AT&T

System V

Interface Definition

1

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Preface

The *System V Interface Definition* specifies an operating system environment that allows users to create applications software that is independent of any particular computer hardware. The *System V Interface Definition* applies to computers that range from personal computers to mainframes. Applications that conform to this specification will allow users to take advantage of changes in technology and to choose the computer that best meets their needs from among many manufacturers while retaining a common computing environment.

The *System V Interface Definition* specifies the operating system components available to both end-users and application-programs. The functionality of components is defined, but the implementation is not. The *System V Interface Definition* specifies the source-code interfaces of each operating system component as well as the run-time behavior seen by an application-program or an end-user. The emphasis is on defining a common computing environment for application-programs and end-users; not on the internals of the operating system, such as the scheduler or memory manager.

An application-program using only components defined in the *System V Interface Definition* will be compatible with and portable to any computer that supports the System V Interface. While the source-code may have to be re-compiled to move an application-program to a new computer system that supports the System V Interface, the presence and behavior of the operating system components as defined by the *System V Interface Definition* would be assured.

The *System V Interface Definition* is organized into a Base System Definition plus a series of Extension Definitions. The Base System Definition specifies the components that all System V operating systems must provide. The Extensions to the Base System are not required to be present in a System V operating system, but when a component is present it must conform to the specified functionality. The *System V Interface Definition* lets end-users and application-developers identify the features and functions available to them on any System V operating system.

Part I

A General Introduction to the System V Interface Definition

Chapter 1
General Introduction

1.1 AUDIENCE AND PURPOSE

The *System V Interface Definition* (SVID) is intended for use by anyone who must understand the operating system components that are consistent across all System V environments. As such, its primary audience is the application-developer building C language application-programs whose source-code must be portable from one System V environment to another. A system builder should also view these volumes as a necessary condition for supporting a System V environment that will host such applications.

This publication is intended to serve the following major purposes:

- To serve as a single reference source for the definition of the external interfaces to services that are provided by all System V environments. These services are designated as the Base System. This includes source-code interfaces and run-time behavior as seen by an application-program. It does not include the details of how the operating system implements these functions.
- To define all additional services (such as networking and data management) at an equivalent external interface level and to group these services into Extensions to the Base System.
- To serve as a complete definition of System V external interfaces, so that application source-code that conforms to these interfaces and is compiled in an environment that conforms to these interfaces, will execute as defined in a System V environment. It is assumed that source-code is recompiled for the proper target hardware. The basic objective is to facilitate the writing of application-program source-code that is directly portable across all System V implementations. Facilities outside of the Base System would require that the appropriate Extension be installed on the target environment.

1.2 STRUCTURE AND CONTENT

1.2.1 Partitioning into Base System and Extensions

The *System V Interface Definition* partitions System V components into a Base System and Extensions to that Base System. This does not change the definition of System V. It is instead a recognition that the entire functionality of System V may be unnecessary in certain environments, especially on small hardware configurations. It also recognizes that different computing environments require some functions that others do not.

The Base System functionality has been structured to provide a minimal, stand-alone run-time environment for application-programs originally written in a high-level language, such as C. In this environment, the end-user is not expected to interact directly with the traditional System V shell and commands. An example of such a system would be a dedicated-use system. That is, a system devoted to a single application, such as a vertically-integrated application package for managing a legal office, To execute, many applications programs will require only the components in the Base System. Other applications will need one or more Extensions.

The Extensions to this Base System have been structured to provide a growth path in natural functional increments that leads to a full System V configuration. The division between Base and Extensions will allow system builders to create machines tailored for different purposes and markets, in an orderly fashion. Thus, a small business/professional computer system designed for novice single-users might include only the Base System and the Basic Utilities Extension. A system for advanced business/professional users might add to this the Advanced Utilities Extension. A system designed for high-level language software development would include the Base System, the Kernel Extension and the Basic Utilities, Advanced Utilities, and Software Development Extensions. Although the Extensions are not meant to specify the physical packaging of System V for a particular product, it is expected that the Extensions will lead to a fairly consistent packaging scheme.

This partitioning allows an application to be built using a basic set of components that are consistent across all System V implementations. This basic set is the Base System. Where necessary, an application developer can choose to use components from an Extension and require the run-time environment to support that Extension in addition to the Base System.

Facilities or side effects that are not explicitly stated in the SVID are not guaranteed, and should not be used by applications that require portability.

1.2.2 Conforming Systems

All conforming systems must support the source code interfaces and runtime behavior of the components of the Base System. A system may conform to none or some Extensions. All the components of an Extension must be present for a system to meet the requirements of the Extension. This does not preclude a system from including only a few components from some Extension, but the system would *not* then be said to have the Extension. Some Extensions require that other Extensions be present on a system, for example, the Advanced Utilities Extension requires the Basic Utilities Extension.

This issue of the *System V Interface Definition* corresponds to functionality in AT&T System V Release 1.0 and System V Release 2.0. An implementation of System V may conform to the System V Release 1.0 functionality or the System V Release 2.0 functionality. All System V Release 2.0 enhancements to System V Release 1.0 are identified as such in the SVID.

1.2.3 Organization of Technical Information

For ease of use, the SVID has been divided into several Volumes containing the following Extensions:

Volume 1.	**Base System**
	Kernel Extension
Volume 2.	**Basic Utilities Extension**
	Advanced Utilities Extension
	Software Development Extension
	Administered System Extension
	Terminal Interface Extension

Additional Volumes will define any further Extensions to System V.

The SVID defines the source-code interface and the run-time behavior of the components that make up the Base System and each Extension. Components include, for example, operating system service routines, general library routines, system data files, special device files, and end-user utilities (commands).

