 1);
    }
  }

  /* add on the rest of the path behind
  ** the soft link if it sits in the middle
  */
  if (is_dir) {
    if(!AddPart(buffer, string, size)) {
      SetIoErr(ERROR_LINE_TOO_LONG);
      return -2;
    }
  }

  /*
  ** The result is the length of the path created
  */
  return strlen(buffer);
}
```

12.7 Packets for Adjusting Metadata

Packets in this section change metadata associated with file system objects, such as name, comment, creation date or protection flags.

12.7.1 Renaming or Moving Objects

The `ACTION_RENAME_OBJECT` changes the name of an object such as a file, directory or a link, and relocates it within the directory tree of a volume.

Table 89: ACTION_RENAME_OBJECT

DosPacket Element	Value
dp_Type	ACTION_RENAME_OBJECT (17)
dp_Arg1	BPTR to source FileLock
dp_Arg2	BPTR to BSTR of the object path
dp_Arg3	BPTR to target FileLock
dp_Arg4	BPTR to BSTR of the target path
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Rename() function of the *dos.library* and relocates and renames objects within the directory structure of a volume. This packet cannot relocate across volumes, i.e. dp_Arg1 and dp_Arg3 are locks to objects within the same volume, and dp_Arg2 and dp_Arg4 represent paths within this volume.

dp_Arg1 represents the directory to which the source dp_Arg2 is relative to.

dp_Arg2 is the path of the original object location. This path need not to consist of a single component, though the object to rename or relocate is the last component of this path. The *file system* needs to walk the provided path, starting from dp_Arg1, to identify the object that is to be renamed or moved.

dp_Arg3 is the directory to which the target path dp_Arg4 is relative to.

dp_Arg4 is the target path of the object, relative to dp_Arg3.

Several cases for renaming exist the *file system* shall consider: If the last component does not yet exist within the file system, the object identified by dp_Arg1 and dp_Arg2 shall be moved into the directory represented by the second to last component of of dp_Arg4 starting from dp_Arg3, or directly into dp_Arg3 if dp_Arg4 only consists of a single component, and shall be renamed to the last component of the path in dp_Arg4.

If the object identified by dp_Arg3 and the path in dp_Arg4 does already exist and represents a directory, the object shall be moved *into* this directory, retaining its original name.

If the last component does already exist and is a file, and this file is different from the source object, an error shall be generated. Renaming a file or directory to itself, or to a file name that only differs in case shall, however, be accepted, and shall adjust its case (i.e. changing letters in its name to lower or upper case is permissible).

Particular care needs to be taken if the object to be relocated is a directory. In such a case, the *file system* shall test whether an attempt is made to move the object into itself, i.e. into one of the subdirectories of its own. As this would render the directory unreachable, an error shall be generated.

Before replying the packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On error, dp_Res1 shall be to DOSFALSE and dp_Res2 to an error code.

12.7.2 Deleting an Object

The ACTION_DELETE_OBJECT removes an object from a directory, releasing the storage it occupies.

Table 90: ACTION_DELETE_OBJECT

DosPacket Element	Value
dp_Type	ACTION_DELETE_OBJECT (16)
dp_Arg1	BPTR to FileLock
dp_Arg2	BPTR to BSTR of the object path
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the DeleteFile() function of the *dos.library*, which can delete files, directories and links.

dp_Arg1 is a lock to the directory to which the path in dp_Arg2 is relative. The DeleteFile() function fills it with the current directory of the calling process.

dp_Arg2 is the path to the object to be deleted. The path can contain multiple components, in which case the file system need to walk the path starting at dp_Arg1 until reaching its last component which is the object to be deleted. If the target is a directory, the *file system* shall check, in addition, if the directory is empty, and if not so, refuse to delete it.

Before replying the packet, dp_Res1 shall be set to a boolean success indicator. In case of success, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.7.3 Changing the Protection Bits

The ACTION_SET_PROTECT changes the protection bits of a file system object.

Table 91: ACTION_SET_PROTECT

DosPacket Element	Value
dp_Type	ACTION_SET_PROTECT (21)
dp_Arg2	BPTR to FileLock
dp_Arg3	BPTR to BSTR of the object path
dp_Arg4	New protection bits
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetProtection() function of the *dos.library*; it changes the protection bits of an object on the file system to that given in dp_Arg4. For the definition of protection bits, see section 6.1, table 21. Some *file systems* may support only a subset of all protection bits, or may not be able to carry them on all objects, such as directories; in such a case, they may ignore the request, or may only implement a subset of all bits.

dp_Arg2 is a lock of a directory which the path in dp_Arg3 is relative to[9].

dp_Arg3 is a path relative to dp_Arg2 whose last component is the object whose protection bits are to be changed.

dp_Arg4 are the new protection bits as specified in table 21. Note that the first four bits are shown inverted by most system tools such as the List command.

Before replying to this packet, the *file system* shall set dp_Res1 to a boolean result code. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 shall be set to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.7.4 Setting the Comment to an Object

The ACTION_SET_COMMENT packet changes, adds or removes a comment on a file system object such as a directory, file or link.

[9] This not a typo, dp_Arg1 is really unused

Table 92: ACTION_SET_COMMENT

DosPacket Element	Value
dp_Type	ACTION_SET_COMMENT (28)
dp_Arg2	BPTR to FileLock
dp_Arg3	BPTR to BSTR of the object path
dp_Arg4	BPTR to BSTR of comment
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetComment() function of the *dos.library* and as such changes, adds or removes a comment on a file, directory or link. Not all file systems will support this request, or may only support comments on a subset of objects.

dp_Arg2 represents a directory relative to which the path in dp_Arg3 shall be interpreted.

dp_Arg3 is the path relative to dp_Arg2 of the object whose comment is to be changed.

dp_Arg4 is a BPTR to a BSTR of the new comment to be set. If this string is empty, the comment will be removed.

Before replying to this packet, the *file system* shall set dp_Res1 to a boolean result code. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 shall be set to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.7.5 Setting the Creation Date of an Object

The ACTION_SET_DATE packet sets the creation date of an object on a file system.

Table 93: ACTION_SET_DATE

DosPacket Element	Value
dp_Type	ACTION_SET_DATE (34)
dp_Arg2	BPTR to FileLock
dp_Arg3	BPTR to BSTR of the object path
dp_Arg4	BPTR to DateStamp structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetFileDate() function of the *dos.library* and sets the creation date of an object on a file system. Not all *file systems* will support this packet, or may only support it with reduced precision of the date.

dp_Arg2 represents a directory relative to which the path in dp_Arg3 is interpreted[10].

dp_Arg3 is the path of the object whose creation date is to be changed. This path shall be interpreted relative to dp_Arg2, and its last component is the object whose creation date shall be changed.

dp_Arg4 is a BPTR to a DateStamp structure as specified in section 3 and defines the target date to install for the object.

Before replying to this packet, the *file system* shall set dp_Res1 to a boolean result code. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 shall be set to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

[10] The information in [1] is incorrect, and dp_Arg1 is, indeed, unused.

12.7.6 Setting the Owner of an Object

The ACTION_SET_OWNER packet sets the owner and group ID of an object in a file system.

Table 94: ACTION_SET_OWNER

DosPacket Element	Value
dp_Type	ACTION_SET_OWNER (1036)
dp_Arg2	BPTR to FileLock
dp_Arg3	BPTR to BSTR of the object path
dp_Arg4	Owner information
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetOwner() function of the *dos.library* and is supposed to set a group and user ID of an object in a file system; the actual encoding of this information is specific to the *file system* and not defined by the *dos.library* or the packet. dp_Arg4 is a literal copy of the second argument of SetOwner(). Note further that most if not all AmigaDOS *file systems* do not implement this packet, and as AmigaDOS is not a multi-user system, the value of this packet is questionable.

dp_Arg2 represents a directory relative to which the path in dp_Arg3 is interpreted.

dp_Arg3 is the path of the object whose owner information is to be changed. This path shall be interpreted relative to dp_Arg2.

dp_Arg4 is a *file system* specific owner information; the *dos.library* does not define its meaning. This argument is a verbatim copy of the second argument of SetOwner().

Before replying to this packet, the *file system* shall set dp_Res1 to a boolean result code. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 shall be set to 0. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.8 Packets for Starting and Canceling Notification Requests

The packets in this section implement notification requests. Once a notification request has been registered, the file system informs a task through a signal or through a message send to a port. Notification requests are explained in section 6.5.

12.8.1 Registering a Notification Request

The ACTION_ADD_NOTIFY packet registers a notification request at a file system.

Table 95: ACTION_ADD_NOTIFY

DosPacket Element	Value
dp_Type	ACTION_ADD_NOTIFY (4097)
dp_Arg1	APTR to NotifyRequest structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the StartNotify() function of the *dos.library*, registering a request at a *file system* to get informed on changes within the file system.

dp_Arg1 is a C pointer[11] to a NotifyRequest structure that defines the object to be monitored, and the task, signal or message port to be triggered on such changes. This structure is specified in section 6.5.1.

[11] In [1] this argument is documented to be a BPTR, though this information incorrect.

The nr_FullName element of the NotifyRequest structure is already filled by an absolute path to the object to be monitored which may or may not yet exist. This path is filled in by the *dos.library* within the StartNotify() function from the nr_Name element and the current directory of the calling process, and the *file system* may depend on this path.

The *file system* should store this request in its internal structures, and then monitor the object identified by nr_FullName for changes. The following table lists the packets which shall or may trigger a notification request upon a monitored object:

Table 96: Packets triggering a Notification

Packet	Notes
ACTION_WRITE	After closing the file with ACTION_END
ACTION_SET_FILE_SIZE	After closing the file with ACTION_END
ACTION_FINDOUTPUT	After closing the file with ACTION_END
ACTION_DELETE_OBJECT	Immediately
ACTION_SET_DATE	Immediately
ACTION_RENAME	Immediately
ACTION_SET_COMMENT	Optionally
ACTION_SET_PROTECT	Optionally
ACTION_SET_OWNER	Optionally

If the NRF_NOTIFY_INITIAL flag is set in nr_Flags, the *file system* shall send a notification immediately after receiving this packet, regardless of whether or not the object has been modified already. If NRF_WAIT_REPLY is set, and a NotifyMessage has already been send out, it shall rather note the modification, though defer any further notification on the same object until the former NotifyMessage has been replied. This avoids queuing up too many notifications at the client port.

A notification event is either signalled through Signal() or by sending a message to a MsgPort:

If NRF_SEND_MESSAGE is set in nr_Flags, then a NotifyMessage is send to the port indicated in nr_Msg.nr_Port. This structure is also specified in section 6.5.1. Its nm_Class element shall be set to NOTIFY_CLASS, and its nm_Code element to NOTIFY_CODE, both are defined in dos/notify.h. In addition, nm_NReq shall point to the NotifyRequest structure through which the object is monitored. The elements nm_DoNotTouch and nm_DoNotTouch2 may be used for internal administration of the *file system*.

If NRF_SEND_SIGNAL is set, then the *file system* should trigger a signal bit on the target task if the monitored object changes by

```
Signal(nr->nr_Signal.nr_Task,1UL<<nr->nr_Signal.nr_SignalNum);
```

For this method, NRF_WAIT_REPLY is, of course, non-functional.

Upon replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.8.2 Canceling a Notification Request

The ACTION_REMOVE_NOTIFY packet cancels a notification request and aborts monitoring the object in the NotifyRequest structure.

Table 97: ACTION_REMOVE_NOTIFY

DosPacket Element	Value
dp_Type	ACTION_REMOVE_NOTIFY (4097)
dp_Arg1	APTR to NotifyRequest structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the EndNotify() function of the *dos.library* and terminates monitoring the object in nr_FullName element of the NotifyRequest structure.

nr_Arg1 is a C-pointer to the structure that indicates which notification request shall be canceled. The NotifyRequest structure is specified in section 6.5.1.

If any notifications are still pending, e.g. because the monitored object has already been changed through a file handle though this file handle has not yet been closed, such pending notifications shall be canceled as well. The *file system* shall be aware that even after this packet has been replied, some NotifyMessages send out to clients may come back because the client is still working on them. In particular, the memory associated to such messages shall not be released upon receiving the ACTION_REMOVE_NOTIFY packet, but only after the NotifyMessage has been replied and was received again by the *file system*. The *dos.library* replies all NotifyMessages it finds still pending in the port of the client application, but clearly cannot handle those messages that are still being processed.

Upon replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9 Packets Operating on Entire Volumes

The packets in this section impact the volume mounted on a *file system* in total and do not interact with individual objects, such as files, directories or links on it.

12.9.1 Determining the Currently Inserted Volume

The packet ACTION_CURRENT_VOLUME determines from a *FileHandle* a BPTR to the DosList structure representing the volume on which the file is located.

Table 98: ACTION_CURRENT_VOLUME

DosPacket Element	Value
dp_Type	ACTION_CURRENT_VOLUME (7)
dp_Arg1	fh_Arg1 of a FileHandle or ZERO
dp_Res1	BPTR to DosList structure
dp_Res2	0

This packet is not exposed by the *dos.library*, but it used by it when constructing an error requester through its ErrorReport() function. If an error is generated by a function taking a *FileHandle* as argument, this function is used to determine the DosList entry representing the volume. From there, the name is copied into the requester, for example to ask the user to insert it.

dp_Arg1 shall be filled with a copy of the fh_Arg1 element of a FileHandle structure, or shall be ZERO. If a handle is provided, a BPTR to the DosList of the volume the handle is located on shall be provided in dp_Res1. In such case, the packet is safe as the volume entry cannot go away as long as the lock implicit to the handle uses it[12].

[12]In [1], dp_Arg1 is not mentioned, though providing it is important to avoid a race condition. The RAM-Handler is probably an exception as it only maintains a single volume that cannot go away during its lifetime.

If dp_Arg1 is ZERO, a BPTR to the DosList of the currently inserted volume, or ZERO if no volume is inserted, shall be returned. Unfortunately, as the volume may be ejected any time, it is unclear whether the DosList entry provided in dp_Res1 is still valid at the time it is interpreted by the issuer of of this packet. In such a case, the issuer of the packet should lock the *device list* upfront, and should copy the name before the list is unlocked again, i.e.

```
char name[256];
struct DosList *dl;

  LockDosList(LDF_VOLUMES|LDF_READ);
  dl = (struct DosList *)BADDR(DoPkt0(port,ACTION_CURRENT_VOLUME));
  if (dl) {
    /* dol_Name is always a 0-terminated BSTR */
    strncpy(name,dl->dol_Name + 1,sizeof(name));
    name[sizeof(name)-1] = 0;
  } else name[0] = 0;
  UnLockDosList(LDF_VOLUMES|LDF_READ);
```

The *file system* shall set dp_Res1 to a BPTR to the DosList entry representing a volume, i.e. an entry on the device list whose dol_Type is DLT_VOLUME and whose dol_Task points to a MsgPort of this *handler*. In case no volume is inserted, dp_Res1 shall be set to ZERO. This packet shall not fail, and dp_Res2 is ignored by the *dos.library*. For practical purposes, dp_Res2 shall be set to 0 indicating that no error has been detected.

12.9.2 Retrieving Information on a Volume from a Lock

The ACTION_INFO packet retrieves information on a volume, given a lock on an object on the volume, and provides it in an InfoData structure.

Table 99: ACTION_INFO

DosPacket Element	Value
dp_Type	ACTION_INFO (26)
dp_Arg1	BPTR to FileLock
dp_Arg2	BPTR to InfoData
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Info() function of the *dos.library* and provides information on the volume on which the locked object is located.

dp_Arg1 is a BPTR to a lock, used to identify a volume from which information is to be requested. If the volume is not inserted, not validated or the lock is invalid, this packet will fail.

dp_Arg2 is a BPTR to an InfoData structure as defined in section 5.2.4 into which information is provided such as the state of the volume, the number of errors detected on it, its capacity and the number of free blocks. Details on this structure are found in section 5.2.4.

Upon replying this packet, dp_Res1 shall be set to a boolean success indicator that includes the result of the validity test of the lock. If the lock is valid and information on the volume could be retrieved, dp_Res1 shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9.3 Retrieving Information on the Currently Inserted Volume

The ACTION_DISK_INFO packet retrieves information on the volume currently mounted by the *file system* (if any) and provides this information in an InfoData structure.

Table 100: ACTION_DISK_INFO

DosPacket Element	Value
dp_Type	ACTION_DISK_INFO (25)
dp_Arg1	BPTR to InfoData
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is currently not exposed by the *dos.library* and must be issued through the packet interface. It is almost identical to ACTION_INFO, except that it does not take a lock as argument. Therefore, it always refers to the currently inserted volume, and not to the volume the locked object is located on. Otherwise, the information provided by this packet and ACTION_INFO is identical.

This packet is also used to retrieve console specific information from the Con-Handler, and is documented as such again in section 12.13. The elements of the InfoData are then interpreted in an alternative way.

dp_Arg1 is a BPTR to an InfoData structure as defined in section 5.2.4 into which information is provided such as the state of the currently inserted volume, the number of errors detected on it, its capacity and the number of free blocks. Details on this structure are found in section 5.2.4.

Upon replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9.4 Relabeling a Volume

The ACTION_RENAME_DISK packet changes the volume name of a medium.

Table 101: ACTION_RENAME_DISK

DosPacket Element	Value
dp_Type	ACTION_RENAME_DISK (9)
dp_Arg1	BPTR to BSTR of new volume name
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Relabel() function of the *dos.library* and changes the volume name of a medium. As such, it shall also change the name of the DosList representing the volume in the *device list*, i.e. adjust the dol_Name element of the DosList structure. Unfortunately, there is no guarantee that the volume that is inserted in the drive or partition managed by the file system when this packet is issued by the client is identical to the volume in the drive when the file system receives it.

dp_Arg1 is a BPTR to a BSTR of the new volume name. Relabeling shall be applied on the currently inserted volume.

Before replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9.5 Initializing a New File System

The ACTION_FORMAT packet initializes a new file system on a disk, writing all administration information on it represting a blank volume. It therefore deletes all information stored previously on the medium, drive or partition.

Table 102: ACTION_FORMAT

DosPacket Element	Value
dp_Type	ACTION_FORMAT (1020)
dp_Arg1	BPTR to BSTR of new volume name
dp_Arg2	Dos type or other private data
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Format() function of the *dos.library*. It performs a soft-initialization of the drive, medium or partition currently inserted into the drive. Note, however, that it does not perform a low-level formatting, such as creating sectors on a floppy disk or issuing a low-level SCSI command. If this is intended, it must be performed by a client application, e.g. the Format command of the workbench disk. This packet only writes administrative information on a volume representing it in empty state. This packet is probably the only one that should be used while a *file system* is inhibited and would usually refuse to alter any information on disk, see also section 12.11.2.

dp_Arg1 is a BPTR to a BSTR of the volume name the medium, partition or drive shall be given[13]. Typically, this packet will be issued while the drive is inhibited, and thus the DosList structure representing the volume will be created or updated at the time the *file system* is unhibited. Otherwise, if the handler also allows an ACTION_FORMAT while not being inhibited, it should update the DosList immediately, in particular its dol_Name, to the name given by this argument.

dp_Arg2 is *file system* specific information that may be used to define its flavour. For example, dp_Arg2 carries for the FFS the DosType, which shall be one of the values documented in table 28 in section 8.1.3. If such a change of the DosType also happens, and the handler allows formatting while not being inhibited, the de_DosType in the environment vector linked through dol_Dostype shall be updated as well. Otherwise, this update will happen when the *file system* is uninhibited. The Format() function will take dp_Arg2 from its third argument.

Before replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9.6 Make a Copied Disk Unique

The ACTION_SERIALIZE_DISK packet serializes a disk, that is, ensures that the disk is unique and distinguishable from other media available to the system.

Table 103: ACTION_SERIALIZE_DISK

DosPacket Element	Value
dp_Type	ACTION_SERIALIZE_DISK (4200)
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*. The packet interface e.g. DoPkt(), needs to be used to issue it. The purpose of this packet is to ensure that the volume inserted in a drive is unique and distinguishable from other volumes. Along with ACTION_FORMAT, this packet should be issued while the file system is inhibited, see sections 7.0.4 and 12.11.2.

[13] The information in [1] that the new volume name is in dp_Arg2 and the DosType is in dp_Arg3 is incorrect.

This packet does not take any arguments, it affects the currently inserted volume. The FFS implements this packet by setting the volume creation date to the system date; other file systems can include volume IDs or other means to uniquely label disks. The DiskCopy command of the workbench uses this packet after performing its job to ensure that the copy of a disk is distinguishable from its original.

Before replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.9.7 Write Protecting a Volume

The ACTION_WRITE_PROTECT packet enables or disables a software write-protection on the currently inserted medium, thus disallowing any write access through the file system on it.

Table 104: ACTION_WRITE_PROTECT

DosPacket Element	Value
dp_Type	ACTION_WRITE_PROTECT (1023)
dp_Arg1	Write protection flag
dp_Arg2	Password hash
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by any function of the *dos.library*, though the Lock command of the workbench uses it to enable or disable write protection on media. Optionally, write protection may be secured by a password of which only an integer hash key is provided to the file system. To re-enable write access, the file system shall check whether the password hash supplied matches the one when setting the write protection, and shall refuse to unblock it if the password hash keys do not match. How a password hash is computed is irrelevant to the file system, it only checks the keys for enabling and disabling the write protection for equality.

dp_Arg1 is a boolean indicator that, if non-zero, enables write protection, and if DOSFALSE releases it. Any attempt to write data to the protected medium, device or partition shall fail with the error code ERROR_DISK_WRITE_PROTECTED, including an attempt to set a write protection on an already write protected file system, regardless of the password key used for re-protection.

dp_Arg2 is an integer password hash key that is stored internally in the file system when the write protection is set, and compared against if it is to be released again. If the stored password hash is not equal to the original hash, attempting to release the protection shall fail with ERROR_INVALID_COMPONENT_NAME.

Before replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10 Packets for Interactive Handlers

The packet types documented in this section are specific for handlers that interact with the environment of the computer system. Examples for interactive handlers are the Con-Handler interacting with the user through a window, the Aux-Handler which makes a console available through the serial port, and the Port-Handler which reads and writes data through the serial or parallel port and also makes the printer accessible to AmigaDOS.

12.10.1 Waiting for Input Becoming Available

The packet ACTION_WAIT_CHAR waits for characters becoming available on an interactive *handler*.

Table 105: ACTION_WAIT_CHAR

DosPacket Element	Value
dp_Type	ACTION_WAIT_CHAR (20)
dp_Arg1	Timeout in ticks
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the WaitForChar() function of the *dos.library*. As such, it checks whether (interactive) input is available to satisfy a potential Read(). Note that this packet does not receive an indicator of a file handle, thus even if input is available, it is not specified which ACTION_READ packet will receive the available data.

dp_Arg1 provides the timeout in ticks, where a tick is 20ms long, see also section 3.

This packet instructs the handler to wait at most dp_Arg1 ticks. If no input becomes available within this time period, dp_Res1 shall be set to DOSFALSE and dp_Res2 to 0.

If at least a single character of input becomes available, dp_Res1 shall be set to DOSTRUE. If the handler implements line buffering such as the Con-Handler, then dp_Res2 shall be set to the number of lines available in the output buffer. This feature is, for example, used by the ARexx interpreter. If it does not implement line buffering, dp_Res2 should be set to 0.

In case of an error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10.2 Setting the Line Buffer Mode

The ACTION_SCREEN_MODE packet changes the buffer mode of an interactive console and disables or enables line buffering.

Table 106: ACTION_SCREEN_MODE

DosPacket Element	Value
dp_Type	ACTION_SCREEN_MODE (994)
dp_Arg1	Buffer mode
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the SetMode() function of the *dos.library*. dp_Arg1 is a copy of the second argument of this function.

The purpose of this packet is to adjust the buffer mode of a console. The CON-Handler, responsible for all types of consoles, serves both the CON:, the RAW: and (through an indirection layer) the AUX: device, all of which are incarnations of the same handler configured differently; the CON-Handler described in section 12.13.

In particular, CON: and RAW: interact with the user through a window of the graphical user interface; they are just two modes of the in total three modes of the console. With this packet, a CON: window can be converted into a RAW: window and vice-versa, and into a third type of window for which no distinct device name exists.

The same type of mode switch can also be performed for the serial terminal represented by the AUX: window, which also exists in three modes in total, though usually only one of them is exposed to the user as AUX: device. This packet makes two additional configurations available.

dp_Arg1 defines the mode into which the console shall be switched. In total three modes are available, regardless whether the console is a graphical console in a window or a serial console on an external terminal. The modes are defined in table 12 in section 4.10.3.

Only values between 0 and 2 shall be provided in dp_Arg1; all other values are reserved for future use and may or may not correspond to modes that are currently not documented. The console does not generate an error if an invalid mode is requested, but may interpret this mode change request in an unexpected way.

Before replying this packet, the console shall set dp_Res1 to DOSTRUE and dp_Res2 to 0 in case the mode switch could be performed. Otherwise, if the mode switch is not possible, the console shall set dp_Res1 to DOSFALSE and dp_Res2 to an error code.

12.10.3 Retrieving IORequest and the Window Pointer from the Console

The ACTION_DISK_INFO packet retrieves from a console pointers to its underlying resources.

Table 107: ACTION_DISK_INFO

DosPacket Element	Value
dp_Type	ACTION_DISK_INFO (25)
dp_Arg1	BPTR to InfoData
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*; it is the same packet as the one introduced in section 12.9.3 and takes the same parameters. However, when applied to consoles, it returns additional information and is thus discussed here again.

The id_DiskType element of the InfoData structure (see section 5.2.4) pointed to by dp_Arg1 provides information on the mode the console is in:

Table 108: id_DiskType

Value of id_DiskType	Console Mode
'CON\0'	Cooked or medium mode
'RAW\0'	Raw mode

Section 12.13 provides more information on console modes; they describe whether the console buffers entire lines and which key presses are reported how.

The id_VolumeNode element of the InfoData structure provided in dp_Arg1 is filled with a pointer to the intuition window the console runs in. For a serial console, or a console running on any other device, this element remains NULL.

The id_InUse element is filled with a pointer to the IoRequest structure (see exec/io.h) which is used to communicate with the device the handler operates on. For a graphical console, this is a IORequest to the console.device; for the AUX: console, it is an IORequest to the corresponding device the console runs on, e.g. of the serial.device. Other devices are also possible.

Even though this packet provides useful information to the caller, it has several drawbacks and its usage is discouraged. First, as it potentially provides information on the intuition window, a window opened in AUTO mode cannot be closed anymore, and neither can be iconified. This is because both operations would invalidate the window pointer provided by this packet.

Applications should inform the console by sending an ACTION_UNDISK_INFO packet at the time the window pointer or the IORequest is no longer required. Console windows then regain the AUTO and iconification capabilities. ACTION_UNDISK_INFO is specified in section 12.10.4.

Second, ACTION_DISK_INFO will not provide a window if the console is not running in an intuition window, but remotely over a serial line or any other device. The IORequest pointer then corresponds to the target device over which the console communicates with the user, and not the console.device.

Often, applications (mis-)use this packet to retrieve the current cursor position or the dimensions of the window in character positions, assuming that the IORequest pointer in id_InUse is, actually, corresponding to a console.device and as such io_Unit of the request is a pointer to a ConUnit. However, this assumption may not be true, and console dimensions and the cursor position cannot be obtained in general in this way.

The following algorithm provides an alternative by switching the console to RAW mode, and requesting the required information through CSI sequences. These sequences operate independent of the device and only require that the local or remote console implements a VT-100 compatible interface.