When referred to individually, components will be identified by a suffix of the form (XX_YYY) where XX identifies the Base System or the Extension that the component is in and YYY identifies the type of the component. For example, components defined in the Operating System Service Routines section of the Base System will be identified by (BA_OS), components defined in General Library Routines of the Base System will be identified by (BA_LIB), and components defined in the Operating System Service Routines section of the Kernel Extension will be identified by (KE_OS). Possible types are OS, LIB, CMD (commands or utilities) and ENV (environment).

The definition of the Base System includes an overview followed by chapters that provide detailed definitions of each component in the Base System. Similarly, the definition of each Extension includes an overview followed by chapters that provide detailed definitions of each component in the Extension.

Pages containing the detailed component definitions are labeled with the name of the component being defined. Some utilities and routines are described with other related utilities or routines, and therefore do not have detailed definition pages of their own.

An alphabetical index is provided in each Volume listing all components defined in that Volume. The index points to the detailed definition pages on which a component is to be found; the header for these pages may not contain the name of the component being sought. For example, in Volume I, the entry for the function `calloc` points to the MALLOC(BA_OS) pages, because the function `calloc` is defined with the function `malloc` on pages labeled MALLOC(BA_OS).

Each component definition follows the same structure. The sections are listed below; not all the following sections may be present in each description. If present, however, they will be in the given order. Sections entitled **EXAMPLE**, **APPLICATION USAGE**, and **USAGE** are not considered part of the formal definition of a component.

- **NAME** — name of component
- **SYNOPSIS** — summary of source-code or user-level interface
- **DESCRIPTION** — interface and runtime behavior
- **RETURN VALUE** — value returned by the function
- **ERRORS** — possible error conditions
- **FILES** — names of files used
- **APPLICATION USAGE** or **USAGE** — guidance on use
- **EXAMPLE** — example
- **SEE ALSO** — list of related components
- **FUTURE DIRECTIONS** — planned enhancements
- **LEVEL** — see **MECHANISM FOR EVOLUTION** below

In general, components that are utilities do not have a **RETURN VALUE** section. Except as noted in the detailed definition for a particular utility, utilities return a zero exit code for *success*, and non-zero for *failure.*

The component definitions are similar in format to AT&T System V manual pages, but have been extended or modified as follows:

- All machine-specific or implementation-specific information has been removed. All implementation-specific constants have been replaced by symbolic names, which are defined in a separate section [see **Implementation-specific constants** in **Volume I: Part II — Base System Definition: Chapter 4 — Definitions**]. When these symbolic names are used they always appear in curly brackets, e.g., {PROC_MAX}. The symbolic names correspond to those defined by the November 1985 draft of the IEEE P1003 Standard to be in a `<limits.h>` header file; however, in this document, they are *not* meant to be read as symbolic constants defined in header files.

- A section entitled **FUTURE DIRECTIONS** has been added to selected component definitions. This section indicates how a component will evolve. The information ranges from specific changes in functionality to more general indications of proposed development.

- A section entitled **APPLICATION USAGE** or **USAGE** has been added to guide application developers on the expected or recommended usage of certain components. Detailed definitions of operating system services and library routines have an **APPLICATION USAGE** paragraph while utilities have a **USAGE** paragraph.

While operating system services and library routines are only used by programs, utilities may be used by programs, by end-users or by system administrators. The **USAGE** paragraph indicates which of these three is appropriate for a particular utility (this is not meant to be prescriptive, but rather to give guidance). The following terms are used in the **USAGE** paragraph: *application-program*, *end-user*, *system-administrator*, or *general*. The term *general* indicates that the utility might be used by all three: application-programs, end-users and system-administrators.

- A section entitled **LEVEL** defines each component's commitment level:

  Level-1 components will remain in the SVID and can be modified only in upwardly compatible ways. Any change in its definition will preserve the previous source-code interface and run-time behavior in order to ensure that the component remains upwardly-compatible.

  Level-2 components will remain unchanged for at least three years following entry into level-2, after which time the component may be modified in a non-upwardly compatible way or may be dropped from the SVID. Level-2 components are labeled with the starting date of this three-year period.

1.3 MECHANISM FOR EVOLUTION

The SVID will be reissued as necessary to reflect developments in the System V Interface. In conjunction with these updates, the following changes may be made to the definitions:

- Level-1 components may be moved to level-2. The date of their entry into level-2 will be the date of the reissue of the SVID in which the change is made.
- Level-1 components will *not* move from one Extension into another Extension.
- Components may move *from* existing Extensions *into* the Base System. Components will *not* move *from* the Base System *into* an Extension.
- New Extensions may be introduced with completely new functionality.

1.4 C LANGUAGE DEFINITION

Source-code interfaces described in the SVID are for the C language.

The following two references define the C language for System V Release 1.0 and System V Release 2.0 respectively:

- *UNIX™ System V Programming Guide*, Issue 1, February 1982.
- *UNIX™ System V Programming Guide*, Issue 2, April 1984.

Chapter 2
Future Directions

2.1 NETWORK SERVICES EXTENSION

The Network Services Extension will provide advanced standard interfaces to support networking applications. It is divided into three functional areas. The Open Systems Networking Interfaces section describes a protocol-independent application interface to transport services based on the Open Systems Interconnection (OSI) Reference Model [IS 7498]. The Streams I/O Interfaces section describes the operating system service routines that provide direct access to protocol modules implemented using the streams framework. The Shared Resource Environment section describes new capabilities for sharing and administering resources among interconnected machines.

2.2 OPERATING SYSTEM STANDARDS

The IEEE P1003 working group is currently pursuing a draft standard for a portable operating system interface. The *System V Interface Definition* is consistent with the trial-use standard (November 1985), with several minor exceptions. Full conformance to the IEEE standard will be strongly considered after its formal approval.

2.3 C LANGUAGE STANDARDIZATION

AT&T is committed to support the standardization of the C language being pursued by ANSI X3J11, in which its representatives take a leading role. Full conformance to the ANSI standard will be strongly considered after formal approval.

2.4 FLOATING POINT STANDARDS

The IEEE P754 Standard for Binary Floating Point Arithmetic will be supported by System V. The existing library routines that deal with floating point numbers, and which are likely to change in order to support the IEEE P754 Standard, belong to the following classes:

- routines that do arithmetic operations;
- routines that do input/output;
- routines that manipulate floating point numbers.

However, these changes are hardware dependent and will appear only on the machines whose underlying floating point data representation and exception handling mechanisms are those specified by the IEEE P754 Standard.

2.5 GRAPHICS EXTENSION

This Extension will track current industry efforts to define standards for graphics functions. One area under active consideration is the Graphical Kernel Subsystem (GKS).

2.6 TERMINAL INTERFACE EXTENSION

The current Terminal Interface Extension consists of the facilities provided by the curses/terminfo package to allow application programs to perform terminal-handling functions in a way that is independent of the type of terminal actually in use. This Extension will be enhanced to support applications on both character and bit-mapped terminals and to provide capabilities for handling windows, menus, icons, etc. which can be accessed by a keyboard or other input device, such as a mouse. Applications written in this environment will have a uniform and easily used human interface. In addition, applications which rely on curses/terminfo will be compatible with the new environment.

2.7 INTERNATIONALIZATION

Where necessary, modifications will be made, in an upwardly compatible way, to existing System V components to support internationalization. In addition, new components will be added to support features not currently available in System V. These will include tools that will allow *national supplements* to be added to an implementation of System V.

National supplements would be small packages that contained the necessary supplementary information, such as messages, databases, documentation, and device-drivers that, when installed, would allow an implementation of System V to process different national languages and support hardware (i.e., terminals, printers) and local conventions found in different countries. System builders would be able to create national supplements using the tools provided in System V.

More than one national supplement could be installed on a system at a time, resulting in a system with multiple language capabilities; however, national supplements are envisioned as self-contained, not requiring or depending on other installed national supplements.

Facilities that System V will provide to support internationalization and the development of national supplements are:

- Messages and text from the kernel, utilities, and application programs will be separated to enable support for national languages.
- Local conventions, or *environments*, will be supported transparently, depending on the language selected by the user. Among the conventions to be supported are date and time formats, collating sequences, and numeric representations.
- Supplementary code-sets will be supported to allow use of multiple code-sets, and consequently character symbols, in addition to the ASCII code-set.

- Sixteen-bit code-sets will be supported. This will allow languages of Far Eastern countries (i.e., Japan, Republic of China, Korea, the People's Republic of China, etc.) to be used.
- Language selection will be provided at the user-level to allow users of different languages to use the same system at the same time in their respective languages.

Message Handling.
In the future, System V will support a facility to produce messages and text in national languages. In conjunction with the *Error Handling Standards* defined in **Volume I: Part II — Base System Definition: Chapter 7 — General Library Routines**, messages and text from the kernel, utilities, and applications would be stored separately. In addition, a set of administrative utilities would be provided to allow the creation of new messages and strings, as well as modification to existing ones.

Local Conventions.
Local conventions define the common forms and rules used to communicate information. The aim of internationalization is to provide System V applications and utilities with the capability to interact with the end-user according to these local-conventions. At the same time, applications and utilities must be portable and easily adapted to other conventions (i.e., they must be shielded from any particular set of conventions). Existing utilities and interfaces will be modified to support both implicit and explicit invocation of these conventions, with the following areas targeted for support:

Collating Sequence: The capability to define one or more *collating sequences* for a specific code-set will be provided. Utilities providing sorted output or requiring sorted input will be modified to allow invocation of different collating sequences. In addition, tools will be provided to support defining of specific collating sequences.

Character Classification: The capability to define, on a language-by-language basis, character classes will be provided. The CTYPE(BA_LIB) library will be enhanced to provide character classification in local languages. Where possible, this capability will be provided through the existing classification routines. In addition, new routines will be provided to support new capabilities (i.e., returning an indication of which code-set a particular character comes from).

Date and Time Format: The capability to enter and display date and time in the local language and according to local formats will be provided. This applies to all utilities or services that operate with date/time specifications.

Numeric Representation: The capability to define the rules for numeric editing (such as decimal delimiter) will be provided.

Currency Representation: The capability to specify rules and formats for editing local currency will be provided.

8th-bit Cleanup.
To support code-sets in addition to **ASCII**, all 8-bits of a byte will be used for character encoding. For example, some existing routines or utilities reject characters with octal values greater than 177. Future releases will eliminate this and similar problems.

Code-Set and Character Support.
There are essentially two representations that make up the code-set:

the *external code-set* and the *internal code-set.*

The external code-set are those code-sets generated by input/output devices (i.e., terminals, printers, etc.). The most notable example is the seven-bit **ASCII**[1] code-set produced by most terminals and printers connected to System V today.

The internal code-set is a transformation of the external code-set according to the rules presented in this section, and is used to represent bytes throughout the rest of System V. Normally, no part of System V, except a device-driver, will see the external code-set; however, in many cases, the external and internal encodings will be the same with only minor exceptions.

The device-driver has the sole responsibility of mapping an external code-set to an internal code-set and vice-versa.

The following sections describe a template for transforming externally coded characters into internally coded characters, methods of designating a particular code-set to be used, and methods of designating a particular language to be used.