```
/* Retrieve the window dimensions in characters
** from a console connected to a file handle "file"
*/
void WindowSize(BPTR file,LONG *width,LONG *height)
{
  if (!ParsePosition(file,'r',width,height)) {
    /* Provide a standard console size in
    ** case of failure.
    */
    if (width)
      *width = 80;
    if (height)
      *height = 24;
  }
}

/* Retrieve the cursor position from a console
** connected to a file handle "file"
*/
void CursorPosition(LONG *x,LONG *y)
{
  ParsePosition(stdOut,'R',x,y);
}

/*
** Maximum time to wait for the console
** to respond in ticks. May require
** adjustment on slow connections.
*/
#define MAX_DELAY       200000

/* Generic CSI sequence parser for a VT-xxx
** console. Returns TRUE if the sequence could
** be parsed.
*/
BOOL ParsePosition(BPTR file,char answer,LONG *width,LONG *height)
{
BOOL success;
BOOL incsi,innum,negative,inesc;
```

```
LONG counter;
LONG args[5];
UBYTE in;

  memset(args,0,sizeof(args));
  SetMode(file,1);

  success  = TRUE;
  incsi    = FALSE;
  inesc    = FALSE;
  innum    = FALSE;
  negative = FALSE;
  counter  = 0;

  /* Now send a window borders request to the stream */
  if (answer == 'R') {
    Write(file,"\033[6n",4);
  } else {
    Write(file,"\033[0 q",5);
  }

  /* Now parse an incoming string */
  for(;;) {
    if (WaitForChar(file,MAX_DELAY) == FALSE) {
      success = FALSE;
      break;
    }

    if (Read(file,&in,1) != 1) {
      success = FALSE;
      break;
    }

    if (incsi) {
      if ((in<' ') || (in>'~')) { /* Invalid sequence? */
        incsi = FALSE;
      } else if ((in>='0') && (in<='9')) {
        /* Valid number? */
        if (innum == FALSE) {
          innum = TRUE;
          args[counter] = 0;
        }
        args[counter] = args[counter]*10+in-'0';
      } else {
        /* Abort parsing the number. Install its sign */
        if (innum) {
          if (negative)
            args[counter] = -args[counter];
          innum    = FALSE;
          negative = FALSE;
        }
```

```
    if ((in>='@') && (in<='~')) { /* End of sequence? */
      /* Is it a bounds report? */
      if ((in=='r') && (answer=='r') && (counter==3)) {
        if (height)
          *height = args[2]-args[0]+1;
        if (width)
          *width  = args[3]-args[1]+1;
        break;
      }
      /* Is it a cursor report? */
      if ((in=='R') && (answer=='R') && (counter==1)) {
        if (height)
          *height = args[0];
        if (width)
          *width  = args[1];
        break;
      }
      incsi = FALSE; /* Abort sequence */
    } else if (in==';') { /* Argument separator? */
      counter++;
      /* Do not parse more than 5 arguments,
      ** throw everything else away
      */
      if (counter>4) counter=4;
      innum    = FALSE;
      negative = FALSE;
    } else if (in=='-') {
      if (innum)
        incsi = FALSE;  /* minus sign in the middle is invalid */
      negative = ~negative;
    } else if (in==' ') {
      /* Ignore SPC prefix */
    } else {
      /* Abort the sequence */
      incsi = FALSE;
    }
  }
} else if (inesc) {
  if (in == '[') {
    inesc    = FALSE;
    incsi    = TRUE;   /* found a CSI sequence */
    innum    = FALSE;  /* but not yet a valid number */
    negative = FALSE;
    counter  = 0;
    args[0]  = args[1]=args[2]=args[3]=args[4] = 1;
  } else if ((in >= ' ') && (in <= '/')) {
    /* ignore the ESC sequence contents */
  } else {
    inesc    = FALSE;  /* terminate the ESC sequence */
  }
} else if (in == 0x9B) {
```

```
    incsi    = TRUE;   /* found a CSI sequence */
    innum    = FALSE;  /* but not yet a valid number */
    negative = FALSE;
    counter  = 0;
    args[0]  = args[1]=args[2]=args[3]=args[4] = 1;
  } else if (in == 0x1B) {
    inesc    = TRUE;  /* found an ESC sequence */
  } /* Everything else is thrown away */
}