A *Code-Set Template* is a template for transforming externally coded characters into internally coded characters accessible by the System V operating system, utilities, and applications. The internal coding method discussed here is based on the **ISO 2022-1982** standard for code extension techniques, which suggests the following two techniques for shifting between code-sets:

- Single-shift
- Locking-shift

The single-shift is a single byte used to announce a temporary shift to another code-set. The byte, or bytes, immediately following the single-shift code are interpreted as part of a new code-set. Subsequent characters are interpreted as belonging to the primary code-set.

1. **ASCII**, as it is used here, is defined as the seven-bit code-set used for information interchange in the United States. It does *not* refer to the extended eight-bit **ASCII** code-set, sometimes known as **ASCII-8**, or local derivatives of the seven-bit **ASCII** code-set used in parts of Europe.

The **ISO** standard defines two single-shift characters:

1. **SS2**, or *single-shift two*, and
2. **SS3**, or *single-shift three*.

The **SS2** character is represented by hexadecimal `8e`, while the **SS3** character is represented by hexadecimal `8f`.

The locking-shift technique is used to temporarily *shift-in* and *shift-out* of code-sets. It consists of a pair of character sequences that allow a new code-set to be used for more than one character. While in the context of a locking-shift sequence, all characters, with the exception of single-shifted characters, are assumed to belong to the new code-set.

Because of the context sensitivity of the locking-shift sequence, this method is not recommended for use in System V. Therefore, the use of the single-shift sequence is recommended to reduce the context sensitivity to as little as possible.

In addition to using the single-shifts to distinguish characters, the eighth-bit will also be used to distinguish between the primary code-set and characters in one of the three supplementary code-sets. By using the combination of eighth-bit and single-shift characters, the internal coding method specifies a template for allowing four code-sets to coexist simultaneously: one primary code-set and three supplementary code-sets, with the two of the latter denoted by a single-shift character. The representations for these internal code-sets are shown below:

Code-Set	Internal Representation
Set 0 (Primary code-set)	`0xxxxxxx`
Set 1 (Supplementary code-set #1)	`1xxxxxxx` — or — `1xxxxxxx 1xxxxxxx`
Set 2 (Supplementary code-set #2)	`SS2 1xxxxxxx` — or — `SS2 1xxxxxxx 1xxxxxxx`
Set 3 (Supplementary code-set #3)	`SS3 1xxxxxxx` — or — `SS3 1xxxxxxx 1xxxxxxx`

Designation of the exact value of the four code-sets is performed through a code-set designation and is discussed in the following section.

A *Code-Set Designation* will be dynamic and accessible/modifiable at the operating system, utility and application levels to satisfy the specific needs for supporting multiple code-sets. It will also reside at the file level, so files with different code-set designations can exist on the same machine. That is, one file may be encoded with one set of code-sets while another file is encoded with another set of code-sets.

Specifically, it is desirable for code-set designation to meet the following requirements:

1. Code-set designations should be supported at the file level. Each file would contain its own set of code-set designation values.
2. At file creation time, all files would be designated with a system-wide default value.
3. Code-set designations could be changed dynamically.
4. The code-set designation value should contain information about:
   - The width of a character in the code-set,
   - The specific code-set designated (e.g., DIS 8859/1[2], JIS 6226[3], etc.),
5. Code-set designation information should be transferrable with the file contents across networks.

In addition to the code-set designation, a *language-designation* would offer the ability to designate which of several languages should be used for producing systems messages and for establishing an overall profile of the user's environment. One method under consideration for this type of designation is to use one or more exported environment-variables. For example, a LANGUAGE variable would be used to denote the language (e.g., French, German, Italian, Japanese, English, etc.). This variable would also be used as an index to user profile information to determine which local conventions to use. The variable could be assigned at initiation of the login session and could also be changed at any time. In this way, language-designation is performed at user-level and controls the language of all system messages and text coming out of the operating system, utilities and applications, as well as particular national conventions.

Handling Non-standard Code-Sets. There are several code-sets in the world that the code-set template described here cannot support. The problem centers around the use of the eighth-bit to distinguish between characters in different code-sets. Specifically, these code-sets are as follows:

- The *shifted*-JIS code-set used in Japan,
- The packed Hangul code-set used in Korea,
- The Big 5 code-set used in the Republic of China (Taiwan),
- The Chinese Code for Data Communications also used in the Republic of China.

2. DIS 8859/1 Latin Language no. 1 is the newly-adopted ISO standard code-set, supporting most of the Western European characters. It is an 8-bit code-set that contains US ASCII as a subset.
3. JIS 6226 is a ISO standard code-set for supporting the Japanese language. It is a 16-bit code-set that contains both hiragana and katakana alphabets, as well as about 7000 of the kanji ideograms.

Present plans are to provide limited support for these code-sets. Limited support means that files containing these code-sets could be stored on System V machines. No other support is currently planned; this implies that the mechanism for processing these files would have to be built into applications.

Character Support. In some applications it will be necessary to manipulate the variable-width characters coming from the supplementary code-sets. Although some application developers may choose to develop their own facilities for supporting this, System V will provide a generic facility for manipulating internally coded eight-bit bytes to a data type that can represent characters in a consistent manner. Initially, a new data type will be defined in the C programming language to support up to 16-bits of information. In addition, routines that use this new data type will be provided to allow application-developers to perform operations on them.

Part II

Base System Definition

Chapter 3 Introduction

The Base System is intended to support a minimal run-time environment for executable applications. The Base System defines a basic set of System V components needed by applications-programs. This basic set would be supported by any conforming system. It defines each component's source-code interface and run-time behavior, but does not specify its implementation. Source-code interfaces described are for the C language. While only the run-time behavior of these components is supported by the Base System, the source-code interfaces to these components are defined because an objective of the SVID is to facilitate application-program source-code portability across all System V implementations. It is assumed that an application-program targeted to run on a system that provides only the Base System (a run-time environment) would be *compiled* on a system supporting software development.

No end-user level utilities (commands) are defined in the Base System. Executable application-programs designed for maximum portability are expected to use library routines rather than System V end-user level utilities. For example, an application-program written in C would use the CHOWN(BA_OS) routine to change the owner of a file rather than using the CHOWN(AU_CMD) user-level utility. This does not say that an application-program running in a target environment that supports only the Base System cannot execute another program. Using the SYSTEM(BA_OS) routine, an application can execute another program or application.

It should be noted that some Extensions may add features to components defined in the Base System. These additional features that are supported in an extended environment are described with the Extension in a section titled EFFECTS(XX_ENV). See, for example, EFFECTS(KE_ENV) in **Volume I: Part III — Kernel Extension Definition: Chapter 10 — Environment.**

Definitions for the Base System are given in the next chapter, **Chapter 4 — Definitions.** Because the Base System is a prerequisite for any Extension, these definitions also apply to the Extensions. **Chapter 5 — Environment** describes the Base System Environment, including error conditions, environmental variables, directory tree structure, data files and special device files that must be present on a Base System. **Chapter 6 — OS Service Routines** defines operating system service routines that provide applications access to basic system resources (e.g., allocating dynamic storage) and **Chapter 7 — General Library Routines** defines general purpose library routines (e.g., string handling routines). The remainder of this introduction gives an overview of the contents of **Chapter 6 — OS Service Routines** and **Chapter 7 — General Library Routines.**

3.1 OPERATING SYSTEM SERVICE ROUTINES

Table 3-1 lists the Operating System Service Routines whose run-time behavior must be supported by any implementation of the Base System.

TABLE 3-1. Base System: OS Service Routines

abort	ABORT(BA_OS)	getuid	GETUID(BA_OS)
access	ACCESS(BA_OS)	ioctl	IOCTL(BA_OS)
alarm	ALARM(BA_OS)	kill	KILL(BA_OS)
calloc	MALLOC(BA_OS)	link	LINK(BA_OS)
chdir	CHDIR(BA_OS)	lockf††	LOCKF(BA_OS)
chmod	CHMOD(BA_OS)	mallinfo†	MALLOC(BA_OS)
chown	CHOWN(BA_OS)	malloc	MALLOC(BA_OS)
clearerr	FERROR(BA_OS)	mallopt†	MALLOC(BA_OS)
dup	DUP(BA_OS)	mknod	MKNOD(BA_OS)
exit	EXIT(BA_OS)	pause	PAUSE(BA_OS)
fclose	FCLOSE(BA_OS)	pclose	POPEN(BA_OS)
fcntl	FCNTL(BA_OS)	pipe	PIPE(BA_OS)
fdopen	FOPEN(BA_OS)	popen	POPEN(BA_OS)
feof	FERROR(BA_OS)	realloc	MALLOC(BA_OS)
ferror	FERROR(BA_OS)	rewind	FSEEK(BA_OS)
fflush	FCLOSE(BA_OS)	setgid	SETUID(BA_OS)
fileno	FERROR(BA_OS)	setpgrp	SETPGRP(BA_OS)
fopen	FOPEN(BA_OS)	setuid	SETUID(BA_OS)
fread	FREAD(BA_OS)	signal	SIGNAL(BA_OS)
free	MALLOC(BA_OS)	sleep	SLEEP(BA_OS)
freopen	FOPEN(BA_OS)	stat	STAT(BA_OS)
fseek	FSEEK(BA_OS)	stime	STIME(BA_OS)
fstat	STAT(BA_OS)	system	SYSTEM(BA_OS)
ftell	FSEEK(BA_OS)	time	TIME(BA_OS)
fwrite	FREAD(BA_OS)	times	TIMES(BA_OS)
getcwd	GETCWD(BA_OS)	ulimit	ULIMIT(BA_OS)
getegid	GETUID(BA_OS)	umask	UMASK(BA_OS)
geteuid	GETUID(BA_OS)	uname	UNAME(BA_OS)
getgid	GETUID(BA_OS)	unlink	UNLINK(BA_OS)
getpgrp	GETPID(BA_OS)	ustat	USTAT(BA_OS)
getpid	GETPID(BA_OS)	utime	UTIME(BA_OS)
getppid	GETPID(BA_OS)	wait	WAIT(BA_OS)

close	CLOSE(BA_OS)	fork	FORK(BA_OS)
creat	CREAT(BA_OS)	lseek	LSEEK(BA_OS)
execl	EXEC(BA_OS)	mount	MOUNT(BA_OS)
execle	EXEC(BA_OS)	open	OPEN(BA_OS)
execlp	EXEC(BA_OS)	read	READ(BA_OS)
execv	EXEC(BA_OS)	umount	UMOUNT(BA_OS)
execve	EXEC(BA_OS)	write	WRITE(BA_OS)
execvp	EXEC(BA_OS)		

_exit	EXIT(BA_OS)	sync	SYNC(BA_OS)

The operating system service routines provide access to and control over system resources such as memory, files, process execution. Some System V routines that provide operating system services are not supported by the Base System. An application-program that used any of these would require an *extended* environment. See, for example, **Part III — Kernel Extension.**

All the routines in Table 3-1, except those marked with † or ††, are common to System V Release 1.0 and System V Release 2.0. Those marked with † first appeared in System V Release 2.0. The function `lockf`, marked with ††, is a post System V Release 2.0 component.

Table 3-1 is shown as three sets of routines, which reflect recommended usage by application-programs.