SetMode(file,0);
return success;
}
```

The above algorithm supports both 7-bit and 8-bit consoles and is aware of the 7-bit two-character equivalent of CSI.

Upon replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10.4 Releasing Console Resources

The ACTION_UNDISK_INFO packet releases any resources obtained by ACTION_DISK_INFO.

Table 109: ACTION_UNDISK_INFO

DosPacket Element	Value
dp_Type	ACTION_UNDISK_INFO (513)
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*, the packet needs to be issued through the DoPkt() function.

The purpose of this packet is to let the console know that the pointers to the window and the IORequest provided by ACTION_DISK_INFO are no longer needed and the console may close the window or release the IORequest if needed. This has the the practical consequence that AUTO windows can be closed again, and the console can also be iconified again.

To implement this packet, the console should keep a counter to track the number of times its resources have been provided to clients. An ACTION_DISK_INFO increments it, and ACTION_UNDISK_INFO decrements it. As long as the counter is non-zero, the window shall be open and the connection to the device implementing the console functionality shall be established. This includes that the window needs to be forced open on the first ACTION_DISK_INFO if it is closed, either by iconification or because it is an AUTO window that was closed by the user.

This packet does not take any arguments. Even though there is practically no reason why this packet could fail, the console handler shall set dp_Res1 to DOSTRUE and dp_Res2 to 0 on success. On an error, if such an error should be possible, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10.5 Stack a Line at the Top of the Output Buffer

The ACTION_STACK packet injects a line at the start of the output buffer of the console.

Table 110: ACTION_STACK

DosPacket Element	Value
dp_Type	ACTION_STACK (2002)
dp_Arg1	fh_Arg1 of a FileHandle
dp_Arg2	APTR to characters
dp_Arg3	Size of the buffer in bytes
dp_Res1	Number of characters stacked
dp_Res2	Error code

This packet is not exposed by the *dos.library*, it rather needs to be issued through the packet interface, e.g. DoPkt(). This packet injects a line at the end of the output buffer of the console. This buffer keeps all lines entered by the user, and lines injected by ACTION_STACK and ACTION_QUEUE. The number of lines in this output buffer can be obtained through ACTION_WAIT_CHAR which delivers the line count in dp_Res2.

Lines from this buffer are provided to clients on ACTION_READ packets that empty this buffer line by line. Thus, a line provided through this packet will be delivered to the next reading client, before any other buffered lines, but after user input.

Lines injected into the console output buffer are not echoed on the screen. Arexx uses this packet to employ the console as "external stack". This packet places a line at the top of this stack.

dp_Arg1 is a copy of the fh_Arg1 element of a FileHandle structure interfacing to the console.

dp_Arg2 is a C pointer (not a BPTR) to an array of characters to be injected into the output buffer of the console.

dp_Arg3 is the size of the buffer in characters.

Upon replying this packet, dp_Res1 shall be set to the number of characters that could be stacked in the output buffer of the console, or to -1 in case of failure. On success, dp_Res2 shall be set to 0, or to an error code on failure.

12.10.6 Queue a Line at the End of the Output Buffer

The ACTION_QUEUE packet injects a line at the end of the output buffer of the console.

Table 111: ACTION_QUEUE

DosPacket Element	Value
dp_Type	ACTION_QUEUE (2003)
dp_Arg1	fh_Arg1 of a FileHandle
dp_Arg2	APTR to characters
dp_Arg3	Size of the buffer in bytes
dp_Res1	Number of characters stacked
dp_Res2	Error code

This packet is not exposed by the *dos.library*, it rather needs to be issued through the packet interface, e.g. DoPkt(). This packet injects a line at the end of the output buffer of the console. This buffer keeps all lines entered by the user, and lines injected by ACTION_STACK and ACTION_QUEUE. The number of lines in this output buffer can be obtained through ACTION_WAIT_CHAR which delivers the line count in dp_Res2.

Lines from this buffer are provided to clients on ACTION_READ packets that empty this buffer line by line. Thus, a line provided through this packet will be delivered to a reading client after all other buffered lines have been read from the console, including user input.

Lines injected into the console output buffer are not echoed on the screen. ARexx uses this packet to employ the console as "external stack". This packet places a line at the end of this stack, i.e. queues them up.

dp_Arg1 is a copy of the fh_Arg1 element of a FileHandle structure interfacing to the console.

dp_Arg2 is a C pointer (not a BPTR) to an array of characters to be injected into the output buffer of the console.

dp_Arg3 is the size of the buffer in characters.

Upon replying this packet, dp_Res1 shall be set to the number of characters that could be stacked in the output buffer of the console, or to -1 in case of failure. On success, dp_Res2 shall be set to 0, or to an error code on failure.

12.10.7 Force Characters into the Input Buffer

The ACTION_FORCE packet injects characters into the keyboard input buffer of the console, as if the user typed them.

Table 112: ACTION_FORCE

DosPacket Element	Value
dp_Type	ACTION_QUEUE (2001)
dp_Arg1	fh_Arg1 of a FileHandle
dp_Arg2	APTR to characters
dp_Arg3	Size of the buffer in bytes
dp_Res1	Number of characters stacked
dp_Res2	Error code

This packet is not exposed by the *dos.library*, it rather needs to be issued through the packet interface, e.g. DoPkt(). This packet injects characters into the input buffer of the console, at the same place keystrokes are recorded. Such characters are echoed on the console, or executed in case of control sequences. E.g, this packet allows also to move the cursor left or right, or erase the current line by emulating the corresponding keystrokes.

Note that the keyboard input buffer is different from the line output buffer; lines entering the console through ACTION_FORCE qualify as keyboard input[14]. The main user of this packet is the Shell which injects TAB-expanded file names into the console. The ConClip command also uses this packet to insert the paths of icons dropped on the console.

dp_Arg1 is a copy of the fh_Arg1 element of a FileHandle structure interfacing to the console.

dp_Arg2 is a C pointer (not a BPTR) to an array of characters to be injected into the output buffer of the console.

dp_Arg3 is the size of the buffer in characters.

Upon replying this packet, dp_Res1 shall be set to the number of characters that could be injected into the keyboard input buffer of the console, or to -1 in case of failure. On success, dp_Res2 shall be set to 0, or to an error code on failure.

12.10.8 Drop all Stacked and Queued Lines in the Output Buffer

The ACTION_DROP packet disposes all lines that have been injected into the output buffer and thus reverts any ACTION_STACK and ACTION_QUEUE packets.

[14] Even though the V40 CON-Handler already supported this packet, it is there implemented incorrectly and does not impact the keyboard buffer. This was fixed in V47.

Table 113: ACTION_DROP

DosPacket Element	Value
dp_Type	ACTION_DROP (2004)
dp_Arg1	fh_Arg1 of a FileHandle
dp_Arg2	0
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*, it rather needs to be issued through the packet interface, e.g. DoPkt(). This packet removes any lines injected by ACTION_STACK and ACTION_QUEUE from the output buffer of the console and thus reverts their results. User keyboard inputs remain unaffected. Thus, this packet resets the line stack in the console. The intended purpose this packet is ARexx which, however, at the time of writing does not use it.

dp_Arg1 is a copy of the fh_Arg1 element of a FileHandle structure interfacing to the console.

dp_Arg2 shall be 0. This element is reserved for future use as a priority and shall be zero-initialized for forewards compatibility.

Upon replying this packet, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0 on success. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10.9 Bring the Console Window to the Foreground

The ACTION_SHOWWINDOW activates the console window, if it is open, and brings it to the foreground.

Table 114: ACTION_SHOWWINDOW

DosPacket Element	Value
dp_Type	ACTION_SHOWWINDOW (506)
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*. The packet interface, e.g. DoPkt(), is required to issue it. This packet brings the window associated console, should such a window exist, to foreground and activates it. If the console is a serial console or the console window is closed or iconified, no activity is performed and no error is reported. Unlike ACTION_DISK_INFO, it will not force the window open if the window is currently closed.

The primary user of this packet is the ConClip tool which sends this packet to make the window visible whenever an icon is dropped on it. The path of the icon is injected into the keyboard input buffer with ACTION_FORCE.

Upon replying this packet, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0 on success. On error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.10.10 Change the Target Port to Receive BREAK signals

The ACTION_CHANGE_SIGNAL packet sets a MsgPort to whose task the console sends break signals generated by the Ctrl-C to Ctrl-F key combinations.

Table 115: ACTION_CHANGE_SIGNAL

DosPacket Element	Value
dp_Type	ACTION_CHANGE_SIGNAL (995)
dp_Arg1	fh_Arg1 of a FileHandle
dp_Arg2	APTR to MsgPort structure
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library*. The packet interface, e.g. `DoPkt()`, is required to issue it. It defines a port to which break signals as generated by the `Ctrl-C` to `Cltr-F` key combinations are send. Actually, this *break port* is not used as a target of a message, but only its `mp_Task` element to which the signal is send.

Despite this port, the console also sends break signals to the last process that issued an `ACTION_WRITE` request, provided this process is not a Shell process running in background. To avoid race conditions of applications forgetting to reset this port, the console resets this port whenever an `ACTION_CLOSE` is received from the *break port*, i.e. whenever the process to which this port belongs closes its connection to the console. Furthermore, the console also tests the validity of the *break port* by testing whether its `mp_Task` field is known to the exec scheduler.

This packet is, for example, used when a Shell is started in a console window, or a `NewShell` command creates another in an already open console window. In such a case, the `System()` function as part of the *dos.library* sends a `ACTION_CHANGE_SIGNAL` to the console to ensure that break signals are received by the new Shell just started, and not the Shell then running in the background. This packet is *not* send for executables placed by the `Run` command in the background. Even though `Run` also goes through `System()`, it uses different parameters.

`dp_Arg1` is a copy of the `fh_Arg1` element of a `FileHandle` structure that is opened to the console.

`dp_Arg2` is a pointer to a `MsgPort` to whose task break signals will be send. In addition to this port, the console also sends break signals to the last issuer of an `ACTION_WRITE` packet, provided it is not a background Shell process.

Before replying this packet, `dp_Res1` shall be set to `DOSTRUE` on success, and `dp_Res2` the port that was previously installed as *break port*, or `NULL` if no such port was configured. On error, `dp_Res1` shall be set to `DOSFALSE` and `dp_Res2` to an error code.

12.11 Packets Controlling the Handler in Total

The packets in this section impacts file systems and handlers at global. They do not apply to a particular volume.

12.11.1 Adjusting the File System Cache

The `ACTION_MORE_CACHE` packet increases or decreases the number of file system buffers.

Table 116: `ACTION_MORE_CACHE`

DosPacket Element	Value
`dp_Type`	`ACTION_MORE_CACHE (18)`
`dp_Arg1`	Buffer increment
`dp_Res1`	Boolean result code
`dp_Res2`	Buffer count or error code

This packet implements the `AddBuffers()` function of the *dos.library*. In increases or decreases the number of buffers the file system may use to cache data. How exactly a file system uses these buffers and how large these buffers are is specific to the file system implementation and its configuration.

The FFS uses these buffers to temporary store administrative data such as blocks describing the directory structure or information on which blocks a particular file occupies on disk. Providing additional buffers (within limits) can thus help to improve the performance of a file system by reducting the number of times the underlying device needs to be contacted. The FFS also uses these buffers to store payload data if the source or destination buffer of the client is not reachable by the exec device driver. The de_Mask element of the environment vector is used to determine such incompatibilities, see section 8.1.3.

dp_Arg1 is the increment (or decrement, if negative) of the number of buffers to be added (or removed) from the pool of cache buffers of the file system. File systems may clamp this value to guarantee that a minimum number of buffers are available, or limit the buffer count to a useful value.

If this packet succeeds, the file system shall set dp_Res1 to DOSTRUE and dp_Res2 to the number of buffers currently allocated. Thus, the current buffer count can obtained by sending this packet with dp_Arg1 set to 0. On an error, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.11.2 Inhibiting the File System

The ACTION_INHIBIT packet disables or enables access of the *file system* to the underlying device; once file system access is disabled, application programs such as Format may access the underlying device directly.

Table 117: ACTION_INHIBIT

DosPacket Element	Value
dp_Type	ACTION_INHIBIT (31)
dp_Arg1	Inhibit flag
dp_Res1	Boolean result code
dp_Res2	Error code

This packet implements the Inhibit() function of the *dos.library*. An inhibited file system is blocked from accessing its underlying medium for read and write access, with the exception of ACTION_FORMAT and ACTION_SERIALIZE_DISK which remain operational. An inhibited file system changes its disk type as reported by ACTION_INFO or ACTION_DISK_INFO in the InfoData structure to 'BUSY', see table 19 in section 5.2.4.

Once the file system is unhibited again, it shall perform a validation of the medium, as if the medium was been re-inserted. This is necessary because an application bypassing the file system to access it directly could have changeed the file system structure, the volume name or the date, or may have even written a completely new file system structure to it. This check thus implies checking the flavour of the file system, e.g. the DosType for the FFS, and potentially creating and inserting a DosList entry into the *device list* representing the volume. Thus, first inhbiting and uninhibiting a file system is equivalent to simulating a medium change; in fact, the DiskChange command enforces a medium change by first inhibiting and then unhibiting the file system.

id_Arg1 is a boolean indicator that defines whether the file system shall be inhibited or uninhibited. If dp_Arg1 is DOSFALSE, the file system is unhibited and a file structure check shall be performed. In all other cases, the file system shall be inhibited and, with the exception of ACTION_FORMAT, should refrain from accessing the medium, partition or device.

Before replying this packet, dp_Res1 shall be set to a boolean success indicator. On success, it shall be set to DOSTRUE and dp_Res2 shall be set to 0. On failure, dp_Res1 shall be set to DOSFALSE and dp_Res2 to an error code.

12.11.3 Check if a Handler is a File System

The ACTION_IS_FILESYSTEM tests whether a handler is a file system.

Table 118: ACTION_IS_FILESYSTEM

DosPacket Element	Value
dp_Type	ACTION_IS_FILESYSTEM (1027)
dp_Res1	Boolean result code
dp_Res2	Buffer count or error code

This packet implements the IsFileSystem() function of the *dos.library* and tests whether a particular handler provide sufficient services to operate as a *file system*. A file system shall be able to access multiple separate files, shall be able to support locks and shall also be able to examine directories. A file system may be either a flat or a hierarchical file system, i.e. a file system is not required to support multiple directories on a storage medium, device or partition.

This packet does not take any arguments. It shall set dp_Res1 to DOSTRUE and dp_Res2 to 0 in case the handler qualifies as a file system. In case the handler supports this packet but does not implement a file system, it shall set dp_Res1 to DOSFALSE and dp_Res2 to 0.

If the handler sets dp_Res1 to DOSFALSE and dp_Res2 to ERROR_ACTION_NOT_KNOWN, then this is an indication that the handler cannot interpret this particular packet. If this secondary result code is identified by the IsFileSystem() function, it falls back to a heuristic for determining whether a handler is a file system: It uses Lock(":",SHARED_ACCESS), i.e. ACTION_LOCATE_OBJECT on the file system root. If such a lock can be obtained, then this heuristic assumes that the handler is, in fact, a file system.

12.11.4 Write out all Pending Modifications

The ACTION_FLUSH packet instructs the file system to write all pending or cached modifications out to disk[15].

Table 119: ACTION_FLUSH

DosPacket Element	Value
dp_Type	ACTION_FLUSH (27)
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed by the *dos.library* and thus can only be send manually through the packet interface, e.g. DoPkt(). File systems may cache writes in order to improve their performance, and may defer any write operations an arbitrary amount of time. This packet instructs the file system to write out all modifications immediately.

This packet shall not be replied before all changes have been written and, if applicable, the drive motor has been turned off. However, FFS versions of V40 and before replied ACTION_FLUSH immediately and thus only established a write barrier. This was fixed in V43.

Even though it is unclear how clients could make use of the result code, file systems should set dp_Res1 to DOSTRUE and dp_Res2 to 0 on success[16]. In case of error, file systems should set dp_Res1 to DOSFALSE and dp_Res2 to an error code.

12.11.5 Shutdown a Handler

The packet ACTION_DIE requests a file system or handler to unmount its volumes and terminate.

[15] Users of unixoid systems may consider this as the AmigaDOS equivalent of sync.

[16] The official reference [1] only states that dp_Res1 shall be set to DOSTRUE. This is probably what most AmigaDOS file systems implement, though the value of unconditionally indicating success is questionable.

Table 120: ACTION_DIE

DosPacket Element	Value
dp_Type	ACTION_DIE (5)
dp_Res1	Boolean result code
dp_Res2	Error code

This packet is not exposed through the *dos.library*; rather, the packet needs to be send through the packet interface, i.e. through DoPkt(). This packet requests the file system to release all resources, set the dol_Task elements of the DosList structures in the *device list* to NULL, and then terminate the process.

A file system or handler may not be able to terminate itself if some files are still open or some locks have not yet been unlocked. In such a case, this packet should fail with an error by setting dp_Res1 to DOSFALSE and dp_Res2 to an error code, e.g. ERROR_OBJECT_IN_USE. In case of success, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0.

After unmounting the volume and replying to this packet, the MsgPort(s) of this handler or file system used for packet communication may still contain packets that were submitted after ACTION_DIE has been received. In order to avoid a deadlock, the file system still needs to reply these packets, for example by the default result codes from table 61, see also section 12.2.3.

Some handlers do not initialize the dol_Task element of its DosList entrie(s) with an address of their port(s); file systems are typical examples. Such handlers shall terminate themselves without requiring an ACTION_DIE when the last lock and file have been released.

12.11.6 Do Nothing

The ACTION_NIL packet performs no activity.

Table 121: ACTION_NIL

DosPacket Element	Value
dp_Type	ACTION_NIL (0)
dp_Res1	DOSTRUE
dp_Res2	0

This packet is not exposed by the *dos.library*. It does not perform any activity. A handler or file system implementation should indicate success when replying this packet. Another reason why a seemingly ACTION_NIL packet can appear at a handler MsgPort is because the startup package has its dp_Type set to 0, too, and thus identifies itself also as ACTION_NIL. While ACTION_NIL does not provide any arguments, the startup package does, see section 12.2.1.

There is no reason why this packet should actually fail, unless a handler implements startup handling through the packet type ACTION_NIL. On success, dp_Res1 shall be set to DOSTRUE and dp_Res2 to 0. On an error dp_Res2 shall be set to DOSFALSE and dp_Res2 to an error code.

12.12 Handler Internal Packets

The packets in this section shall never be sent to a handler or filesystem as part of an application request. Instead, these packets are only used internally within the handler, and are rather an implementation trick to uniform the handler event processing. While regular DosPackets are carried by an exec message, the packets listed here are instead linked to an IORequest (see exec/io.h). This allows using a shared port, typically the pr_MsgPort of the handler process, for receiving replied IORequests and incoming packets as both appear as DosPackets.

The io_Message.mn_Node.ln_Name points to the DosPacket structure, and its dp_Link elements points back to qthe IORequest. Handlers dispatch these IORequest to exec devices asynchronously with SendIO(), and continue to process requests while the exec device is busy with the requested input or output command. Due to its linkage to a DosPacket, a completed IORequest is received by the packet interface of the handler as one of the packet types listed here.

12.12.1 Receive a Returning Read

The ACTION_READ_RETURN packet is part of a returning CMD_READ or similar read IORequest sent to an exec device and indicates that reading data completed.

Table 122: ACTION_READ_RETURN

DosPacket Element	Value
dp_Link	APTR to IORequest
dp_Type	ACTION_READ_RETURN (1001)

This packet does *not* constitute a request to the handler, it rather indicates that the IORequest pointed to by dp_Link completed and the requested data is now available. As such, this packet shall never be replied.

12.12.2 Receive a Returning Write

The ACTION_WRITE_RETURN packet is part of a returning CMD_WRITE or similar write IORequest sent to an exec device and indicates that writing data completed.

Table 123: ACTION_WRITE_RETURN

DosPacket Element	Value
dp_Link	APTR to IORequest
dp_Type	ACTION_WRITE_RETURN (1002)

This packet does *not* constitute a request to the handler, it rather indicates that the IORequest pointed to by dp_Link completed and writing data completed. As such, this packet shall never be replied.

12.12.3 Receive a Returning Timer Request

The ACTION_TIMER packet is part of a returning TR_ADDREQUEST, a timer.device request to wait for a time period.

Table 124: ACTION_TIMER

DosPacket Element	Value
dp_Link	APTR to IORequest
dp_Type	ACTION_TIMER (30)

This packet does *not* constitute a request to the handler, it rather indicates that the IORequest pointed to by dp_Link completed and the requested time span passed. As such, this packet shall never be replied. The FFS uses this packet to turn off the drive motor after the last read or write operation, and interactive handlers such as the console use it to implement ACTION_WAIT_CHAR.

12.13 The CON-Handler

The CON-Handler implements the console of AmigaDOS. It not only serves the graphical console, but also the serial console. The AUX-Handler is only a minimal wrapper that locates the CON-Handler in the ROM and then initates the CON-Handler with a suitable startup packet. Therefore, it serves the `CON:`, `RAW:` and `AUX:` device.

Quite similar to file systems, the CON-Handler does not implement all of its functionality itself. It rather depends on services of exec devices. For the graphical console, it creates an intuition window and initializes the `console.device` to run within. For the serial console, i.e. `AUX:`, it operates on top of the `serial.device`, but can be made to use any other interface device with proper mount parameters.

12.13.1 CON-Handler Path for Graphical Consoles

The path through which a stream to the CON-Handler is opened determines for the graphical console the size, position and features of the window the console appears within; for the serial console, it defines connection parameters such as the baud rate and the parity. The path for the graphical console accessed through `CON:`, and for `RAW:` likewise are as follows:

```
CON:<left>/<top>/<width>/<height>/<title>[/<options>]
```

The `<left>` parameter determines the left edge of the window within which the console shall appear; it is measured in pixels. If this parameter is not present or negative, intuition is instructed to pick a default. This is usually under the cursor position.

The `<top>` parameter is the top edge of the window, also measured in pixels. If this parameter is not present or negative, intuition is instructed to pick a default.

The `<width>` parameter is the width of the window, including all window decorations. If this is not present or negative, the handler instructs intuition to pick a default. This is typically the width of the screen. If no parameters are present at all, i.e. the path is just `CON:`, the width of the window is set to 640 pixels for legacy reasons.

The `<height>` parameter is the height of the window, including all window decorations. If this parameter is not present, the window height is set to 100 pixels for legacy reasons. If this parameter is negative, the window height will be the height of the screen.

The `<title>` parameter is the string that is put into the drag bar of the console window to create. To insert the forward slash ("`/`") into the string, it is escaped with a backslash, i.e. "`\/`" creates a single forwards slash that does not act as a path separator[17], the backslash is escaped by itself, i.e. "`\\`" creates a single backslash in the title.

All following path components configure options for the graphical terminal; multiple of these parameters may be combined, separated by a forwards slash ("`/`") from each other:

`CLOSE` adds a close gadget to the window. Pressing on it creates an end-of-file indication on the next attempt to read data from the console, similar to the key combination Ctrl+\.

`NOCLOSE` is the negative form of the above option and removes a potentially added close gadget from the window.

`AUTO` delays opening the window to the point where an attempt is made to read data from the console or write data into the console. Up to that point the console remains closed. If neither read requests nor write requests are pending, the close gadget will also close the window without queuing an end-of-file; the window will pop-open again as soon as input or output requests appear. Unfortunately, an `ACTION_DISK_INFO` will lock the window open, see section 12.10.3 for alternatives to this packet or how to regain the `AUTO` feature.

[17] Given the overall syntax of AmigaDOS, the asterisk $\star$ would have been a more logical choice.

`WAIT` delays closing the window after every file handle to the console has been closed. With this flag, the window stays open until the close gadget has been pressed, even if no client is connected to the terminal anymore to receive input or perform output.

`SMART` enforces smart refresh of the window. If this is enabled, more RAM is required, but it is not necessary to re-render the contents of the console window if it is made visible behind another window. In most cases, this makes little difference and only increases the RAM footprint.

`SIMPLE` enforces simple refresh of the window. If hidden window contents are made visible again they will be reprinted. This does usually not cost a lot of time, saves RAM and is also the default.

`INACTIVE` prevents that the window is receiving automatically the input focus when it is opened. The user has to click into it to type in the console.

`BACKDROP` instructs intuition to place the window behind all other windows on a screen. This works best in conjuction with `NOBORDER`, an empty window title, the `NOSIZE`, `NODRAG` and `NODEPTH` option and a console redirected to a public screen. If the window is made as large as the screen, the result will create a full-screen console.

`NOBORDER` removes the window decorations; if a title is present, the drag bar will still appear. Thus, this option is ideally combined with an empty title string.

`NOSIZE` removes the size gadget of the console on the top right edge of the window and thus creates a fixed-size window.

`NODRAG` removes the dragbar at the top of the window and makes the window non-movable. A potential application is to create a non-movable console as screen background.

`WINDOW` instructs the console to hijack an already open window and place the console within this window. This window will also be closed if the console closes. The address of the `Window` structure is provided in hexadecimal behind the parameter, optionally separated by spaces, e.g. `WINDOW 200AFC0`. An optional “0x” string may appear upfront the hexadecimal window address to indicate the base. This parameter replaces a legacy startup mechanism by which the console could also be placed into an already opened window.

`SCREEN` provides a name of a public screen on which the console shall appear instead of the workbench. The public screen name follows, optionally separated by spaces, e.g. `SCREEN myProgram.1`. If the screen name is `*`, then the frontmost public screen will be used as host for the console.

`ALT` provides alternative window dimensions and placement to which the window can be toggled by the top-left zoom gadget of the window. The alternative window placement provides left edge, top edge, width and height, similar to the main window placement, though numerical arguments are separated by comma (“`,`”) and not by the forwards slash. This alternate placement shall follow directly behind the `ALT` keyword, e.g. `ALT 0,0,320,200`.

`ICONIFY` equips the window with an iconfication gadget. This requires the `ConCip` program running in order to have an icon available for the console. If the iconification gadget is pressed, this icon will appear on the workbench, and the window will disappear. The window will be forced open when a incoming read or write request requires a window to read from or write data into. Similar to the `AUTO` option, windows will loose the ability to become iconified if a program requests the window pointer through `ACTION_DISK_INFO`, see again section 12.10.3 for details.

12.13.2 CON-Handler Path for Serial Consoles

If the console is a serial console, e.g. mounted as `AUX:` handler, another set of parameters becomes available that configures the serial connection; if the console is run on any other than the `serial.device` through mount parameters, this device shall support the `SDCMD_SETPARAMS` command through which these path parameters are installed.

```
AUX:<baud>/<control>[/<options>]
```

baud defines the baud rate of the serial console, e.g. 9600. If this parameter is not provided, it is taken from the BAUD mount option, and if that is not provided, the settings come from the serial preferences.

control defines the number of data bits, the parity and the number of stop bits, all concatenated into a string of 3 characters. The number of data bits is a digit between "1" and "8" and does not include the parity bit. The parity is either "N" for no parity, "E" for even and "O" for odd parity, or "M" for mark and "S" for space parity. The number of stop bits is either the digit "0", "1" or "2". A rather typical setting is 8N1, i.e. 8 data bits, no parity, one stop bit. This is also the configuration within which the performance of the serial.device is optimal. If this parameter is not present, it is taken (with identical encoding) from the CONTROL parameter of the mount list, and if it is not present there, from the serial preferences editor.

As for the graphical console, several optional parameters follow:

RAW forces the console into the (non-cooked) raw mode within which input characters are not echoed and no line buffering takes place. The same can be reached with the mount parameter STARTUP=1.

UNIT defines the unit of the device over which the connection shall be made if multiple units exist. The unit follows the keyword as decimal number, optionally separated by spaces, e.g. UNIT 1. The unit can also be configured through the mount list UNIT keyword.

AUTO indicates that the serial connection shall not be opened immediately, but only after the first attempt is made to write data through it or to read data from it. This works similar to the AUTO keyword for the graphical console.

WAIT indicates that the serial connection stays open even after every file handle to the console was closed. To shut down the serial connection, an ASCII FS character = Hex 0x1c shall be send by the user. This character is created on the Amiga keyboard with Ctrl+\. This also mirrors the WAIT keyword of the graphical console.

12.13.3 CON-Handler Line Buffer Modes

In addition to the window or serial parameters communicated to the path, the console is also configured through the SetMode() function, see section 4.10.3 and table 12. This mode sets the buffer mode of the console, regardless of the device the console runs on. In particular, SetMode() allows to convert a CON: window into a RAW: window, create an equivalent of a RAW: handler from an AUX: connection.

The buffer mode 0 corresponds to a regular CON: window and also to the AUX: console. In this so called *cooked mode*, the console echoes every keystroke on the window, and provides line editing functionalities such as cursor movements. Only when the user presses RETURN, an entire line of data enters the output buffer, and there becomes available for an ACTION_READ.

One particular difference between the V47 console and previous versions its predecessors is that the console no longer offers a history. Rather, the history functions have been moved to the Shell using the medium mode corresponding to buffer mode 2 described below.

In the cooked mode, and also in the medium mode, the CON-Handler interprets the following keystrokes:

Table 125: Cooked Keyboard Sequences

Keystroke	Function
Cursor left	Move left one character
Cursor right	Move right one character
Cursor up	Do nothing*
Cursor down	Do nothing*
Shift+cursor up	Do nothing*
Shift+cusor down	Do nothing*
Shift+cursor left	Move to the start of line
Shift+cursor right	Move to the end of line

Shift+cursor up	Move to the start of line*
Shift+cursor down	Erase line*
TAB	Inserts a TAB control code*
Shift+TAB	Do nothing*
Ctrl+a	Move to the start of line
Ctrl+b	Erase entire line
Ctrl+c	Sends signal 12
Ctrl+d	Sends signal 13
Ctrl+e	Sends signal 14
Ctrl+f	Sends signal 15
Ctrl+x	Erase entire line
Cltr+k	Kill characters into yank buffer
Cltr+q	Resume output
Ctrl+s	Suspend output
Ctrl+r	Do nothing*
Ctrl+u	Delete beginning of line
Cltr+w	Delete word
Cltr+y	Paste characters from yank buffer
Ctrl+z	Move to end of line
Ctrl+\	Signal an end-of-file
Backspace	Delete character upfront cursor
Del	Delete character under cursor
* Interpreted differently in medium mode, see table 126	

As seen in the table, some keystrokes operate differently in the medium mode; in that mode, they request a particular function from the shell by sending a "TAB Report" CSI sequence.

The "yank buffer" keeps characters that have been cut out with Ctrl+k. Its contents can be reinserted into the console with Ctrl+y. It operates independently of the clipboard and is local to each console window.

The buffer mode 1 corresponds to a `RAW:` window and is denoted the *raw mode*. In this mode, every keystroke becomes available to client programs as it enters the output buffer immediately. Cursor movements thus become available as CSI sequences. In this mode, the console does not echo user input. The CSI sequences are those defined by the `console.device`, resp. the current keymap of the device.

The buffer mode 2 is not available under a device name, even though one could in principle create a suitable mount list for it. The mode is reserved for the shell and forewards TAB-Expansion and history functions to the shell. While the console again provides line editing features and echoes most keys on the screen, some keyboard sequences create immediate output through a "TAB Report" CSI sequence that enters the output buffer immediately. These sequences are interpreted by the Shell and trigger there corresponding functions, such as expanding a pattern or working through the command history. A TAB Report sequence looks as follows:

```
CSI <m>;<s>;<c>U <line>
```

Here CSI is the ANSI "control sequence introducer", which has the byte value 0x9b. The <m> value is a decimal number that identifies the keystroke and also the function the Shell is requested to perform. Such functions browse in the history or expand a file name pattern. The Shell re-inserts the result of such a function back into the console with an ACTION_FORCE packet, see section 12.10.7.

The parameters <s> and <c> provide the length of the current line input buffer of the console the user is editing, and the (1-based, i.e. cursor at the left edge corresponds to <c> = 1) cursor position within this buffer.

The `U` is a literal character and identifies this sequence as TAB-Report. `<line>` is a copy of the current line that is edited by the user. For many sequences, this input is used as a template the shell to perform the requested action, e.g. for a TAB-expansion, it provides the entire input, though the command line argument within which the cursor is positioned is used to generate a wildcard the Shell uses to find possible candidates for its expansion.

The keystrokes that trigger such TAB Report sequences, along with their purpose, are as follows:

Table 126: Medium Mode CSI Sequences

Keystroke	Sequence
Cursor up	`<U>`=2, move upwards in the history
Cursor down	`<U>`=3, move downwards in the history
Shift+cursor up	`<U>`=4, search history upwards
Shift+cursor down	`<U>`=5, search history downwards
Ctrl+r	`<U>`=6 ,search history upwards, partial pattern
Ctrl+b	`<U>`=10,rewind history
TAB	`<U>`=12,iterate forwards through expansion
Shift+TAB	`<U>`=13,iterate backwards through expansion

The only difference between the cases `<U>`=6 and `<U>`=4 is that the former only uses the line input buffer up to the cursor position as search pattern and ignores everything past it.

12.13.4 CON-Handler Startup Parameters

In addition to the window or serial parameters communicated to the path, the console is also configurd through the handler startup mechanism. It provides defaults for the serial console, but also define the line buffer mode of the console described in the previous section.

The mount parameters for `CON:` and `RAW:` are hard-coded into the Kickstart ROM, though the mountlist for `AUX:` is available in the `DEVS:DosDrivers` directory and can be altered there; however, users can create custom mount lists for additional devices with custom mount parameters.

The handler startup mechanism is described in section 12.2.1, and in particular, `dp_Arg2` of the startup packet is a copy of the `dol_Startup` entry of the `DosList` created from the mount list; details on this mechanism are described in section 8.1.2.

The following table specifies the values of `dol_Startup` the CON-Handler recognizes:

Table 127: CON-Handler Startup Code

`dol_Startup`	Description
< 0	RAW: raw mode, within a window pointed to by `dp_Arg1`
0	CON: cooked mode, create a new window
1	RAW: raw mode, create a new window
2	CON: medium mode, create a new window
3	RAW: reserved for future extensions
BPTR with bit 30 cleared	raw mode open on a device specified by a FileSysStartupMsg
BPTR with bit 30 set	cooked mode open on a device specified by a FileSysStartupMsg

The values 0 to 3 configure the line buffer mode and are correspond to the buffer mode selected through `SetMode()`. The buffer mode 3 is currently not used and reserved for future extensions.

The case of a negative `dol_Startup` value is a legacy startup mechanism of the console. In this confguration, `dp_Arg1` of the startup packet (see section **??**) is not a BPTR to a path as usual, but instead a pointer (not a BPTR) to an intuition `Window` structure; the CON-Handler then creates a graphical console within this window. It is quite hard to make practical use of this startup mechanism and thus it is discouraged, but [10] provides example code how to trigger it. A better mechanism to redirect a console to a particular window is the `WINDOW` argument of the command path which is described in section 12.13.1.

In all other cases, `dol_Startup` is a BPTR to a `FileSysStartupMsg` described in more detail in section 8.1.2. The `fssm_Device` and `fssm_Unit` elements of this structure provide a device and unit the console shall run on. The `AUX:` handler uses this mechanism to create a `FileSysStartupMsg` to the CON-Handler which points to the `serial.device` unit 0, but also accepts custom mount parameters to mount it on other devices through the `EHandler` mount parameter. The `Device` parameter of the mount list is then extracted, and forwarded to the CON-Handler through a startup packet. Thus, a console can be generated on either type of device provided it supports `CMD_WRITE` to write data out and `CMD_READ` to receive keystrokes.

As BPTRs are upshifted by two bits to gain a regular pointer, the otherwise unused bit 30 of the BPTR is used for mode selection. If this bit is 1, the console will be a cooked console with line buffer, and if this bit is 0, the console is raw.

To make the `Mount` command create a `DosList` corresponding to the latter case, the CON-Handler needs to be mounted as `EHANDLER`. The following is an example mountlist providing a serial console on a custom serial hardware:

```
EHandler = CON-Handler
Device   = duart.device
Unit     = 0
Baud     = 9600
Control  = "8N1"
```

The very same mountlist can be used with the AUX-Handler; if it is mounted as an extended handler, it will just take its mount parameters and forwards them to the CON-Handler. If mounted with the (regular) `HANDLER` keyword in the mountlist, it will create a `FileSysStartupMsg` corresponding to the `serial.device` and provide this to the CON-Handler. The AUX-Handler is therefore rather minimal.

12.14 The Port-Handler

The Port-Handler is responsible for the `PAR:`, `SER:` and `PRT:` devices and thus represents the Amiga hardware interfaces as AmigaDOS devices. Clearly, `PAR:` interfaces to the `parallel.device`, `PRT:` to the `printer.device` and `SER:` to the `serial.device`. The difference between `SER:` and `AUX:` is that the former processes raw streams of bytes transmitted over a serial connection, whereas `AUX:` provides line buffering and line editing capabilities and thus implements a console.

12.14.1 Port-Handler Path

Access to the Port-Handler is configurable through the path following the device name. The path looks as follows:

```
SER:[<options>]
```

The following keywords in `options` exist, where options are separated by a forwards slash ("/") from each other.

`BAUD` sets the baud rate, which is only relevant for serial connections. It specifies the number of bits per second transmitted over a serial connection. If this parameter is not present, the default from the serial preferences is used. Optionally, this parameter may be introduced with the keyword `BAUD` which shall be separated from the decimal baud rate by spaces or an equals sign, e.g. `BAUD 9600`. Clearly, this parameter is only used by `SER:`.

control specifies additional parameters of the serial connection such as number of data bits, parity and number of stop bits, represented as 3 letter string. The string follows the same convention used for the AUX: terminal. The first digit is between "1" and "8", specifying the data bits, the second letter the parity, which is either N, E, O, M or S, indicating no parity, even or odd parity, or mark or space parity. The last digit is the number of stop bits and is a digit between "0" and "2".

A typical control string is 8N1 indicating 8 data bits, no parity and 1 stop bit, corresponding to the fastest possible console. Optinally, this parameter may be introduced with the keyword CONTROL which shall be separated from the control string by spaces or an equals-sign, e.g. CONTROL 8N1.

If this parameter is not present, the default from the serial preferences is used. Obviously, this parameter is only used by SER: and ignored otherwise.

TRANSPARENT is a boolean switch that, if present, indicates that CSI sequences written over this device shall not be translated to the configured printer, but shall rather be send directly to the printer. By default, the PRT: device uses the AmigaDOS defined CSI sequences that are device independent. This option is only used by the PRT: device and ignored otherwise.

RAW is a boolean switch that, if present, disables translation of the AmigaDOS newline-character 0x0a to 0x0a 0x0c pairs, i.e. a line feed followed by carriage return. This switch only applies to the PRT: device and is not used otherwise.

UNIT takes a numeric argument and provides the device unit that will be opened. This makes most sense if the Port-Handler is not mounted on the standard exec devices, but a custom device is provided through the DEVICE keyword of a custom mountlist. The unit number is represented as decimal number separated from the keyword by spaces or an equals-sign, e.g. UNIT 1. This option is operational regardless of the underlying device.

NOWAIT is boolean switch that, if present, avoids blocking when reading from a serial connection. If no data is available at the serial port, a connection configured with NOWAIT will report an end-of-file condition. Otherwise, such a stream would block until data is available. This option is only supported for serial connections.

Another possibility to implement non-blocking reading from the serial port is to use WaitForChar() which is also supported by the Port-Handler. It blocks until either the specified timeout is reached, or input data is available on the port.

12.14.2 Port-Handler Startup

The Port-Handler is also configurable through a mountlist, though mount parameters for PAR:, SER: and PRT: are hard-coded within the Kickstart ROM. However, users may create custom mountlists and mount the handler under a custom name.

As for all handlers, it is customized through dol_Startup, transmitted in dp_Arg2 in the handler startup packet. The following values are recognized:

Table 128: Port Handler Startup Code

dol_Startup	**Description**
0	SER: serial output through the serial.device
1	PAR: parallel output through the parallel.device
2	PRT: printer output through the printer.device
BPTR	serial output with parameters from the FileSysStartupMsg

The values 0 to 2 represent the standard handlers SER:, PAR: and PRT: mounted by the kickstart. They can be recreated by a STARTUP=<n> entry in a mountlist. For these options, the standard Amiga device names for the serial, parallel and printer interface is used.

The last option allows to customize the target exec device to run on. In this case, dol_Startup is a BPTR to a FileSysStartupMsg described in section 8.1.2. To make the Mount command create a suitable DosList entry, EHANDLER keyword is used, and a DEVICE and UNIT option can be provided. If the mountlist includes in addition a BAUD value, that is used as default value for the baud rate, which can be overridden by the Port-Handler path described in the previous section. The CONTROL parameter in the mountlist, if present, also control sthe serial settings. An example mountlist would look as follows:

```
EHandler = Port-Handler
Device   = duart.device
Unit     = 1
Baud     = 19200
Control  = "8N1"
```

12.15 The Queue-Handler

The Queue-Handler provides inter-process communication on the basis of AmigaDOS file handles. It is used by the Shell to implement pipes; they collect the output of one command and provide it as input to another, without requiring to store the entire output. The reading end of a pipe blocks as long as no data becomes available at the writing end, and the writing end blocks if the reading end is not able to consume data fast enough. If the reading end closes the pipe, the Queue-Handler attempts to abort the writing end.

Even though the Queue-Handler is disk-based, it is already mounted by the Kickstart-ROM as PIPE:, though additional instances under other device names can be mounted through the user.

12.15.1 Queue-Handler Path

Pipes are created and identified by a unique name; reading and writing ends of the same name are connected together. The name itself does not matter as long as it uniquely identifies the pipe; the Shell constructs a pipe name from the process indicator and a second unique number that is incremented for each pipe used. The packet ACTION_FINDINPUT opens the reading end, and ACTION_FINDOUTPUT the writing end. The third open mode, ACTION_FINDUPDATE is not supported.

The empty name establishes a special case. It identifies a pipe that is already open as standard input or standard output of a process. In case a pipe is openend without a name, the Queue-Handler checks whether the standard input or standard output of the client process is already open to a pipe, and if so, this end is reused. This allows constructions such as

```
list | type PIPE: hex
```

where the reading end of the pipe is explicitly addressed by an empty pipe name as it is already established by the Shell as standard input of the type command. It is necessary here because the command line syntax of type does not include provisions to read from its input stream.

The pipe path may follow by options configuring the pipe, thus the complete path specification is as follows:

```
PIPE:name[/quantumsize[/buffercount]]
```

The quantumsize is the size of a block the Queue-Handler uses to buffer intermediate data. Written data is is queued up until a buffer is full or the writing end is closed, and the full block is then made available to the reading end. This minimizes the communication overhead as the reading process does not need to wake up for every single byte. The default quantum size is 1024 bytes.

The buffercount configures the number of buffers the Queue-Handler makes available to the writing end. If all buffers are full without being retrieved by the reading end, the writing end blocks. This avoids that a fast writing process floods the memory of the system. The special value of 0 indicates that system memory may be filled up to a safety margin of 64K. The default buffer count is 8, i.e. at most 8K of data can be waiting in a pipe.

12.15.2 Queue-Handler Startup

The Queue-Handler can also be configured through its startup packet. For this, `dol_Startup` in its `DosList` entry shall be a BPTR to a `FileSysStartupMsg` as specified in section 8.1.2. The device and unit found there are irrelevant, though the environment vector in `fssm_Environ` discussed in section 8.1.3 contains some relevant entries.

`de_SizeBlock` set the size of the Quantum, and thus corresponds to the default of the first optional argument in the path.

`de_NumBuffers` sets the number of such buffers for each pipe and corresponds to the default of the second optional argument of the path.

The Kickstart ROM does not provide a startup value and thus mounts the Queue handler with its defaults parameters. However, within a custom mountlist, they can be provided as follows:

```
EHandler        = Queue-Handler
BlockSize       = 1024
Buffers         = 8
```

The `BlockSize` keyword sets the quantum size, and the `Buffers` keyword the number of quantum buffers.

12.16 The RAM-Handler

The RAM-Handler is a ROM-based file system that places its data in available RAM of the system. It implements almost all of the file system packets listed in sections 12.3 and following, with the exception of record locking. The RAM-Handler provides one extended feature, namely external links, also explaned in section 6.4. Such a link points to a target outside of the RAM disk; while such objects are initially empty, their contents will be made accessible by copying the objects within the link target to the RAM disk.

This feature is used within AmigaDOS to realize the `ENV:` assign which contains the system preferences. This allows to save RAM by only keeping those files in `RAM:` that are actually accessed.

The RAM handler does not interpret any arguments in its startup packet and cannot be configured through it.

12.17 The Fast File System

The Fast File System (FFS) is the standard Amiga file system and as such included in the ROM. However, the bootstrap code of Amiga hostadapters are typically able to load an updated version of this (and other) file systems from the *rigid disk block* of the boot disk and make it available to the system. The *System-Startup* module will make such updated version then also available for all other devices.

The same code serves multiple flavours of the file system that differ in the structure and organization of on disk. Table 28 in section 8.1.3 provides an overview on the available flavours.

As standard file system, the FFS supports all file-system relevant packets listed from section 12.3 onwards with the exclusion of packets specific to interactive handlers listed in section 12.10, and the `ACTION_SET_OWNER` packet which remains exclusive to multi-user network file systems. The FFS does support record locking, soft- and hard links and notification requests. External links remain currently exclusive to the RAM-Handler and are neither supported. Latest versions of the FFS can also be shut down by `ACTION_DIE` and thus be unmounted.

12.17.1 Configuring the FFS

The FFS is configured through multiple sources. First of all, the DosList, the FileSysStartupMsg pointed to by this structure, and the environment vector in the latter. Section 8.1 provides a list of the configurable options and the corresponding entries in the mountlist.

In some situations, however, the FFS will override the parameters found in the above sources, and therefore parameters from the mountlist. In case the device name is either "trackdisk.device" or "carddisk.device", the FFS will instead request the disk geometry from the underlying exec device by a TD_GETGEOMETRY when validating an available medium. The same logic can also be enabled for all other devices by the mountlist parameter SUPERFLOPPY, which corresponds to the ENVF_SUPERFLOPPY flag in the de_Interleave element of the environment vector. This flag, along with the environment vector is defined in the file dos/filehandler.h and also introduced in section 8.1.3.

Upon detecting device parameters, data from the device provided DriveGeometry structure documented in devices/trackdisk.h are copied into the environment vector of the file system. The following algorithm is used to adjust the data in the environment vector:

```
void AdjustEnv(struct DosEnvec *env,
               const struct DriveGeometry *dg) {
     env->de_SizeBlock      = dg->SectorSize >> 2;
     env->de_HighCyl        = dg->dg_Cylinders - 1;
     env->de_Surfaces       = dg->dg_Heads;
     env->de_BlocksPerTrack = dg->dg_TrackSectors;
}
```

All other entries of the environment vector remain untouched. The right-shift for the sector size is necessary because the environment vector measures it in long-words rather than bytes as provided by the drive geometry, and dg_Cylinders is a count, whereas de_HighCyl is an inclusive upper bound. In particular, dg_BufMemType is not copied over, and therefore de_BufMemType shall be setup though the mountlist or the rigid disk block. Ideally, of course, any memory type should be supported and this workaround should not be necessary.

The number of blocks kept in the file system cache is read from de_NumBuffers in the environment vector, but ACTION_MORE_CACHE can be used to adjust this parameter anytime.

12.17.2 The Boot Block

The FFS flavour is initially read from de_DosType element of the environment vector, see section 8.1.3. However, the initial choice is overridden either by formatting (initializing) a volume, or during the (quick) validation that is triggered if a volume becomes available to the FFS.

During formatting, the flavour is taken from dp_Arg2 of the ACTION_FORMAT packet. If dp_Arg2 is none of known FFS flavours from table 28, the currently active flavour remains in force and is used to initialize the disk structure. If the FFS did not adjust its flavour from accessing a previous volume, this remains the value from de_DosType.

During disk insertion, or if a volume becomes accessible to the FFS by other means such as mounting it or uninhibiting a volume through ACTION_INHIBIT, the FFS reads the flavour from the first long-word of the *boot block*, even if this block is placed on a hard-disk and not actually used for booting. It is found at sector

$$\texttt{BootBlock} = \texttt{de\_LowCyl} \times \texttt{de\_Surfaces} \times \texttt{de\_BlocksPerTrack}$$

of the device. Note that this is not necessarily the sector 0 if the volume is a partition of a hard-disk. The remaining data of the boot block is not used by the FFS but, at least for floppy disks, for bootblock booting which is described in mored detail in [8].

12.17.3 Disk Keys and Sectors

Except for the boot block, the FFS does not address sectors through their physical sector number, but due to their *key*, which addresses data on disk relative to the start of the partition in blocks, and not sectors. The relation between the physical sector S and the key K is given by the following equation:

$$S = \texttt{de\_LowCyl} \times \texttt{de\_Surfaces} \times \texttt{de\_BlocksPerTrack} + K \times \texttt{de\_SectorPerBlock}$$

In particular, the boot block has therefore the key 0. The sector number is used directly for the "direct SCSI" transfer which is enabled by the `ENVF_SCSIDIRECT` flag in the `de_Interleave` element of the environment vector.

For the default trackdisk-like transfer, exec device drivers expect a byte offset instead of a sector, which is computed by multiplying S by `de_SizeBlock` $\times 4$. The additional factor of 4 is because `de_SizeBlock` is in units of long-words and not a byte count.

Even though `de_SizeBlock` and `de_SectorPerBlock` could be any number, the FFS, and likely many other file systems, only accept powers of two here. Thus, any multiplication or division by these numbers are easily implementable as shifts.

12.17.4 The Root Block

The Root Block represents the root directory of a volume and contains the creation date and the volume name. It is placed in the middle of the volume at key

$$\left\lfloor \frac{\texttt{de\_Reserved} + \left\lfloor \frac{(\texttt{de\_HighCyl} - \texttt{de\_LowCyl} + 1) \times \texttt{de\_Surfaces} \times \texttt{de\_BlocksPerTrack}}{\texttt{de\_SectorPerBlock}} \right\rfloor - 1}{2} \right\rfloor$$

Note that the element name `de_BlocksPerTrack` is actually misleading as this the size of a track in (physical) sectors and not in (logical) blocks or keys. The division by `de_SectorPerBlock` computes from the sector index a key. The brackets $\lfloor \cdot \rfloor$ indiciate rounding down to the next integer.

The structure of the root block is as follows:

Table 129: FFS Root Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`0`	header key, always 0 in root
2	`0`	highest sequence number, always 0 in root
3	`HTSize`	entries in the hash table = Block size - 56
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6...	`Hash`	hash chains for objects in the root
L-50	`BMFlag`	-1 if Bitmap is valid
L-49...	`BMKeys`	keys of the bitmap
L-24	`BMExt`	key of the bitmap extension block
L-23	`Days`	timestamp of last directory change
L-22	`Mins`	
L-21	`Ticks`	
L-20...	`Name`	volume name as BSTR
L-12	`0`	reserved for future use
L-11	`0`	reserved for future use

L-10	`Days`	timestamp of last volume change
L-9	`Mins`	
L-8	`Ticks`	
L-7	`Days`	volume creation time
L-6	`Mins`	
L-5	`Ticks`	
L-4	`0`	reserved for future use
L-3	`0`	reserved for future use
L-2	`DCache`	key of directory cache block if used
L-1	`SecType`	shall be 1, this is the BPCL constant ST.ROOT

Each entry in the above table is 4 bytes, i.e. one long-word large. As the FFS supports multiple block sizes, some elements of this structure are placed relative to the end of the block. Such element are indicated in the above table as $L - x$ where L is the block size in long works, i.e.

$$L = \texttt{de\_SizeBlock} \times \texttt{de\_SectorPerBlock}$$

The notation ... indicates that the corresponding element extends over multiple long-words. In particular, the list of hash-keys is a variably sized number of long-words large, it always extends over $L - 56$ longs.

The block type is indicated by `Type` and `SecType`. For the root block, these elements shall be 2 and 1, respectively.

`HTSize` is the number of hash keys stored in the root block. The FFS stores in the root block $L - 56$ hash keys, from offset 6 to $L - 51$.

`Chksum` is a checksum over the block. Its value is chosen such that the long-word sum over all long-words, including the checksum, is zero.

`Hash` stores the hash-chain of all objects in the root directory. The FFS computes for each file system object a *hash key* that is derived from its name. As multiple objects can have the same hash and thus hash conflicts may arise, all objects of the same hash are kept in a singly linked list. The head of each list is kept in the `Hash` array.

How the FFS computes the hash key from the name depends on the FFS flavour. The following algorithm computes the hash key from the object name, represented as a BSTR, i.e. the first character is the length of the string:

```
ULONG ComputeHash(UBYTE *name)
{
ULONG size = *name++; /* String size, this is a BSTR */
ULONG hash = size;    /* Initial hash is string length */

  while(size) {
   ULONG c = *name++;
   /* Is this an international flavour? */
   if (isInternational) {
    if (c != 0xf7 && ((c >= 0xe0 && c<= 0xfe) ||
                      (c >= 0x61 && c <= 0x7a))) {
     c -= 0x20; /* make upper case */
    }
   } else if (c >= 0x61 && c <= 0x7a) {
     c -= 0x20; /* make upper case */
   }
```

```
   hash = (hash * 13 + c) & 0x7ff;
  }
  return hash % HTSize;
}
```

In the above, `HTSize` is the value of the element of the same name in the disk root block. As seen from the code, the non-international versions of the FFS only convert the ASCII characters between 'a' and 'z' to upper case, whereas the international version performs this conversion also for all characters in the latin-1 character set. The FFS *does not* use the *utility.library* for the upper-case conversion and thus hashing does not depend on the selected locale. However, it depends on the latin-1 encoding and will not map characters correctly for many other encodings. Latin-15 only replaces the international currency symbol with the Euro-sign which is outside the range of characters that are converted to upper case. It therefore also works correctly for this encoding.

`BMFlag` is `DOSTRUE` in case the bitmap is valid. If the quick validation on disk insertion finds that this element is 0, then the disk status is set to non-validated and the bitmap is recomputed through a complete disk scan. The bitmap keeps information on which blocks of the volume are allocated and which are free.

`BMKeys` is an array containing the keys of the bitmap blocks. How many bitmap blocks are required to represent the bitmap depends on the size of the volume and the size of a bitmap block. Unused keys remain 0.

`BMExt` is the key of a bitmap extension block if the above bitmap array is not sufficient to represent all blocks of the volume.

The elements at offsets $L-23$ to $L-21$ form a `DateStamp` structure as specified in section 3. The date and time there indicate the last change within the root directory.

`Name` is the volume name, encoded as BSTR; the first character is therefore the size of the name. This element is 8 long-words large and thus limits the volume name to 30 characters (one extra character is reserved, even though there would be sufficient space for 31 characters).

The elements at offsets $L-10$ to $L-8$ form a `DateStamp` structure that is updated on every change of the volume.

The elements at offsets $L-7$ to $L-5$ are also a `DateStamp` structure that represent the time and date at which the volume was initialized. The packet `ACTION_SERIALIZE_DISK` updates this date, too, but it remains otherwise unchanged.

`DCache` is the key of the directory cache list of blocks. It is only used for the flavours of the FFS that utilize such a cache.

Unlike user directories, the root block lacks a list of hard-links that points to it. This has the consequence that the FFS does not allow to create hard-links to the root directory of a volume.

12.17.5 The User Directory Block

The user header block represents a sub-directory of the volume root, or another user directory. It is enqueued in one of the hash-chains of the root block or its parent user directory block. This block exists in multiple variants, depending on the flavour of the FFS. Table 131 applies to all FFS variants except the long-file variants `DOS\06` and `DOS\07`.

Table 130: FFS User Header Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`0`	reserved for future use
3	`0`	reserved for future use

4	0	reserved for future use
5	Chksum	LW sum over block is 0
6...	Hash	hash chains for objects in the directory
L-50	0	reserved for future use
L-49	Owner	reserved for owner ID
L-48	PrtBits	protection bits as in section 6.1
L-47	0	reserved for future use
L-46...	Comment	directory comment as BSTR
L-26...	0	reserved for future use
L-23	Days	timestamp of last directory change
L-22	Mins	
L-21	Ticks	
L-20...	Name	directory name as BSTR
L-12	NameX1	name extension for DOS\08
L-11	0	reserved for future use
L-10	BckLink	key of first hard-link to this object
L-9...	NameX2	name extension for DOS\08
L-4	NxtHash	next key of the same hash
L-3	Parent	key of the parent directory
L-2	DCache	key of directory cache block if used
L-1	SecType	shall be 2, setthis is the BCPL constant ST.USERDIR

`Type` is the primary type of this block. It is always 2, which is the BCPL constant `T.SHORT`

`OwnKey` is the key of this object, i.e. it is the block number of this block itself.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Hash` contains for user directories all the hash keys of the file system objects contained within.

`OwnerID` is reserved for the owner ID of this directory that can be set with `ACTION_SET_OWNER`. As the FFS has no means to validate the directory owner, this element does not bear any practical meaning.

`PrtBits` are the protection bits of this directory. The FFS actually ignores the protection bits on the directory, but stores the value here anyhow.

`Comment` contains a potential comment for this directory. The comment is represented as a BSTR with the comment length in the first character. There is room for 80 bytes, i.e. the maximum comment size is 79 characters.

The elements at offset $L-23$ to $L-21$ form a `DateStamp` structure that identifies the timestamp of the last change of this directory.

`Name` is the name of this directory encoded as BSTR with the name length in the first byte; even though 32 bytes are available here, the FFS reserves one character, thus limiting the maximal directory name size to 30.

`NameX1` and `NameX2` are name extensions that are used by the `DOS\08` flavour of the FFS. They add additional 24 bytes of storage for the directory name. Again, one character is reserved, limiting the maximum directory name size for this variant to 54. The directory name extends from `Name`, then overflows into `NameX1` and from there to `NameX2`.

`BckLink` is the key of the first hard link to this directory. The link of this key replaces the original directory header block in case the directory itself is deleted, and then is converted from a link to a directory.

`NxtHash` is the key of the next object using the same hash key as this directory itself.

`Parent` is the key of the parent directory, or the key of the root block in case this directory is directly in the volume root.

`DCache` is the key of the first directory cache block. This key is only used for FFS flavours with directory caching enabled. Otherwise, it stays 0.

`SecType` along with `Type` identifies the type of this block. The value of this element shall be 2, identifying this as a user directory block.

For the long file-name enabled flavours of the FFS, namely `DOS\06` and `DOS\07`, this block looks somewhat different:

Table 131: Long-Filename FFS Directory User Header Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`0`	reserved for future use
3	`0`	reserved for future use
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6…	`Hash`	hash chains for objects in the directory
L-50	`0`	reserved for future use
L-49	`Owner`	reserved for owner ID
L-48	`PrtBits`	protection bits as in section 6.1
L-47	`0`	reserved for future use
L-46…	`NaC`	name and comment BSTR
L-18	`CmtBlk`	key of comment block if necessary
L-17	`0`	reserved for future use
L-16	`0`	reserved for future use
L-15	`Days`	timestamp of last directory change
L-14	`Mins`	
L-13	`Ticks`	
L-12	`0`	reserved for future use
L-11	`0`	reserved for future use
L-10	`BckLink`	key of first hard-link to this object
L-9…	`0`	reserved for future use
L-4	`NxtHash`	next key of the same hash
L-3	`Parent`	key of the parent directory
L-2	`DCache`	key of directory cache block if used
L-1	`SecType`	shall be 2, setthis is the BCPL constant ST.USERDIR

Compared to the regular directory header block, the time stamp of the last modification date is relocated to offsets $L - 15$ and following, and the name and comment field is replaced by a new field at offset $L - 46$.

`NaC` contains both the file name and file comment as two BSTRs, directly placed next to each other. The file name comes first, followed by the comment. This element is capable of storing 112 bytes, but the FFS reserves one byte making in total 110 bytes available. In case the comment is too long and cannot be placed in this element, an additional comment block is created keeping only the comment, and this element then only keeps the file name.

`CmtBlk` is the key of the comment block, keeping the file comment if the `NaC` element is too short. If no comment block is needed, this element is 0.

12.17.6 The File Header Block

The file header block represents a file in a directory or the volume root. It is enqueued in one of the hash-chains of the root block or its parent user directory block. This block exists in multiple variants, depending on the flavour of the FFS. Table 132 applies to all FFS variants except the long-file variants `DOS\06` and `DOS\07`.

Table 132: FFS File Header Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`BlkCnt`	number of data block keys included
3	`0`	reserved for future use
4	`Data1st`	first data block of the file
5	`Chksum`	LW sum over block is 0
6...	`DataBlk`	first $L - 56$ data blocks of the file
L-50	`0`	reserved for future use
L-49	`Owner`	reserved for owner ID
L-48	`PrtBits`	protection bits as in section 6.1
L-47	`Size`	size of the file in bytes
L-46...	`Comment`	file comment as BSTR
L-26...	`0`	reserved for future use
L-23	`Days`	timestamp of last file change
L-22	`Mins`	
L-21	`Ticks`	
L-20...	`Name`	directory name as BSTR
L-12	`NameX1`	name extension for `DOS\08`
L-11	`0`	reserved for future use
L-10	`BckLink`	key of first hard-link to this object
L-9...	`NameX2`	name extension for `DOS\08`
L-4	`NxtHash`	next key of the same hash
L-3	`Parent`	key of the parent directory
L-2	`FileExt`	key of first file extension block
L-1	`SecType`	shall be -3, this is the BCPL constant ST.FILE

`Type` is the primary type of this block. It is always 2, which is the BCPL constant `T.SHORT`

`OwnKey` is the key of this object, i.e. it is the block number of this block itself.

`BlkCnt` is the number of occupied data block keys included in this block. Due to the limited number of slots, this number is smaller or equal than $L - 56$.

`Data1st` is the key of the first data block of the file. This data block is actually made available twice, once here, and once again at offset $L - 49$. Probably the key at this offset was historically used for sequential access into the file, whereas the block list at offset $L - 6$ following were used for random access.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`DataBlk` is an array containing the first $L - 56$ data blocks of the file. The array is filled from its bottom-end, i.e. $L - 49$ contains the key of first data block, $L - 50$ the second key and so on. If this array overflows, additional blocks are in one or more file extension blocks chained at $L - 2$.

`OwnerID` is reserved for the owner ID of this file that can be set with `ACTION_SET_OWNER`. As the FFS has no means to validate the file owner, this element does not bear any practical meaning.

`PrtBits` are the protection bits of the file, encoded as in section 6.1. The four least-significant bits corresponding to the readable, writable, executable and deletable features are stored inverted, i.e. a bit being 0 indicates that the corresponding feature is available. This is the same encoding as in the `FileInfoBlock` structure.

`Comment` contains a potential comment for this file. The comment is represented as a BSTR with the comment length in the first character. There is room for 80 bytes, i.e. the maximum comment size is 79 characters.

The elements at offset $L - 23$ to $L - 21$ form a `DateStamp` structure that identifies the timestamp of the last change of this file.

`Name` is the name of this file encoded as BSTR with the name length in the first byte; even though 32 bytes are available here, the FFS reserves one character, thus limiting the maximal file name size to 30 characters.

`NameX1` and `NameX2` are name extensions that are used by the `DOS\08` flavour of the FFS. They add additional 24 bytes of storage for the file name. Again, one character is reserved, limiting the maximum file name size for this variant to 54. The file name extends from `Name`, then overflows into `NameX1` and from there to `NameX2`.

`BckLink` is the key of the first hard link to this file. The link of this key replaces the original directory header block in case the file itself is deleted, and then is converted from a link to a file.

`NxtHash` is the key of the next object using the same hash key as this directory itself.

`Parent` is the key of the directory containing this file, or the key of the root block in case this file is directly in the volume root.

`FileExt` is the key of the first file extension block. This key is only used if the file requires more than $L - 56$ blocks. Otherwise, it stays 0.

`SecType` along with `Type` identifies the type of this block. The value of this element shall be -3, identifying this as file header block.

For the long file-name enabled flavours of the FFS, namely `DOS\06` and `DOS\07`, this block looks somewhat different:

Table 133: Long-Filename FFS File Header Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`HighSeq`	total number of blocks occupied
3	`0`	reserved for future use
4	`Data1st`	first data block of the file
5	`Chksum`	LW sum over block is 0
6…	`DataBlk`	first $L - 56$ keys of data blocks
L-50	`0`	reserved for future use
L-49	`Owner`	reserved for owner ID
L-48	`PrtBits`	protection bits as in section 6.1
L-47	`0`	reserved for future use
L-46…	`NaC`	name and comment BSTR
L-18	`CmtBlk`	key of comment block if necessary
L-17	`0`	reserved for future use
L-16	`0`	reserved for future use
L-15	`Days`	timestamp of last file change
L-14	`Mins`	
L-13	`Ticks`	

L-12	`0`	reserved for future use
L-11	`0`	reserved for future use
L-10	`BckLink`	key of first hard-link to this object
L-9…	`0`	reserved for future use
L-4	`NxtHash`	next key of the same hash
L-3	`Parent`	key of the parent directory
L-2	`FileExt`	key of first file extension block
L-1	`SecType`	shall be 2, setthis is the BCPL constant ST.USERDIR

Compared to the regular file header block, the time stamp of the last modification date is relocated to offsets $L-15$ and following, and the name and comment field is replaced by a new field at offset $L-46$.

`NaC` contains both the file name and file comment as two BSTRs, directly placed next to each other. The file name comes first, followed by the comment. This element is capable of storing 112 bytes, but the FFS reserves one byte making in total 110 bytes available. In case the comment is too long and cannot be placed in this element, an additional comment block is created keeping only the comment, and this element then only keeps the file name.

`CmtBlk` is the key of the comment block, keeping the file comment if the `NaC` element is too short. If no comment block is needed, this element is 0.

12.17.7 The Soft- and Hard-Link Block

The soft- and hard-link block represent a soft-link or a hard-link to another file system object. Similar to the file header and user directory blocks, this block exists in two variants, depending on the flavour of the FFS. Table 134 applies to all FFS variants except the long-file variants `DOS\06` and `DOS\07`.

Table 134: FFS Link Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`0`	reserved for future use
3	`0`	reserved for future use
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6…	`Target`	link target for soft-links
L-50	`0`	reserved for future use
L-49	`Owner`	reserved for owner ID
L-48	`PrtBits`	protection bits as in section 6.1
L-47	`0`	reserved for future use
L-46…	`Comment`	link comment as BSTR
L-26…	`0`	reserved for future use
L-23	`Days`	timestamp of link creation
L-22	`Mins`	
L-21	`Ticks`	
L-20…	`Name`	link name as BSTR
L-12	`NameX1`	name extension for `DOS\08`
L-11	`Link`	key of link target for hard-links
L-10	`BckLink`	key of next hard-link to the same object
L-9…	`NameX2`	name extension for `DOS\08`
L-4	`NxtHash`	next key of the same hash

L-3	`Parent`	key of the parent directory
L-2	`0`	reserved for future use
L-1	`SecType`	identifies the type of the link

`Type` is the primary type of this block. It is always 2, which is the BCPL constant `T.SHORT`

`OwnKey` is the key of this object, i.e. it is the block number of this block itself.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Target` is the path of the link target for soft-links. This is stored as `NUL`-terminated C-string, not as BSTR[18]. The maximum path name that can be stored here is $(L-56)\times 4-1$ characters long. Unfortunately, all versions of the FFS currently do not check the maximum link name and damage the file system structure if this path is too long, though in a default floppy with 512 bytes per sector, this element leaves room for paths up to 287 characters.

`OwnerID` is reserved for the owner ID of this link that can be set with `ACTION_SET_OWNER`. As the FFS has no means to validate the link owner, this element does not bear any practical meaning.

`PrtBits` are the protection bits of the link, encoded as in section 6.1. However, the practical value of these protection bits is zero as locking a link provides a lock to the linked object, and thus the protection bits stored here are not actually checked and neither accessible, except by walking a directory through `ACTION_EXAMINE_NEXT` or `ACTION_EXAMINE_ALL`.

`Comment` contains a potential comment for this link. The comment is represented as a BSTR with the comment length in the first character. There is room for 80 bytes, i.e. the maximum comment size is 79 characters. Comments of links *can* be set with `ACTION_SET_COMMENT` as the FFS does not attempt to follow the link.

The elements at offset $L-23$ to $L-21$ form a `DateStamp` structure that identifies the timestamp of the creation of the link. For hard-links, this element bears no practical meaning as even an `ACTION_SET_DATE` will update the date of the link target and not the link itself. An attempt to change the date of a soft-link creates an `ERROR_IS_SOFT_LINK` and thus instructs the client of the FFS to rather redirect the request to the linked target. Thus, this date may potentially be seen when walking a directory, but it cannot be changed.

`Name` is the name of this file encoded as BSTR with the name length in the first byte; even though 32 bytes are available here, the FFS reserves one character, thus limiting the maximal file name size.

`NameX1` and `NameX2` are name extensions that are used by the `DOS\08` flavour of the FFS. They add additional 24 bytes of storage for the directory name. Again, one character is reserved, limiting the maximum name for this variant to 54. The link name extends from `Name`, then overflows into `NameX1` and from there to `NameX2`.

`Link` is the key of the file header or user directory key for hard-links. For soft-links, this element is not used and set to 0.

`BckLink` is the key to the next hard-link to the same link target, or 0 if there is no further hard-link to the same target. Thus, all links to the same target are chained through `BckLink`.

`NxtHash` is the key of the next object using the same hash key as this directory itself.

`Parent` is the key of the directory containing this link, or the key of the root block in case this file is directly in the volume root.

`SecType` along with `Type` identifies the type of this block. This can be either -4, corresponding to `ST.LINKFILE` for a hard-link to a file, or 4 (`ST.LINKDIR`) for a hard-link to a directory, or 3, corresponding to `ST.SOFTLINK` for soft-links.

[18] The information in [1] that this is a BSTR is incorrect

For the long file-name enabled flavours of the FFS, namely `DOS\06` and `DOS\07`, this block looks somewhat different:

Table 135: Long-Filename FFS Link Block

Long-word Offset	Content	Notes
0	`Type`	shall be 2, this is the BCPL constant T.SHORT
1	`OwnKey`	key of this block (self-reference)
2	`0`	reserved for future use
3	`0`	reserved for future use
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6...	`Target`	link target for soft-links
L-50	`0`	reserved for future use
L-49	`Owner`	reserved for owner ID
L-48	`PrtBits`	protection bits as in section 6.1
L-47	`0`	reserved for future use
L-46...	`NaC`	name and comment BSTR
L-18	`CmtBlk`	key of comment block if necessary
L-17	`0`	reserved for future use
L-16	`0`	reserved for future use
L-15	`Days`	timestamp of last directory change
L-14	`Mins`	
L-13	`Ticks`	
L-12	`0`	reserved for future use
L-11	`Link`	key of link target for hard-links
L-10	`BckLink`	key of next hard-link to the same object
L-9...	`0`	reserved for future use
L-4	`NxtHash`	next key of the same hash
L-3	`Parent`	key of the parent directory
L-2	`0`	reserved for future use
L-1	`SecType`	identifies the type of the link

Compared to the regular link block, the time stamp of the last modification date is relocated to offsets $L - 15$ and following, and the name and comment field is replaced by a new field at offset $L - 46$.

`NaC` contains both the link name and file comment as two BSTRs, directly placed next to each other. The link name comes first, followed by the comment. This element is capable of storing 112 bytes, but the FFS reserves one byte making in total 110 bytes available. In case the comment is too long and cannot be placed in this element, an additional comment block is created keeping only the comment, and this element then only keeps the file name.

`CmtBlk` is the key of the comment block, keeping the file comment if the `NaC` element is too short. If no comment block is needed, this element is 0.

12.17.8 The File Extension Block

The file extension block keeps keys of additional file data blocks in case the $L - 56$ keys in the file header block are not sufficient to keep all keys. It looks as follows:

Table 136: File Extension Block

Long-word Offset	Content	Notes

0	`Type`	shall be 16, this is the BCPL constant T.LIST
1	`OwnKey`	key of this block (self-reference)
2	`BlkCnt`	number of data block keys included
3	`0`	reserved for future use
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6...	`DataBlk`	next $L - 56$ keys of data blocks
L-50...	`0`	reserved for future use
L-3	`Parent`	key of the file header block
L-2	`NextExt`	key of next file extension block
L-1	`SecType`	shall be -3, this is the BPCL constant ST.FILE

`Type` is the primary type of this block. It is always 16, which is the BCPL constant `T.LIST`

`OwnKey` is the key of this block itself.

`BlkCnt` is the number of occupied data block keys included in this block. Due to the limited number of slots, this number is smaller or equal than $L - 56$.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`DataBlk` is an array containing the next $L - 56$ data blocks of the file. The array is filled from its bottom-end, i.e. $L - 49$ contains the key of first data block referenced in this extension block, $L - 50$ the second key and so on. If this array overflows, additional blocks are in another file extension block chained at $L - 2$.

`Parent` is the key of the file header block of the file whose data block keys are extended by this block.

`FileExt` is the key of the next file extension block if this block is not sufficient to keep all data block keys. Otherwise, it is 0.

`SecType` along with `Type` identifies the type of this block. The value of this element shall be -3, identifying this block as belonging to a file.

12.17.9 The Bitmap Extension Block

The bitmap extension block keeps the keys of additional bitmap blocks in case the number of bitmap keys in the root block (25, namely) are not sufficient. This block has the following structure:

Table 137: Bitmap Extension Block

Long-word Offset	Content	Notes
0...	`BMKeys`	additional $L - 1$ bitmap keys
L-1	`BMNext`	key of another bitmap extension block

`BMKeys` is an array of $L - 1$ keys, each of contains a bitmap for the subsequent part of the volume. The slots in this block are allocated top to bottom, with non-used entries set to 0.

`BMNext` is the key of another extension block if this extension block is not sufficient. It is 0 in case this is the last bitmap extension block.

12.17.10 The Comment Block

This block keeps a file comment for the long filename FFS flavours `DOS\06` and `DOS\07` in case the file header, user directory or link block does not provide sufficient room to keep both the file name and the file comment.

Table 138: Comment Block

Long-word Offset	Content	Notes
0	`Type`	shall be 64, this is T.COMMENT
1	`OwnKey`	key of this block (self-reference)
2	`Parent`	key of the header block
3	`0`	reserved for future use
4	`0`	reserved for future use
5	`Chksum`	LW sum over block is 0
6...	`Comment`	object comment as BSTR
26...	`0`	reserved for future use

`Type` identifies the type of this block. The value placed here shall be 64, corresponding to the constant T.COMMENT.

`OwnKey` is the key of this block itself.

`Parent` is the key of the file header, user directory or link block to which the comment in this block applies and which is extended by this block.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Comment` is the comment, stored as a BSTR with the first character containing its size. This element is 80 bytes large, sufficient for comments of 79 characters.

The remaining bytes of this block shall be 0 and remain available for future extension.

12.17.11 The Directory Cache Block

This block type is only used by the directory cache flavours of the FFS, namely `DOS\04` and `DOS\05`. It keeps, in a more compact form, the contents of directories. This block looks as follows:

Table 139: Directory Cache Block

Long-word Offset	Content	Notes
0	`Type`	shall be 33, this is T.DIRLIST
1	`OwnKey`	key of this block (self-reference)
2	`Parent`	key of the user directory block
3	`NumNtry`	number of entries in this block
4	`NextBlk`	key of the next directory cache block
5	`Chksum`	LW sum over block is 0
6...	`Entries`	Directory content (see below)

`Type` identifies the type of this block; the constant put here is actually `DIRLIST_KEY` = 32 or'd with the version of the directory cache data, which is currently 1.

`OwnKey` is the key of this block itself.

`Parent` is the key of the directory header block of the user directory cached here, or the key of the root block if this is the cache of the volume root directory.

`NumNtry` is the number of directory entries cached in this block. Each entry has a structure as indicated in table 140. Such entries cannot extend over block boundaries; if a new entry does not fit entirely into a block, another directory cache block is allocated. A directory cache block may also contain 0 entries as these blocks are never released. Thus, directory caches can grow very large, and they are only rebuild when the disk requires full validation.

`NextBlk` is the key of the next directory cache block for the same directory, or 0 in case this is the last block.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Entries` contains the payload data of the directory cache. It consists of zero or more entries of the following variably sized structure:

Table 140: Directory Cache Entry

Size	Content	Notes
32	`Key`	key of the referenced object
32	`Size`	size of the object in bytes
32	`PrtBits`	protection bits of the object
32	`Owner`	owner ID of the object
16	`Days`	timestamp of last change
16	`Mins`	
16	`Ticks`	
8	`SecType`	secondary type of the object
variable	`Name`	object name as BSTR
variable	`Comment`	object comment as BSTR
pad(16)	`padding`	padding to 16-bit boundary

The elements of this structure are as follows:

`Key` is the key of the file header block, the user directory block or the link block, depending on the file system object to which this entry belongs.

`Size` is the byte size of the object, or 0 for links and directories.

`PrtBits` are the protection bits as represented in the `FileInfoBlock` structure.

`Owner` is reserved for a 32-bit group and owner ID that can be set by the `ACTION_SET_OWNER` packet. However, as the FFS has no means to verify access rights to an object, the purpose of this field remains opaque.

`Days`, `Mins` and `Ticks` are the timestamp of the last time the corresponding object was modified and a copy from the corresponding header block provided by `Key`. However, unlike there, only 16 bits are available for each element. This is sufficient if the `DateStamp()` structure is normalized, i.e. each element is as small as possible.

`SecType` is a copy from the `SecType` element of the file, user directory or link block indexed by `Key`. All possible values can be represented by a signed byte and are thus abbreviated here in an 8-bit element.

`Name` is a copy of the `Name` element of the file, user directory or link, though only the minimal number of bytes are copied, i.e. $N+1$ bytes for a file name of size N. The first byte of `Name` is its length, i.e. it is a BSTR without `NUL`-termination.

`Comment` follows directly after the last byte of `Name` and is a copy of the `Comment` element of the file, user directory or link block; again, only the minimal amount of bytes are copied to the directory cache, i.e. the length byte and the comment itself. This forms again a BSTR, not a C string, and there is no `NUL`-termination.

`padding` is an optional padding byte to make the entire structure an even number of bytes large such that the key of the next directory entry is on an even address in memory.

The directory cache does not store the targets of hard-links or soft-links; that is, if the contents of a directory of a cache-enabled file system is listed, this information is gained from the regular directory structure.

Within a directory cache block, zero or more directory cache entries follow each other; their count is provided by the `NumNtry` element in the directory cache block. If the FFS has to delete entries from the directory, it moves entries within the current block upwards over the released entry. In worst case, no entries remain in a directory cache block. Such blocks are not released, but remain available to accept new entries.

While the directory cache increases the performance of listing directory contents, keeping the directory cache in sync with the regular directory structure requires additional overhead as directory cache blocks need to be allocated, filled, and entries be moved within the blocks.

12.17.12 The Data Block

Data blocks contain the payload data of files. It comes in two variants: The "OFS" variants of the FFS, namely `DOS\00`, `DOS\02`, `DOS\04` and `DOS\06` keep a lot of redundant information within the data block that makes the file system structure very robust against media corruption; however, this information needs to be stripped off before the payload data is delivered to the FFS client, these variants are very slow.

All remaining variants, including `DOS\08` only keep payload data in the data blocks. This enables the FFS to directly transmit data from the medium to the target buffer of the client if the `de_Mask` allows it. If the host adapter offers DMA, the CPU is not even involved in copying the data and thus these variants of the FFS are faster, though also less robust. However, modern media rarely corrupt data, unlike floppy disks, and therefore are generally recommended. The OFS flavours are therefore only useful for slow and unreliable data carriers.

The following table describes the structure of an OFS data block:

Table 141: OFS Data Block

Long-word Offset	Content	Notes
0	`Type`	shall be 8, this is T.DATA
1	`Header`	key of the file header
2	`SeqNum`	sequence number of this block
3	`Size`	data bytes in this block
4	`NxtBlk`	next data block of this file
5	`Chksum`	LW sum over block is 0
6...	`Data`	payload data

`Type` is the primary type of this block. It is always 8, which is the BCPL constant `T.DATA`

`Header` is the key of the file header block this file belongs to.

`SeqNum` is the sequential number of this block within the file. The first data block of the file has the sequential number 1, the next one"2 and so on.

`Size` is the number of valid bytes within this data block. Valid data does not necessarily extend to the end of the block.

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Data` is the actual payload data of the block. It consists of `Size` arbitrary bytes.

The FFS data block does not have any structure, it contains only payload data. This has the consequence that a disk scan, e.g. by a disk salvage tool, cannot safely identify whether a block carries administrational information of the disk, or is rather a data block that, by pure coincidence, reassembles an administration block of one of the types listed in this section. Various disk salvage tools fell into this pitfall identifying blocks as adminstration blocks that were, actually, data blocks allocated for a file.

12.17.13 The Bitmap Block

Bitmap blocks keep a bitmap — one bit per key — which keys are already occupied for administrational or payload data, and which keys are still free. Depending on the size of the volume, one or many bitmap blocks exist, sometimes even so many that bitmap extension blocks are needed as the 25 keys available in the root block.

The structure of a bitmap block is as follows:

Table 142: Bitmap Block

Long-word Offset	Content	Notes
0	`Chksum`	LW sum over block is 0
1...	`Bitmap`	bitmap of avaiable blocks

`Chksum` is the checksum over the entire block. It is chosen such that the long-word sum over the entire block, including this element, is zero.

`Bitmap` holds for every available key administrated by this bitmap a bit that indicates whether that key is available or not. If the bit is 1, the key is free, and if 0, the key is released.

Bits are addressed in groups of long-words such that the least-significant bit of each long-word corresponds to the lowest key and the most significant bit of a long-word to the highest key within this long-word. The least significant bit of the long-word at offset 1 of the first bitmap of a volume corresponds to the key `de_Reserved`, i.e. the reserved blocks at the start of a volume *are not* represented in the bitmap. As key 0 corresponds to the boot-block and this block keeps the flavour of the FFS, and potentially boot code, `de_Reserved` cannot be 0 as otherwise the FFS could allocate it as key, and thus overwrite parts of its administration information. While the FFS could, in principle, always reserve key 0 for such purpose, no such provisions are made.

Identifying whether a particular key is allocated is demonstrated by the following algorithm: It takes the number of long words per block (e.g. 128 for a standard floppy disk, i.e. 512 bytes per block), the number of reserved blocks, the key to investigate and the key of the root block. It assumes that `readKey()` brings the key provided by its argument to memory, and that this function returns a pointer to an array of `ULONG`s representing the block contents:

```
/* Bring key to memory */
ULONG *readKey(ULONG key);

/* Check whether a particular key is allocated */
LONG isKeyAllocated(ULONG longsperblock,ULONG reservedblocks,
                    ULONG key,ULONG rootkey)
{
ULONG  keysperbitmap;
ULONG  bitmap;
ULONG  keyinbitmap;
ULONG  longoffset;
ULONG *block;

  /* compute the number of keys per bitmap */
  keysperbitmap = (longsperblock - 1) * 32;
  /* compute the bitmap index in all bitmaps */
  bitmap        = (key - reservedblocks) / keysperbitmap;
  /* compute the key within the bitmap */
  keyinbitmap   = (key - reservedblocks) % keysperbitmap;
  /* compute the LW offset within the bitmap */
```

```
  longoffset    = keyinbitmap / 32 + 1;
  /* compute the bit within the long */
  bitinlong     = keyinbitmap % 32;
  /* read the root block */
  block         = readKey(rootkey);

  /* Check whether the bitmap is linked in the root
  ** block or not. The first 25 are
  */
  if (bitmap < 25) {
    /* Bring the proper keymap into memory */
    block = readKey(block[bitmap + BMKeys]);
  } else {
     LONG extension,keyoffset;
     /* Compute the extension block required,
     ** and key offset within the extension block
     ** to the bitmap block.
     */
     extension = (bitmap - 25) / (longsperblock - 1);
     keyoffset = (bitmap - 25) % (longsperblock - 1);
     /* read the first extension block */
     block     = readKey(block[BMExt]);
     /* Follow the link chain of extension
     ** blocks to find the right one
     */
     while(extension > 0) {
       block   = readKey(block[BMNext]);
       extension--;
     }
     /* Now read the right bitmap */
     block     = readKey(block[keyoffset]);
  }