The first set of routines (from `abort` to `wait`) should fulfill the needs of most application-programs.

The second set of routines (from `close` to `write`) should be used by application-programs only when some special need requires it. For example, application-programs, when possible, should use the routine `system` rather than the routines `fork` and `exec` because it is easier to use and supplies more functionality. The corresponding Standard Input/Output, *stdio* routines [see **stdio-routines** in **Chapter 4 — Definitions**] should be used instead of the routines `close`, `creat`, `lseek`, `open`, `read`, `write` (e.g., the *stdio* routine `fopen` should be used rather than the routine `open`).

The third set of routines (`_exit` and `sync`), although they are defined as part of the basic set of routines supported by any System V operating system, are not expected to be used by application-programs. These routines are used by other components of the Base System.

3.2 GENERAL LIBRARY ROUTINES

Table 3-2 lists the basic set of General Library Routines that are likely to be used by application-programs.

TABLE 3-2. Base System: General Library Routines

abs	ABS(BA_LIB)	j0	BESSEL(BA_LIB)
acos	TRIG(BA_LIB)	j1	BESSEL(BA_LIB)
asin	TRIG(BA_LIB)	jn	BESSEL(BA_LIB)
atan2	TRIG(BA_LIB)	ldexp	FREXP(BA_LIB)
atan	TRIG(BA_LIB)	log10	EXP(BA_LIB)
ceil	FLOOR(BA_LIB)	log	EXP(BA_LIB)
cos	TRIG(BA_LIB)	matherr	MATHERR(BA_LIB)
cosh	SINH(BA_LIB)	modf	FREXP(BA_LIB)
erf	ERF(BA_LIB)	pow	EXP(BA_LIB)
erfc	ERF(BA_LIB)	sin	TRIG(BA_LIB)
exp	EXP(BA_LIB)	sinh	SINH(BA_LIB)
fabs	FLOOR(BA_LIB)	sqrt	EXP(BA_LIB)
floor	FLOOR(BA_LIB)	tan	TRIG(BA_LIB)
fmod	FLOOR(BA_LIB)	tanh	SINH(BA_LIB)
frexp	FREXP(BA_LIB)	y0	BESSEL(BA_LIB)
gamma	GAMMA(BA_LIB)	y1	BESSEL(BA_LIB)
hypot	HYPOT(BA_LIB)	yn	BESSEL(BA_LIB)
_tolower	CONV(BA_LIB)	memccpy	MEMORY(BA_LIB)
_toupper	CONV(BA_LIB)	memchr	MEMORY(BA_LIB)
advance	REGEXP(BA_LIB)	memcmp	MEMORY(BA_LIB)
asctime	CTIME(BA_LIB)	memcpy	MEMORY(BA_LIB)
atof	STRTOD(BA_LIB)	memset	MEMORY(BA_LIB)
atoi	STRTOL(BA_LIB)	setkey#	CRYPT(BA_LIB)
atol	STRTOL(BA_LIB)	step	REGEXP(BA_LIB)
compile	REGEXP(BA_LIB)	strcat	STRING(BA_LIB)
crypt#	CRYPT(BA_LIB)	strchr	STRING(BA_LIB)
ctime	CTIME(BA_LIB)	strcmp	STRING(BA_LIB)
encrypt#	CRYPT(BA_LIB)	strcpy	STRING(BA_LIB)
gmtime	CTIME(BA_LIB)	strcspn	STRING(BA_LIB)
isalnum	CTYPE(BA_LIB)	strlen	STRING(BA_LIB)
isalpha	CTYPE(BA_LIB)	strncat	STRING(BA_LIB)
isascii	CTYPE(BA_LIB)	strncmp	STRING(BA_LIB)
iscntrl	CTYPE(BA_LIB)	strncpy	STRING(BA_LIB)
isdigit	CTYPE(BA_LIB)	strpbrk	STRING(BA_LIB)
isgraph	CTYPE(BA_LIB)	strrchr	STRING(BA_LIB)
islower	CTYPE(BA_LIB)	strspn	STRING(BA_LIB)
isprint	CTYPE(BA_LIB)	strtod†	STRTOD(BA_LIB)
ispunct	CTYPE(BA_LIB)	strtok	STRING(BA_LIB)
isspace	CTYPE(BA_LIB)	strtol	STRTOL(BA_LIB)
isupper	CTYPE(BA_LIB)	toascii	CONV(BA_LIB)
isxdigit	CTYPE(BA_LIB)	tolower	CONV(BA_LIB)
localtime	CTIME(BA_LIB)	toupper	CONV(BA_LIB)
		tzset	CTIME(BA_LIB)

bsearch	BSEARCH(BA_LIB)	perror*	PERROR(BA_LIB)
clock	CLOCK(BA_LIB)	printf	PRINTF(BA_LIB)
ctermid	CTERMID(BA_LIB)	putc	PUTC(BA_LIB)
drand48	DRAND48(BA_LIB)	putchar	PUTC(BA_LIB)
erand48	DRAND48(BA_LIB)	putenv†	PUTENV(BA_LIB)
fgetc	GETC(BA_LIB)	puts	PUTS(BA_LIB)
fgets	GETS(BA_LIB)	putw	PUTC(BA_LIB)
fprintf	PRINTF(BA_LIB)	qsort	QSORT(BA_LIB)
fscanf	SCANF(BA_LIB)	rand	RAND(BA_LIB)
fputc	PUTC(BA_LIB)	scanf	SCANF(BA_LIB)
fputs	PUTS(BA_LIB)	seed48	DRAND48(BA_LIB)
ftw	FTW(BA_LIB)	setbuf	SETBUF(BA_LIB)
getc	GETC(BA_LIB)	setjmp	SETJMP(BA_LIB)
getchar	GETC(BA_LIB)	setvbuf†	SETBUF(BA_LIB)
getenv	GETENV(BA_LIB)	sprintf	PRINTF(BA_LIB)
getopt	GETOPT(BA_LIB)	srand48	DRAND48(BA_LIB)
gets	GETS(BA_LIB)	srand	RAND(BA_LIB)
getw	GETC(BA_LIB)	sscanf	SCANF(BA_LIB)
gsignal*	SSIGNAL(BA_LIB)	ssignal*	SSIGNAL(BA_LIB)
hcreate	HSEARCH(BA_LIB)	swab	SWAB(BA_LIB)
hdestroy	HSEARCH(BA_LIB)	tdelete	TSEARCH(BA_LIB)
hsearch	HSEARCH(BA_LIB)	tempnam	TMPNAM(BA_LIB)
isatty	TTYNAME(BA_LIB)	tfind†	TSEARCH(BA_LIB)
jrand48	DRAND48(BA_LIB)	tmpfile	TMPFILE(BA_LIB)
lcong48	DRAND48(BA_LIB)	tmpnam	TMPNAM(BA_LIB)
lfind†	LSEARCH(BA_LIB)	tsearch	TSEARCH(BA_LIB)
longjmp	SETJMP(BA_LIB)	ttyname	TTYNAME(BA_LIB)
lrand48	DRAND48(BA_LIB)	twalk	TSEARCH(BA_LIB)
lsearch	LSEARCH(BA_LIB)	ungetc	UNGETC(BA_LIB)
mktemp	MKTEMP(BA_LIB)	vfprintf†	VPRINTF(BA_LIB)
mrand48	DRAND48(BA_LIB)	vprintf†	VPRINTF(BA_LIB)
nrand48	DRAND48(BA_LIB)	vsprintf†	VPRINTF(BA_LIB)

The general library routines perform a wide range of useful functions including: mathematical functions shown in the first part of Table 3-2; string and character handling routines shown in the second part of Table 3-2; I/O routines, search routines, sorting routines and others shown in the third part of Table 3-2.

The *run-time* behavior of these routines, as defined in the SVID, must be supported by any System V operating system. The libraries themselves are not required to be present on a system that consists only of the Base System. While the Base System is required to support the execution of application-programs that use these routines, the Software Development Extension [see **Volume II: Part V — Software Development Extension Definition**] is required to support the compilation of those application-programs.

Routines marked with † are in System V Release 2.0 only, while all others are in both System V Release 1.0 and System V Release 2.0. Routines marked with * are level-2, as defined in **Chapter 1 — General Introduction**. Routines marked with # are optional and may not be present on all conforming systems.

Chapter 4
Definitions

ASCII character set

Tables 3-1 and 3-2 are maps of the **ASCII** character set, giving octal and hexadecimal equivalents of each character. Although the **ASCII** code does not use the eighth-bit in an octet, this bit should not be used for other purposes because codes for other languages may need to use it (see section on **INTERNATIONALIZATION** in **Chapter 2 Future Directions**).

000	nul	001	soh	002	stx	003	etx	004	eot	005	enq	006	ack	007	bel
010	bs	011	ht	012	nl	013	vt	014	np	015	cr	016	so	017	si
020	dle	021	dc1	022	dc2	023	dc3	024	dc4	025	nak	026	syn	027	etb
030	can	031	em	032	sub	033	esc	034	fs	035	gs	036	rs	037	us
040	sp	041	!	042	"	043	#	044	$	045	%	046	&	047	'
050	(	051	)	052	*	053	+	054	,	055	-	056	.	057	/
060	0	061	1	062	2	063	3	064	4	065	5	066	6	067	7
070	8	071	9	072	:	073	;	074	<	075	=	076	>	077	?
100	@	101	A	102	B	103	C	104	D	105	E	106	F	107	G
110	H	111	I	112	J	113	K	114	L	115	M	116	N	117	O
120	P	121	Q	122	R	123	S	124	T	125	U	126	V	127	W
130	X	131	Y	132	Z	133	[	134	\	135	]	136	^	137	_
140	`	141	a	142	b	143	c	144	d	145	e	146	f	147	g
150	h	151	i	152	j	153	k	154	l	155	m	156	n	157	o
160	p	161	q	162	r	163	s	164	t	165	u	166	v	167	w
170	x	171	y	172	z	173	{	174	¦	175	}	176	~	177	del

TABLE 3-1. Octal map of ASCII character set.

00	nul	01	soh	02	stx	03	etx	04	eot	05	enq	06	ack	07	bel
08	bs	09	ht	0a	nl	0b	vt	0c	np	0d	cr	0e	so	0f	si
10	dle	11	dc1	12	dc2	13	dc3	14	dc4	15	nak	16	syn	17	etb
18	can	19	em	1a	sub	1b	esc	1c	fs	1d	gs	1e	rs	1f	us
20	sp	21	!	22	"	23	#	24	$	25	%	26	&	27	'
28	(	29	)	2a	*	2b	+	2c	,	2d	-	2e	.	2f	/
30	0	31	1	32	2	33	3	34	4	35	5	36	6	37	7
38	8	39	9	3a	:	3b	;	3c	<	3d	=	3e	>	3f	?
40	@	41	A	42	B	43	C	44	D	45	E	46	F	47	G
48	H	49	I	4a	J	4b	K	4c	L	4d	M	4e	N	4f	O
50	P	51	Q	52	R	53	S	54	T	55	U	56	V	57	W
58	X	59	Y	5a	Z	5b	[	5c	\	5d	]	5e	^	5f	_
60	`	61	a	62	b	63	c	64	d	65	e	66	f	67	g
68	h	69	i	6a	j	6b	k	6c	l	6d	m	6e	n	6f	o
70	p	71	q	72	r	73	s	74	t	75	u	76	v	77	w
78	x	79	y	7a	z	7b	{	7c	¦	7d	}	7e	~	7f	del