  /* check the bit corresponding to the key */
  if (block[longoffset] & (1UL << bitinlong)) {
    return DOSTRUE; /* is allocated */
  } else {
    return DOSFALSE; /* is free */
  }
}
```

12.17.14 The Deleted Block

The FFS also mark unused administration blocks as deleted to ensure that a disk scan does not confuse them with a used block. This does not happen to data blocks.

Table 143: Deleted Block

Long-word Offset	Content	Notes
0	`Type`	shall be 1, this is T.DELETED
1...	`junk`	whatever remained here

This makes it particularly easy for disk salvage tools to identify which keys are actually still in active use and which have been scratched on purpose.

Chapter 13

The AmigaDOS Shell

The Shell is the command line interpreter of AmigaDOS and is a simple language of itself. User applications can use services of the shell by requesting it to interpet a shell script or launching a new shell in a user-provided console window, then interpreting commands entered by the user. The latter is called an *interactive* shell, the former is non-interactive.

The Shell is built into the ROM of the kickstart, even though AmigaDOS is flexible enough to allow custom shells and make them available to user applications. The Shell is also responsible for booting up the system by executing the `Startup-Sequence` script in the `S:` assign.

13.1 The Shell Syntax

The Shell reads commands along with its arguments line by line from the console or a script. Each line consists of at least one command upfront and its arguments, where the arguments amongst each other and the command are are separated by spaces. The command refers to a file within the *path*, a list of directories that can be adjusted by the user. It always contains the current directory and the `C:` assign, though additional directories can be added or removed with the `path` command any time.

The following sections describe the Shell syntax in detail. Even though it stems from the Tripos system, AmigaDOS added over the years features such as variable substitution, compound commands including pipes, backtick expansion and additional redirection operators.

13.1.1 Input/Output Redirection

Commands receive from the shell an input and output stream, and a console handler to which commands can refer by the special file name `*`. Optionally, they can be provided with an error stream through which diagnostic messages are printed. The shell allows redirecting or creating these streams by operators on the command line that shall also be separated by the spaces from the arguments and the command.

The shell supports the following redirection operators:

>*path* redirects the output of a command to a particular file, creating the file if it does not yet exist, or overwriting it if does.

>>*path* appends the output of a command to a file if the file already exists, or creates a the output file if it does not yet exist.

<*path* redirects the input of a command from an already existing file which must exist; otherwise, an error is indicated.

<<*ind* uses the current console or the shell script itself from which the command is run as input, line by line, until a line starting with `ind` is found. The indicator can be choosen arbitrarily. A typical choice is `EOF`. This avoids creating temporary files.

<>*path* redirects both the standard input and the standard output of the command to a path. The file must exist already, otherwise an error is indicated.

*>*path* redirects the error output of the command to the given path. If this path identifies an interactive stream (see section 4.6.1), such as a console, then the console process of the command is set to it as well. This will also redirect output of commands that prints errors to the * file that is contacted for this special file name.

*>>*path* appends the error output of a command to a file, or creates a new file for error output if it does not yet exist. If the target file is interactive, the console process of the command is also updated.

*<> creates a standard error stream and redirects it to the standard output. If none of the three above redirection operators are present, then (unlike in other operating systems) the command *does not* receive a standard error stream. What happens in such a case with error output is specific to the implementation of the command. The system error handling functions will still provide error output to the standard output as if an implicit *<> would be present.

Where the redirection is placed within a command line does typically not matter, e.g. wether it is directly following the command or placed at the end of the command line. There are, however, three exceptions the shell makes when parsing the command line:

For the `Alias` and `Run` command, redirections of the command itself shall be placed directly following the command. The same applies if the shell variable `oldredirect` is set to `on`. In the above cases, redirections placed at a later point of the command line will become part of the command line arguments. That is, for `Run`, the command run in back will redirect its streams rather than the streams of the `Run` command, and for `Alias`, the redirection will become part of the alias and will become active when the alias is expanded. The `oldredirect` variable will do likewise for all other commands, except that they will typically not interpret redirection requests in a useful way and will instead take the angle brackets as regular arguments.

13.1.2 Compound Commands

The Shell allows combining multiple commands on the command line, then forming *compound* commands. The following operators go *between* commands such that the last argument of the first command is directly to the left of such an operator, and the next argument start to the right. As for arguments, these operators need to be separated by arguments and commands with blank spaces:

`|` The vertical bar creates a pipe such that the standard output of the command to the left becomes the standard input of the command to its right. As some commands require an explicit file name they read data from, or they write data to, the pipe itself can be explicitly addressed through the `PIPE:` file name, both for the reading and the writing end. Pipes require the Queue-Handler, which is mounted by the Kickstart during the system startup.

`||` Two vertical bars concatenate the output of two commands together into one common stream which can then redirected to a common output[1].

`&&` Sequences two commands, first executes the one to the left, and if its return value is below the `FailAt` value, continues to execute the command to its right.

[1]This syntax is different from the `bash` operator that looks similar.

The brackets "(" and ")" group commands and execute the grouped command in a separate process in a sub-shell. For this, both the opening and closing bracket shall be separated by commands and arguments by at least a single space as otherwise the shell interprets them as part of the command or arguments. This provides logical grouping of commands into compound commands.

13.1.3 Unary Shell Operators

In addition, the Shell recognizes two unary operators that do not stand between commands, but only at their end or at the end of the command line.

& The ampersand operator works similar to the `Run` command, it starts the command line within which it appears in background. The command will receive a new logical console, and its output and error streams will be redirected to this console, unless of course redirected explicitly to other files. Unfortunately, at this time, the ROM-based Console-Handler does not take advantage of this information and will simply merge the output of the process run back with that of the regular shell, though extended Console-Handlers use this information for job control and hold the output of the background process until made explicitly active.

+ The plus operator shall only appear at the end of a command line. If it is present, it injects a line-feed and the following line of the current input of the shell into the argument line of the command. It thus forms an argument string that consists of multiple lines. Only very few commands can actually process a line-feed as part of their argument line, most will ignore all characters behind the first line feed. One particular command that supports such argument lines is `Run`. It feeds its argument line unprocessed into a new non-interactive Shell as command stream, building it from a string using a technique similar to that explained in section 4.9.2. This sub-shell will thus receive a shell script as input which consists of multiple lines, and will execute the commands one after another.

13.1.4 Quoting and Escaping

To allow spaces and the above operators as parts of command names and arguments, e.g. to handle file names containing spaces, the Shell allows quoting. Blank spaces within double quotes ("`"`") become part of the argument, and are not interpreted by the shell. A quote only starts a quoted argument or command and is thus a functional element of the Shell if it is preceeded by a blank space, quotes *within* an otherwise unquoted argument are literals and stand for itself. A quote, however, does terminate a quoted string even if it is *not* followed by a blank space.

Within quotes, the Shell recognizes the asterisk "`*`" as an escape character, and only there. That is, the asterisk is a literal outside of double quotes; for example, it is the file name that identifies the current console, and as isolated character outside of quotes is not interpreted as escape character. The escape sequences supported by the Shell can be roughly broken up into two classes:

The first class, the legacy escape sequences, are recgonized and interpreted by the Shell, but the actual substitution of the escape sequence by the escaped character is left to the executing program and thus happen *outside* of the Shell:

`*N` The newline character, ASCII `0x0a`.

`*E` The ESC character, ASCII `0x1b`. There is no escape sequence for the CSI control character `0x9b`, but there is a 7-bit equivalent sequence all terminals support, namely `*E[`. The Shell does not establish this equivalence, but the console does.

`*"` The double quote; a double quote escaped as such does not terminate the quoted argument, but represents the quote itself as part of the argument.

`**` The asterisk itself.

As the Shell does not perform substitutions for the above sequences, they can also appear within the command line of the executed program, which is then responsible to perform the above substitutions correctly itself.

Proper interpretation and escape sequence substitution is ensured if the command uses the `ReadArgs()` or `ReadItem()` functions of the *dos.library*. This distribution of responsibilities has the inconvenient side effect that some third-party argument parsers, e.g. the ones provided by some C compilers, do not fully support the (admittedly unorthogonal) quotation and escaping rules of the Shell and thus do not deliver the expected results.

The second class of escape sequences is transparently substituted by the Shell, and thus no additional burden arises for the executed program to handle them[2]:

`*$` The literal dollar sign. The non-escaped dollar sign is a syntax element that indicates variable expansion, see section 13.1.5.

`` *` `` The literal backtick. The non-escaped backtick is a syntactical element for command output substitution, see section 13.1.6.

13.1.5 Variables and Variable Expansion

The AmigaDOS shell supports variables, both local to the shell and system-global, and expands variables as part of the regular command line parsing. A variable is indicated by a string starting with a dollar-sign ("`$`") and followed by alpha-numerical characters, i.e. 0-9, A-Z and a-z. Variable names are case-insensitive. The lst character that is outside this range terminates the variable name.

An equivalent but more flexible way of referring to a variable is by enclosing the variable name after the "`$`" sign in braces, i.e. "`$ {`*name*`}`" within which all other characters are allowed as components of the name as well.

Local variables are represented as entries in the `pr_LocalVars` list that is part of the process structure that represents the Shell, see section 10. When expanding variables, the Shell first checks there for a variable of a matching name. Only if that fails, the Shell tests for global variables. They are represented as files in the `ENV:` assign, which is typically an external link within the `RAM:` device copying elements from the `ENVARC:` assign. That is, local variables take priority over global variables.

Variables are substituted by the Shell *before* the resulting argument line is provided to the command, i.e. it is not necessary to expand variables within commands. The Shell does not attempt to generate pairs of double quotes to ensure that an expanded variable corresponds to a single argument. In fact, if a variable contains spaces and it is not included in double quotes, it will be seen in the expanded command line as multiple arguments. However, if a variable contains asterisks or double quotes, and the variable appears within double quotes, such asterisks or double quotes are escaped by the Shell with an (additional) asterik as escape character to ensure the resulting argument is represented appropriately.

If the variable name is started with "`$?`" instead of "`$`", then the Shell will check whether the variable exists or not, and instead of inserting its value, it will substitute the name by a 1 if the variable exists, or by a 0 if it does not exist, i.e. is undefined. If a variable reference starts with "`$??`", the Shell checks whether the variable exists as *global* variable, and if so, expands the entire reference to 1, otherwise to 0. Finally, if the variable reference starts with "`$!`", the variable may contain control characters such as line feeds that are included in the expansion. This binary expansion is only applicable to global variables, and as potential control characters are injected into the Shell tokenizer, it is necessary to include such binary expanded variables in double quotes. This ensures that the Shell escapes the control characters properly and makes them accessible to commands and their argument parser.

[2]This inconsistency can probably be only understood in historical contents as variable expansion and backtick substitution were later Amiga specific extensions to the original Tripos Shell.

13.1.6 Backtick Expansion

After variable expansion, the Shell checks the command line for backticks, ("`"). The characters within two terminating backticks form a command itself that is executed *before* interpretation of the containing command line continues, and the standard output of the enclosed commands is substituted for the command line within the backticks. As this output may include line feeds, these are furthermore substituted with blank spaces.

Note that the result of the executed commands may even contain functional syntax elements of the Shell, e.g. angle brackets as output of the command in backticks will become shell stream redirection operators which are then further interpreted by the shell. Needless to say, this can cause bad surprises.

The backticked sequence can itself be enclosed in double quotes. While this avoids the above surprise, it will necessarily only generate a single logical argument. Only in that case, namely a backticked sequence contained in another pair of double quotes, the Shell performs backwards escaping of asterisks and double quotes — same as for variable expansion. Each double quote or asterisk in the output of the quoted backticked command is escaped with (another) asterisk. This ensures that the resulting output string within double quotes retains its original value once interpreted through `ReadItem()` or `ReadArgs()`. Note that backwards-escaping does not take place without the additional layer of double quotes surrounding the backticked command, same as in variable substitution.

13.1.7 Command Execution

The Shell takes the first argument of each component of a compound command as a command to be executed. The Shell attempts to locate this command first on the list of resident commands, see section **??**, if the command is not quoted. If no match is found there, or the command is quoted, then the Shell keeps looking in the current directory, and if it is not found there, in all elements of the *path*, as set by the `path` command. If no matching file or directory is found there, the Shell finally looks into the `C:` directory[3].

Once a matching file system object has been found, the Shell attempts to "execute" it and for that checks its type and contents. If this "command" turns out to be a directory, the Shell performs an implicit change to this directory by inserting a `CD` command upfront, and then triggers iteratively command execution again with this replacement.

If the `s` protection bit is set, see section 6.1, the Shell assumes that command is actually a script. If this script starts with the magic character sequence "`/*`", it is assumed to be a Rexx script and an implicit `RX` command is prepended to the command line. If the script starts with the two-character sequence "`#!`" or "`;!`", then the remaining first line of the script file contains the path of the command interpreter which is injected into the Shell command line upfront the script file, and command interpretation starts again.

If none of the above conditions hold true and the `s` protection bit is set, the Shell assumes that this file is a Shell script prepends an `Execute` command upfront the script file name, thus interpretiing it through the Shell itself — more on the Execute command in section 13.1.8.

If the `e` protection bit is set indicating an executable file, the Shell attempts to load the file through `LoadSeg()` and, after performing input, output and error stream redirection, transfers program execution to this binary through `RunCommand()`, passing it the remaining command line arguments.

If the `e` protection bit is *not* set, but the shell variable `$VIEWER` is set, then the Shell attempts to check whether the system *datatypes.library* knows anything about the file. If so, the Shell prepends the contents of this variable to the command line and then continues execution. By setting `$VIEWER` to the system program `MultiView`, the Shell can therefore display any system-known datatype by just typing its name.

Finally, if none of the above conditions is true, or `LoadSeg()` failed, the Shell indicates an error that the file is not executable.

[3]Note that unlike under unixoid systems, the current directory is always an implicit first member of the path and cannot be removed from it.

13.1.8 The Execute Command

Unlike its name suggests, the `Execute` command does not actually perform interpretation Shell scripts and does not "execute" them directly. Instead, it performs argument substitution within an existing shell script through a simple interpreter, and then leaves the execution of the resulting script to the Shell itself by adjusting its command input stream. Thus, `Execute` does not actually execute anything, it rather prepares a script for execution through the Shell.

Argument substitution through `Execute` is controlled through additional syntax elements that are only implemented within `Execute` and that are unrelated, and even partially conflicting with the syntax elements of the Shell itself[4].

Argument substitution and its syntax elements are controlled through "pseudo"-commands that are only interpreted though `Execute` but removed before the resulting script is fed back into the Shell. All these pseudo-command start by default with a dot ("`.`"), though even this character can be changed through a pseudo-command. Such pseudo-commands controlling the `Execute` syntax elements shall be placed at the top of scripts as the `Execute` one-pass interpreter needs to see them first. If none of these pseudo-commands are present, `Execute` bypasses argument substitution and feeds the script unaltered into the Shell, without further processing.

The following pseudo-commands are supported by the `Execute`:

`.dot` takes a single argument and changes the character by which all (following) peudo-command start. This is by default a dot ("`.`"), and for the sake of simplicity, the following pseudo-commands are all shown with this default.

`.key` or `.k` defines which arguments a shell script takes. The argument is a `ReadArgs()` type template, defining the type of the command line arguments the shell script takes, and also the names of the formal parameters which will be substituted with the arguments provided during invokation of the script. Clearly, only a single `.key` pseudo-command shall be present within a script.

`.default` or `.def` defines defaults for arguments that are not present on the command line that invoked the script. It takes two arguments, first the key — the formal name of the parameter for which a default is to be provided — and the default value itself. Key and default value can be either separated by blank spaces, or an equals-sign "(=)". If no default value is provided, an empty string is used. One `.default` peudo-command can be provided per formal parameter. Another mechanism to provide default parameters is through the "`$`" character.

`.bra` defines the character that marks the beginning of a formal parameter that is to be substituted. A logical choice for such formal parameters would be to place them in local variables, and let the Shell perform the substitution[5]. However, `Execute` uses another syntax by which formal parameters are enclosed in pairs of characters, one starting the parameter, and one ending it. The initial character is by default the "<" sign, but the `.bra` pseudo-command can change it. As "<" also redirects the standard input of commands, this default is probably not a very wise choice, and it should be changed by `.bra`. Suggested alternatives are curly or square brackets.

`.ket` defines the character that marks the end of a formal parameter that is to be substituted. This is by default the ">" sign, i.e. formal parameters are enclosed in pairs of angle brackets. Unfortunately, this default is not a very wise choice as it makes output redirections in scripts impossible. To override this default, `.ket` should be used. A suggested alternative is a closing curly or square bracket.

`.dollar` or `.dol` defines the character that defines an alternative mechanism for providing defaults for formal parameters. Without this pseudo-command, this character is the dollar sign ("`$`") An optional "`$`" sign, or its replacement defined through this pseudo-command, separates the formal parameter from its default value. The formal name, the "`$`" sign, and its default are all enclosed in this order in the angle brackets, or the characters defined by `.bra` and `.ket`. Two "`$`" signs in angle brackets expand to the Shell

[4]This is probably another historical accident from Tripos legacy

[5]This is another historical accident, likely.

number and may be used as unique identifier, e.g. to generate a file name of a temporary file. Even though the "`$`" sign as syntax element for default value separation is only active within `.bra` and `.ket`, it is still a bad choice as it conflicts with the Shell syntax which uses the same character to indicate Shell variables.

Formal argument substitution otherwise follows the same path as variable expansion, and `Execute` attempts to preserve the original command line arguments as good as possible. That is, if a formal parameter is enclosed within double quotes in the script, asterisks and double quotes are escaped properly. If the formal parameter included spaces and thus was quoted on the command line, `Execute` generates suitable double quotes when substituting the formal parameter with its value, unless the formal parameter is already enclosed in double quotes. If a formal parameter takes multiple arguments, as indicated by a `/M` modifier in its template (see section **??**), then `Execute` also expands it as multiple parameter in scripts.

The generated script after substitution of formal parameters is placed into the `T:` assign, its name in `cli_CommandFile` and the command input of the invoking Shell, namely `cli_CurrentInput` (see section **??**), is redirected to a *file handle* to this temporary script. Thus, the shell continues execution of commands, but rather takes its input from the temporary file rather than its current input. As this construction would forbid the recursive execution of another Shell script within a Shell script, the Shell detects `Execute` as a special case for which it keeps a "stack" of script files and active redirections. Through that, it provides each recursive execution a "clean" environment[6] that allows redirection of its input. Once `cli_CurrentInput` exhausted, the Shell terminates execution there, closes the *file handle* stored there, deletes the temporary file whose name is stored in `cli_CommandFile` and continues execution from `cli_StandardInput`.

13.2 Interacting with the AmigaDOS Shell

The functions in this section interact with the Shell in one way or another. They start a new Shell, execute a Shell script or retrieve information from the Shell a program has been started within.

13.2.1 Execute Shell Scripts

The `System()` function creates a new Shell, and potentially executes a Shell script. Depending on parameters, it waits for the script to complete, or launches an interactive Shell in a console or a non-interactive Shell in the background. The same *dos.library* entry point exists under 3 names that only differ in how the code generator of a compiler provides parameters for it.

The `SystemTagList()` function is equivalent to the `System()` function and does not differ in arguments and call syntax. It is only present to harmonize function naming across all library entry points. It takes a pointer to a string containing a Shell script, possibly only a single command, and additional parameters encoded in a `TagItem` array as defined in `utility/tagitem.h`.

The `SystemTags()` function also receives this string, but provides the `TagItem`s explicitly as one or multiple exra arguments to the function. Compilers typically build then the `TagItem` array on the stack and pass the pointer to the first item on the stack to the *dos.library* entry point.

```
error = SystemTagList(command, tags)
D0          D1       D2

LONG SystemTagList(STRPTR, struct TagItem *)

error = System(command, tags)
```

[6] This is a major difference compared to previous versions of AmigaShell which instead resolved this situation by appending recursively executed scripts to each other. This construction had a series of bad side effects, one being that a script could not skip backwards over an `Execute` command.

```
D0  D1       D2
LONG System(STRPTR, struct TagItem *)

error = SystemTags(command, Tag1, ...)

LONG SystemTags(STRPTR, ULONG, ...)
```

This function is the generic Shell execution function that creates a Shell in one or multiple modes, and executes the commands provided as first argument in that Shell. Hence, the first argument establishes a Shell script, encoded as a string, and multiple commands separated by newline characters may be provided that will be executed one after another. Argument substitutions as by the `Execute` command (see section 13.1.8) are *not* performed, but otherwise the entire Shell syntax, including variables, compound commands and pipes is available. If such mechanisms are necessary, `Execute` shall be called directly, receiving its input from a temorary file.

Depending on its arguments, this function is synchronous, i.e. waits for the completion of the called commands, or asynchronous and then detaches from the caller. By proper usage of arguments, this function can emulate (or is actually even used by) the `Run` and `NewShell` commands, and is also used by the system startup module to create the initial boot shell.

By default, the newly created Shell receives the input and output file handles of the caller, i.e. `pr_CIS` and `pr_COS` are copied from the calling process, see section 10 for the documentation of the process structure. However, with suitable tags the caller can provide alternative input and output streams. Whether these file handles are closed upon termination of the shell depends on further arguments, but the default is not to close them when run synchronously, and to close them otherwise, even if they were the streams of the caller, so beware and provide suitable tags.

The input and output file handles provided to the Shell *shall be different*, i.e. it is not permissible to provide the same file handle as input and as output stream. If the input and output handle should go to an interactive stream such as the console, then only provide an input stream and set the output stream to `ZERO` by `SYS_Output`, see the list of tags below. The *dos.library* will in that case create an output file handle by opening another stream to the console through the `*` file name.

The newly creates Shell will receive a copy of the path, the local shell variables, the prompt, the current directory and the stack size of the shell of the caller, if such shell exists, i.e. `pr_CLI` is non-`ZERO`. Otherwise, a default path containing only the `C:` directory and the current directory will be created, no local variables will be defined, the prompt will be set to "`%N> `" and the current directory to "`SYS:`".

By default, the executing shell will be the system shell, whose segment is available as a system segment of the name "`BootShell`" in the list of resident modules, see section **??**. Other shells can be provided by their name, and the list of resident segments will be scanned for a match then. Section **??** provides more information on how to implement a custom shell.

The tags this function tags are documented in `dos/dostags.h` and consist of the `SYS_` tags and a subset of the `NP_` tags.

`SYS_Input` This tag takes a BPTR to a file handle as argument which becomes the input stream of the new shell. If this tag is not provided, the input stream of the calling process (`pr_CIS`) will be used.

`SYS_InName` This tag takes a string as argument. This string will be used as argument to `Open()` to create a stream that will be used as input stream to the newly created shell. This stream will always be closed when done, regardless of other tags. This tag is mutually exclusive to `SYS_Input`.

`SYS_Output` This tag defines a BPTR to a file handle which will be used as output stream of the new shell. This handle *shall be different* than the handle provided by `SYS_Input`. If this tag is not present, the output stream of the calling process (`pr_COS`) will be used for shell output. If this stream is explicitly set to `ZERO`, then AmigaDOS will attempt to re-open a console through the "`*`" file name. If an input stream is present and interactive, and command is non-NULL or SYS_Async is non-zero, then the handler of the input stream is used to open the replacement output stream. Otherwise, the handler provided through the NP_ConsoleTask or the console task of the caller if the former tag is not present is used to open "*". If opening the console fails, AmigaDOS will instead provide a handle to NIL: as output stream, thus disregarding any output. Any stream implicitly provided by the *dos.library* by the above mechanism rather than explicitly through a non-ZERO argument to SYS_Output will also be closed transparently upon termination of the shell.

SYS_OutName provides an output file name that will be opened by the *dos.library* and used as output stream for the newly created shell. This file will always be closed when the shell terminates. This tag is mutually exclusive to SYS_Output.

SYS_CmdStream provides a BPTR to a file handle from which commands are read, i.e. a shell script is supplied as stream, and not as a string. This tag is only used if the command argument is NULL and then provides an alternative (stream-based) source for the script to be executed. This stream is *always* closed on exit, and closure cannot be prevented by any other tag. If SYS_Asynch is set and command is NULL, then the Shell first reads commands from SYS_CmdStream, and once this stream reaches an EOF, it is closed and the shell continues reading from SYS_Input until this stream also reaches an EOF, or an EndCLI command. Thus, the configuration of providing a SYS_CmdStream and setting SYS_Asynch is equivalent to the newshell command.

SYS_CmdName provides a file name of a shell script whose contents is interpreted. This tag is mutually exclusive to SYS_CmdStream and only used if the command argument is NULL. This stream will always be closed on exit.

SYS_Asynch If the argument to this tag is non-zero, the shell is detached from the calling process and executes concurrently with the calling process; setting this tag also implies that the streams provided by SYS_Input and SYS_Output are always closed. It is thus necessary to explicitly provide SYS_Input or SYS_InName and SYS_Output or SYS_OutName, as otherwise the input or output streams of the calling process will be closed. For legacy reasons, setting the command argument to NULL also enforces asynchronous execution, independent of the value of tag.

SYS_UserShell If this boolean tag is set to non-zero, then the "user shell" is launched. This corresponds to the segment "Shell" on the resident list of AmigaDOS. The default of this tag is DOSFALSE, indicating that the boot shell is to be used. This corresponds to the "BootShell' segment on the resident list. Upon system startup, and in all typical configurations of AmigaDOS, both correspond to the AmigaDOS shell. Users can, however, replace both shells with custom segments, see section **??**.

SYS_CustomShell this tag provides the name of a custom shell to be used instead. The AmigaDOS list of resident segments is scanned for a fitting name, and the fitting segment is then used as shell.

The following tags defined for CreateNewProc(), see section 10.1.1, are also recognized:

NP_StackSize defines the stack size in bytes for the shell to be created and the stack size the shell will allocate for its clients. The default is 4096 bytes for the shell itself; for the shell clients, the stack size is taken by default from the shell of the calling process, or 4096 bytes if the caller is not a shell process.

NP_Name is the name of the shell process to be created. The default is "Background CLI".

NP_Priority is the priority of the shell process to be created. The default priority is 0.

NP_ConsoleTask provides a pointer to the MsgPort of the console handler that is used for opening the * and CONSOLE: files, which will be copied to pr_ConsoleTask. This tag is only used if the input stream of the new shell is not interactive, and otherwise overridden by the process MsgPort port of the input file handle.

NP_CopyVars is a boolean tag that specifies whether local shell variables are copied into the new shell. The default is to copy the variables.

NP_Path contains a linked list of directory locks that establish the path of the newly created shell. The structure of this path is specified in section 13.2.3. The path provided by this tag *is not* copied for the new shell, but directly used *and released* by it when it exits. Thus, callers should make a copy of the path upfront as it will be released by the created shell.

NP_ExitCode and NP_ExitData define a function that is called when the shell process exits. This mechanism is described in more detail in section 10.1.1.

The return code of the System() and related functions is -1 in case creating the shell failed. In such a case IoErr() delivers an error code providing more details on the cause of the failure. Otherwise, if the commands were executed synchronously, the return code is the result code of the last command in the shell executed, and IoErr() is set to the error code set by the last command executed. If an asynchronous shell was created, the result code is 0 on success, and IoErr() will be set to 0.

This function is used to implement a couple of essential system functionalities, and all Shell commands and system functions that create a Shell go through this function. This includes the NewShell and Run shell commands and the Shell icon on the workbench. The initial CLI interpreting S:Startup-Sequence is also created through the System() function.

The Run command creates a new shell process by the following:

```
System(NULL,SYS_Input,instream,SYS_Output,Output(),
       SYS_UserShell,TRUE,TAG_DONE);
```

where the input stream instream is a string stream (see section 4.9.2) containing the commands to be executed; they are taken from the input arguments of the command.

Even though SYS_Asynch is not set, the System() function detaches the created shell because its first argument is NULL, see above. Surprisingly, it is the System() call and not the Run command that prints the CLI number of the created shell on the console in this particular case.

The NewShell command uses System() as follows:

```
System(NULL,SYS_InName,window_arg,
       SYS_CmdStream,Open(from_arg,MODE_OLDFILE),
       SYS_Asynch,TRUE,SYS_UserShell,TRUE,
       NP_Name,"Shell Process",TAG_DONE);
```

where the window argument and the from argument are coming from the command line arguments of NewShell of the same names. That is, System() receives a console as new input file handle, and a command stream which is by default "S:Shell-Startup". Setting SYS_Asynch to TRUE ensures that the shell continues to read commands from its input file handle as soon as the command file depletes.

The Execute() function described in section 13.2.2 is equivalent to

```
System(NULL,SYS_CmdStream,cmd,
       SYS_Input,in,SYS_Output,out,SYS_UserShell,FALSE,
       NP_Priority,0,TAG_DONE)?DOSTRUE:DOSFALSE;
```

where cmd is a string stream (see section **??**) containing the commands to be executed, constructed from the first argument of Execute(), and in and out are its second and third argument. The difference of System() and Execute() is only the result code, but internally run into the same code.

13.2.2 Execute Shell Scripts (Legacy)

The Execute() function creates a new AmigaDOS shell, which then executes commands from a string, and continues executing commands from an input stream. This function is obsolete, and should be replaced by System() which is more flexible.

```
success = Execute( commandString, input, output )
D0        D1    D2   D3

BOOL Execute(STRPTR, BPTR, BPTR)
```

This function is a deprecated function to create AmigaDOS shells and interpret shell scripts that has been superceeded by `System()`, see section 13.2.1.

The first argument is a string containing a shell script. If this argument is `NULL` and thus no command string is present, a new shell is created and run asynchronously in the background, i.e. `Execute()` returns then immediately. The new shell receives its input, and thus its commands from the file handle provided as second argument. The output of the commands go to the stream provided as third argument if non-`ZERO`, or to a console cloned by opening "`*`" from the console task of caller if possible, or to a `NIL:` handle if this fails.

If the first argument is non-`NULL`, the `Execute()` command is synchronous and will not return until the shell completed its job. It first reads commands from the the command string, and once this depletes, switches over to the stream provided by `input`. If this does not exist, it returns at that point. Otherwise, it continues reading from `input` until this stream reaches its EOF, or an `EndCLI` command. The output of the shell goes through the `output` stream provided as third argument. If the third argument is `ZERO`, and the input stream is interactive, AmigaDOS opens "`*`" from the input stream handler if it is interactive, or otherwise disregards all output by providing a `NIL:` handle as output.

Unlike `System()`, this function returns `DOSTRUE` on success and `DOSFALSE` in case creating the shell failed. It also always executes commands through the boot shell, and not through a custom or user shell.

13.2.3 Retrieving the CLI Structure

The `Cli()` function returns a pointer to the `CommandLineInterface` structure describing the shell within which the calling process is executing, or `NULL` in case the process is not run from a shell.

```
cli_ptr = Cli()
D0

struct CommandLineInterface *Cli(void)
```

This function returns a pointer to the `CommandLineInterface` structure that describes properties of the shell the calling process runs within. The function returns `NULL` if the caller is not part of a shell process. This structure, defined in `dos/dos.h`, looks as follows:

```
struct CommandLineInterface {
    LONG   cli_Result2;
    BSTR   cli_SetName;
    BPTR   cli_CommandDir;
    LONG   cli_ReturnCode;
    BSTR   cli_CommandName;
    LONG   cli_FailLevel;
    BSTR   cli_Prompt;
    BPTR   cli_StandardInput;
    BPTR   cli_CurrentInput;
    BSTR   cli_CommandFile;
    LONG   cli_Interactive;
    LONG   cli_Background;
    BPTR   cli_CurrentOutput;
```

```
    LONG   cli_DefaultStack;
    BPTR   cli_StandardOutput;
    BPTR   cli_Module;
};
```

The elements of this structure are as follows:

`cli_Result2` is the `IoErr()` the last executed command of the shell left, or the Shell created itself when failing to interpret or execute a command line. This element is for example used by the `why` command to print a textual description of the error. The shell also copies this value into the `$Result2` Shell variable.

`cli_SetName` is a BPTR to a BSTR containing the path of the current directory. This string is used to generate a shell prompt; the AmigaDOS shell substitutes the "`%S`" format directive of the prompt by the string stored here. The `CD` command and its `PushCD`, `PopCD` and `SwapCD` variants update this element.

`cli_CommandDir` contains a linked list of directories that are scanned for commands. It is a BPTR to the following (undocumented) structure:

```
struct PathComponent {
    BPTR pc_Next;
    BPTR pc_Lock;
};
```

where `pc_Next` is the BPTR to the next directory in the path or `ZERO` for the end of the list, and `pc_Lock` is a lock of the directory that will be scanned for a matching command file.

The current directory is always the first component of the path and thus checked first for matching files, even if `cli_CommandDir` is `ZERO`. The `C:` directory is always the last component of a path and neither explicitly included in the linked list.

The `Path` command is used to print and adjust the path stored in this list.

`cli_ReturnCode` is the return code of the last executed command, i.e. the value the command left in the `d0` CPU register when existing to the Shell. The shell also copies this value to the `$RC` Shell variable.

`cli_CommandName` is a BPTR to a BSTR containing the name of the currently executing command. It is placed here by the shell before calling in.

`cli_FailLevel` contains the threshold at which executed commands will cause an abortion of its containing shell script. The value is deposited here by the `FailAt` command. If a command exits with return code larger or equal than the `cli_FailLevel`, this will cause termination of the currently executing script.

`cli_Prompt` contains a BPTR to BSTR that is used by the shell to print the command prompt on interactive shells. The AmigaDOS Shell recognizes the following strings:

`%S` Replaced by the path of the current directory, namely the contents of `cli_SetName`.

`%N` Substituted with the CLI number, which is the closest analogon of a process ID AmigaDOS has to offer. This is taken from `pr_TaskNum` of the process running the shell, see also section 10.

`%R` Represents the return code of the last executed command as contained in `cli_ReturnCode`.

`%%` The percent ("`%`") sign itself.

The AmigaDOS Shell also expands variables as described in section 13.1.5 in the prompt, executes commands backticks, see section 13.1.6, and inejcts its output into the printed prompt. Any "`%`" sign included in expanded variables or backticks is *not* a formatting command but stands for itself.

`cli_StandardInput` is a BPTR to a file handle that represents the primary source of commands. This file handle typically corresponds to a console window within which the shell is executed. The `Run` command will deposit here a string stream (see section 4.9.2) containing the command or commands to be run in background. The file handle provided through the `SYS_Input` or `SYS_InName` tags of the `System()` function will be placed here. Once this stream is exhaused, the Shell terminates.

`cli_CurrentInput` is a BPTR to a file handle from which the shell is currently executing commands. This stream is either comming from the `SYS_CmdStream` or `SYS_CmdIn` tags of the `System()` function, or a string stream constructed from its first argument. Also, the `Execute` command, see section 13.1.8, places here the file handle of the original or processed shell script that is to be executed. Once this file is exhaused, the Shell will close it, and set this BPTR to `cli_StandardInput`. This happens, for example, if a script reaches its end of file or is aborted by the `Exit` command.

`cli_CommandFile` is a BPTR to the BSTR of a temporary shell script that is currently being executed. The only reason why its path is stored here is to allow the Shell to clean up such temporary scripts. Whenever the `Execute` command requires processing a script for argument substitution, it creates a temporary script in `T:` whose name is stored in `cli_CommandFile`. Once its execution completes, the Shell ensures that this temporary script is deleted again. For details on how `Execute` actually works see section 13.1.8.

`cli_Interactive` is a boolean flag that indicates whether the Shell is interactive, i.e. requesting data from the console. If this boolean is non-zero and `cli_Background` is `DOSFALSE`, a prompt is printed before attempting to read a command from `cli_CurrentInput`. If the shell is executing a script, this element becomes `DOSFALSE` and the Shell then checks for a Ctrl-D signal to potentially abort a running script.

`cli_Background` is a boolean that indicates whether the Shell runs in background. This flag is set for shells that are started asynchronously or are equipped with a non-interactive (non-console) output stream. If this flag is cleared, then the shell also prints a message when its input stream reaches its EOF, indicating that the shell terminates.

`cli_CurrentOutput` is currently not used by the Shell. It is currently initialized with the same file handle as `cli_StandardOutput`.

`cli_DefaultStack` is the minimum stack in long-words the Shell allocates for commands before executing them. The Shell also checks the command for a stack cookie, see section 11.4.2, that may enlarge the stack further. This element is set by the `Stack` command. Note that this element is *not* the stack size of the shell process itself, but a lower limit of the stack size for its clients.

`cli_StandardOutput` is the file handle the shell provides as default output handle to its clients, and to which it prints output. This handle is copied from the `SYS_Output` or `SYS_OutName` tags of the `System()` function if they are provided.

`cli_Module` is a BPTR to the first segment of the command currently executed. The Shell also uses this BPTR to release loaded, non-resident commands. This BPTR is either filled with the segment provided by `LoadSeg()` in section 11.2.1, or an element of the list of resident segments, see section **??**. A common technique for load and stay resident commands is to set this BPTR to `ZERO` to prevent the shell from releasing the loaded program and thus keep it in memory.

Even though the `CommandLineInterface` function is typically constructed by AmigaDOS, e.g. through the `System()` function, it is sometimes necessary to create it manually. Allocation of this structure shall happen only through `AllocDosObject()` as this structure contains some Shell-internal fields for extended Shell features. These extended features are instead accessible through the `DoShellMethod()` function specified in section 13.2.13.

This function does not change `IoErr()`.

13.2.4 Obtaining the Name of the Current Directory

The `GetCurrentDirName()` function copies the current directory of the shell into the provided buffer if such a shell exists, or retrieves the current directory of the calling process instead.

```
success = GetCurrentDirName(buf, len)
D0                          D1   D2

BOOL GetCurrentDirName(STRPTR, LONG)
```

This function checks whether the caller is a shell command. If so, it copies what the shell believes to be its current directory into the supplied buffer. That is, the function then copies `cli_SetName` into `buf`, see section 13.2.3. If the current directory path fits into `len` bytes including a terminating `NUL` byte, then this function returns `DOSTRUE` and sets `IoErr()` to 0. Otherwise, it truncates the name, returns `DOSFALSE` and sets `IoErr()` to `ERROR_LINE_TOO_LONG`, but still returns `DOSTRUE`.

The shell itself does not update `cli_SetName`, namely the field this function depends upon, itself. Rather, the `CD`, `SwapCD`, `PushCD` and `PopCD` commands attempt to keep it consistent. However, if a command changes `pr_CurrentDir` without updating `cli_SetName`, or calls `SetCurrentDirName()` without updating the current directory of its processes, then the string supplied by this function may not correspond to the current directory the shell actually uses.

If the caller is not a shell command, then the function uses the lock representing the current directory of the calling process, namely `pr_CurrentDir`, and converts it to a string by `NameFromLock()`. This function, see section 6.3.1, also truncates its result to `len` bytes and, if truncation was performed, sets `IoErr()` to `ERROR_LINE_TOO_LONG` and returns `DOSFALSE` if the directory name does not fit into `len` bytes. On success, the function returns a non-zero result code, but it does not set `IoErr()` consistently then.

13.2.5 Set the Current Directory Name

The `SetCurrentDirName()` sets the buffer within which the shell keeps the string representing the current directory. It does not update the current directory itself.

```
success = SetCurrentDirName(name)
D0                          D1

BOOL SetCurrentDirName(STRPTR)
```

This function updates `cli_SetName` of the shell the caller is part of, if such a shell exists. In such a case, it copies the supplied string into `cli_SetName` and potentially truncates it to the size of the shell-internal buffer. Even if the string is truncated, the function returns `DOSTRUE`. It does not update `IoErr()` in either case. For some legacy reasons, the size of this buffer is rather small, and thus may not reflect the full directory name supplied.

If the caller is not a shell command, this function returns `DOSFALSE` without setting an error code.

This function does not attempt to synchronize `pr_CurrentDir` of the calling process to the supplied directory, If the two are not consistent, the path the shell could print as part of the prompt would be incorrect. Thus, any attempt to change `cli_SetName` through this function *shall also* call `CurrentDir()` to make this change consistent to the Shell.

13.2.6 Obtaining the Current Program Name

The `GetProgramName()` function copies the name of the currently executed program into a buffer.

```
success = GetProgramName(buf, len)
D0                       D1   D2

BOOL GetProgramName(STRPTR, LONG)
```

This function fills buf with the what the Shell assumes to be the name of the currently executed command. This name is taken from cli_CommandName, see section 13.2.3, where the shell deposits it before executing a program. If the program name including NUL termination requires more than len bytes, this function first truncates it and sets IoErr() to ERROR_LINE_TOO_LONG. If the name including a terminating NUL byte fits into len bytes, the name is copied and the function sets IoErr() to 0. In either case, even if the program name is truncated, the function returns DOSTRUE.

If this function is not called from a shell command, the function installs an empty string in buf if len is at least 1 and returns DOSFALSE and sets IoErr() to ERROR_OBJECT_WRONG_TYPE.

The Shell buffer that keeps the current command name is unfortunately due to legacy reasons quite limited in size, and at present shorter than the 106 character limit imposed by the FileInfoBlock structure, see section 6.1. Even though the Shell uses internally a longer buffer and thus is not limited in the file name size of commands it executes, the ability of the Shell to communicate such long command names to the caller is restricted, and thus the command name retrieved from this function may not reflect the correct file name.

13.2.7 Set the Current Program Name

The SetProgramName() sets the name the shell assumes the currently executing program has.

```
success = SetProgramName(name)
D0                       D1

BOOL SetProgramName(STRPTR)
```

If this function is called from a shell command, it installs the supplied string as program name into cli_CommandName, section 13.2.3, and returns DOSTRUE. If the supplied string does not fit into the Shell internal buffer, it is truncated without this function indicating failure.

If this function is not called from a shell command, it returns DOSFALSE. This function does not change IoErr() in any case.

13.2.8 Obtaining the Shell Prompt

The GetPrompt() function copies the prompt format string with all formatting instructions into a caller supplied function.

```
success = GetPrompt(buf, len)
D0                  D1   D2

BOOL GetPrompt(STRPTR, LONG)
```

If this function is called from a shell command, it copies the prompt format string including a terminating NUL into buf if it fits into len bytes, potentially truncating it if it does not. If truncation was performed, IoErr() is set to ERROR_LINE_TOO_LONG, otherwise to 0. In either case, even if the string was truncated, the function returns DOSTRUE.

If this function is not called from a shell command, an empty string is copied into buf if len is at least 1, and IoErr() is set to ERROR_OBJECT_WRONG_TYPE and the function returns DOSFALSE.

The shell prompt provided by this function is the unexpanded prompt including format strings as it is provided by the Prompt command, and not the expanded prompt currently printed by the shell.

13.2.9 Setting the Shell Prompt

The `SetPrompt()` sets the Shell prompt format string.

```
success = SetPrompt(name)
D0                  D1

BOOL SetPrompt(STRPTR)
```

If called from a shell command, this function updates the shell prompt format string to `name`, potentially truncating it to the size of the Shell internal buffer. It returns `DOSTRUE` even if the prompt is truncated.

If this function is not called from a shell command, it returns `DOSFALSE`. In does not change `IoErr()` in any case.

The Shell prompt provided to this function may contain all format strings described in 13.2.3, such as `%S` for the current path, or Shell variables and backticks to construct a prompt dynamically. The shell-internal buffer size for the prompt is unfortunately quite limited. If longer prompts are required, they could be placed in a local shell variable which is expanded in the prompt.

13.2.10 Run a Command Overloading the Calling Process

The `RunCommand()` runs a shell command from a process, and overloads the process with the command.

```
rc = RunCommand(seglist, stacksize, argptr, argsize)
D0                  D1         D2         D3      D4

LONG RunCommand(BPTR, ULONG, STRPTR, ULONG)
```

This function runs a command from the calling process, and provides for this command its own stack, and its own arguments. It does not create a new process nor a new shell, but executes the command as part of the caller. The AmigaDOS Shell uses this function to execute loaded commands within its context.

The `seglist` argument is a BPTR to the first segment of the executable to start, for example as returned by `LoadSeg()` for disk-based commands, or `FindSegment()` for resident commands.

The `stacksize` argument is the size of the stack in bytes to be provided to the command; this has to be provided by the caller as this function does not attempt to identify the minimum stack size necessary. The Shell takes the stack size from `cli_DefaultStack`, see section 13.2.3, and multiplies it by 4. It additionally searches the `seglist` for the stack cookie, see section 11.4.2, and from that potentially increases the size.

The `argptr` and `argsize` arguments provide command line arguments that are passed to the command. They are provided through several mechanisms: First, the CPU register `a0` is loaded with `argptr` and register `d0` is filled with `argsize`. Second, the `pr_Arguments` element of the process is temporarly replaced by `argptr`, see also section 10, and thus the arguments are made available to `GetArgStr()`. Third, a buffer for the input file handle `pr_CIS` of the caller is allocated and filled with a copy of the argument line; more on the file handle structure is in section 4.9.1. Thus, buffered I/O operations as those listed in section 4.8 will retrieve the arguments. This step is necessary to make the arguments available to `ReadArgs()`, the AmigaDOS argument parser.

The `ReadArgs()` function, and probably many other parsers require that the argument is terminated by a newline, hex `0x0a`. While it is possible to provide an argument string containing more than one newline character, `ReadArgs()` will ignore all arguments behind the first newline. However, some commands such as `Run` will make use of the entire string.

All changes performed by `RunCommand()` on the caller and its resources, namely the stack, the modifications of the input file handle and storage of the arguments and the modified stack are reverted when the called command returns.

As the program name *is not* part of the command line arguments, it is advisable to set the path and file name of the loaded program `SetProgramName()` upfront, more on this function in section 13.2.7. The startup code of many C compilers will construct `argv[0]` from it.

This function returns the result code of the called command, or -1 if it failed to allocate resources such as the input file handle buffer or the stack. `IoErr()` remains its value from the called command, or is set to `ERROR_NO_FREE_STORE` if resources could not be allocated.

13.2.11 Finding a Shell

```
proc = FindCliProc(num)
D0              D1

struct Process *FindCliProc(ULONG)
```

13.2.12 Retrieve the Size of the Shell Process Table

```
number = MaxCli()
D0

LONG MaxCli(void)
```

13.2.13 Request a Function of the Shell

```
ptr = DoShellMethodTagList(method, tags)
D0                           D0     A0

APTR DoShellMethodTagList(ULONG, struct TagItem *)

ptr = DoShellMethod(method, Tag1, ...)

APTR DoShellMethod(ULONG, ULONG, ...)
```

13.2.14 Read a Shell Variable

```
len = GetVar( name, buffer, size, flags )
D0         D1     D2     D3    D4

LONG GetVar( STRPTR, STRPTR, LONG, ULONG )
```

13.2.15 Setting a Shell Variable

```
success = SetVar( name, buffer, size, flags )
D0             D1     D2     D3    D4

BOOL SetVar(STRPTR, STRPTR, LONG, ULONG )
```

13.2.16 Finding a Shell Variable

```
var = FindVar( name, type )
D0 D1    D2

struct LocalVar * FindVar(STRPTR, ULONG )
```

13.2.17 Deleting a Shell Variable

```
success = DeleteVar( name, flags )
D0        D1    D2

BOOL DeleteVar(STRPTR, ULONG )
```

13.3 Parsing Arguments

13.3.1 Parsing Command Line Arguments

```
result = ReadArgs(template, array, rdargs)
D0                   D1      D2      D3

struct RDArgs * ReadArgs(STRPTR, LONG *, struct RDArgs *)
```

13.3.2 Reading a Single Argument from the Command Line

```
value = ReadItem(buffer, maxchars, input)
D0                D1        D2      D3

LONG ReadItem(STRPTR, LONG, struct CSource *)
```

13.3.3 Finding an Argument

```
index = FindArg(template, keyword)
D0                D1        D2

LONG FindArg(STRPTR, STRPTR)
```

13.3.4 Releasing the Argument Parser

```
FreeArgs(rdargs)
           D1

void FreeArgs(struct RDArgs *)
```

13.3.5 Initializing a new Shell

```
flags = CliInitRun( packet )
D0        A0

LONG CliInitRun( struct DosPacket * )
```

13.3.6 Finding a Resident Command

```
segment = FindSegment(name, start, system)
D0         D1     D2     D3

struct Segment *FindSegment(STRPTR, struct Segment *, LONG)
```

13.3.7 Adding a Resident Command

```
success = AddSegment(name, seglist, type)
D0        D1     D2      D3

BOOL AddSegment(STRPTR, BPTR, LONG)
```

13.3.8 Removing a Resident Command

```
success = RemSegment(segment)
D0          D1

BOOL RemSegment(struct Segment *)
```

13.4 Miscellaneous Functions

13.4.1 Allocating a DOS Object

```
ptr = AllocDosObject(type, tags)
D0                    D1    D2

void *AllocDosObject(ULONG, struct TagItem *)

ptr = AllocDosObjectTagList(type, tags)
D0                           D1    D2

void *AllocDosObjectTagList(ULONG, struct TagItem *)

ptr = AllocDosObjectTags(type, Tag1, ...)

void *AllocDosObjectTags(ULONG, ULONG, ...)
```

13.4.2 Releasing a DOS Object

```
FreeDosObject(type, ptr)
       D1   D2

void FreeDosObject(ULONG, void *)
```

13.4.3 Checking for Signals

```
signals = CheckSignal(mask)
D0        D1

ULONG CheckSignal(ULONG)
```

13.4.4 Display an Error Requester

```
status = ErrorReport(code, type, arg1, device)
D0                    D1    D2    D3     D4

BOOL ErrorReport(LONG, LONG, ULONG, struct MsgPort *)
```

13.4.5 Generating an Error Message

```
len = Fault(code, header, buffer, len)
D0          D1     D2      D3    D4

LONG Fault(LONG, STRPTR, STRPTR, LONG)
```

13.4.6 Printing an Error Message

```
success = PrintFault(code, header)
D0                   D1     D2

BOOL PrintFault(LONG, STRPTR)
```

13.4.7 Printing a String to the Error Stream

```
error = PutErrStr(str)
D0                D1

LONG PutErrStr(STRPTR)
```

13.4.8 Receive Information when a Volume is Request

```
res = VolumeRequestHook(volume)
D0   D1

LONG VolumeRequestHook(UBYTE *volume)
```

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