TABLE 3-2. Hexadecimal map of ASCII character set.

directory
Directories organize files into a hierarchical system of files where directories are the nodes in the hierarchy. A directory is a file that catalogues the list of files, including directories (sub-directories), that are directly beneath it in the hierarchy. Entries in a directory file are called links. A link associates a file identifier with a file name. By convention, a directory contains at least two links, . (*dot*) and .. (*dot-dot*). The link called *dot* refers to the directory itself while *dot-dot* refers to its parent-directory. The root-directory, which is the top-most node of the hierarchy, has itself as its parent-directory. The **path-name** of the root directory is / and the parent-directory of the root-directory is /.

effective-user-ID and **effective-group-ID**
An active process has an effective-user-ID and an effective-group-ID that are used to determine file access permissions (see below). The effective-user-ID and effective-group-ID are equal to the process's real-user-ID and real-group-ID respectively, unless the process or one of its ancestors evolved from a file that had the set-user-ID bit or set-group-ID bit set [see EXEC(BA_OS)]. In addition, they can be reset with the SETUID(BA_OS) and SETGID(BA_OS) routines, respectively.

environmental variables
When a process begins, an array of strings called the *environment* is made available by the EXEC(BA_OS) routine [see also SYSTEM(BA_OS)]. By convention, these strings have the form `variable=value`, for example, `PATH=:/bin:/usr/bin`. These environmental variables provide a way to make information about an end-user's environment available to programs [see ENVVAR(BA_ENV)].

file access permissions
Read, write, and execute/search permissions [see CHMOD(BA_OS)] on a file are granted to a process if one or more of the following are true:

- The effective-user-ID of the process is super-user.
- The effective-user-ID of the process matches the user-ID of the owner of the file and the appropriate access bit of the *owner* portion of the file mode is set.
- The effective-user-ID of the process does not match the user-ID of the owner of the file and the effective-group-ID of the process matches the group of the file and the appropriate access bit of the *group* portion of the file mode is set.
- The effective-user-ID of the process does not match the user-ID of the owner of the file and the effective-group-ID of the process does not match the group-ID of the file and the appropriate access bit of the *other* portion of the file mode is set.

Otherwise, the corresponding permissions are denied.

file-descriptor
A file-descriptor is a small integer used to identify a file for the purposes of doing I/O. The value of a file-descriptor is from 0 to {OPEN_MAX}−1. An open file-descriptor is obtained from a call to the CREAT(BA_OS), DUP(BA_OS), FCNTL(BA_OS), OPEN(BA_OS), or PIPE(BA_OS) routine. A process may have no more than {OPEN_MAX} file-descriptors open simultaneously.

A file-descriptor has associated with it information used in performing I/O on the file: a file pointer that marks the current position within the file where I/O will begin; file status and access modes (e.g., read, write, read/write) [see OPEN(BA_OS)]; and close-on-exec flag [see FCNTL(BA_OS)]. Multiple file-descriptors may identify the same file. The file-descriptor is used as an argument by such routines as the READ(BA_OS), WRITE(BA_OS), IOCTL(BA_OS), and CLOSE(BA_OS) routines.

file-name
Strings consisting of 1 to {NAME_MAX} characters may be used to name an ordinary file, a special file or a directory. {NAME_MAX} must be at least 14. These characters may be selected from the set of all character values excluding the characters "null" and "slash" (/).

Note that it is generally unwise to use *, ?, !, [, or] as part of file-names because of the special meaning attached to these characters for file-name expansion by the command interpreter [see SYSTEM(BA_OS)]. Other characters to avoid are the hyphen, blank, tab, <, >, backslash, single and double quotes, accent grave, vertical bar, caret, curly braces, and parentheses. It is also advisable to avoid the use of non-printing characters in file names.

implementation-specific constants
In detailed definitions of components, it is sometimes necessary to refer to constants that are implementation-specific, but which are not necessarily expected to be accessible to an application-program. Many of these constants describe boundary-conditions and system-limits.

In the SVID, for readability, these constants are replaced with symbolic names. These names always appear enclosed in curly brackets to distinguish them from symbolic names of other implementation-specific constants that are accessible to application-programs by header files. These names are not necessarily accessible to an application-program through a header file, although they may be defined in the documentation for a particular system.

In general, a portable application program should not refer to these constants in its code. For example, an application-program would not be expected to test the length of an argument list given to an EXEC(BS_OS) routine to determine if it was greater than {ARG_MAX}.

The following lists the implementation-specific constants that may be used in System V component definitions:

Name	*Description*
{ARG_MAX}	max. length of argument to `exec`
{CHAR_BIT}	number of bits in a `char`
{CHAR_MAX}	max. integer value of a `char`
{CHILD_MAX}	max. number of processes per user-ID
{CLK_TCK}	number of clock ticks per second
{FCHR_MAX}	max. size of a file in bytes
{INT_MAX}	max. decimal value of an `int`
{LINK_MAX}	max. number of links to a single file
{LOCK_MAX}	max. number of entries in system lock table
{LONG_BIT}	number of bits in a `long`
{LONG_MAX}	max. decimal value of a `long`
{MAXDOUBLE}	max. decimal value of a `double`
{MAX_CHAR}	max. size of character input buffer
{NAME_MAX}	max. number of characters in a file-name
{OPEN_MAX}	max. number of files a process can have open
{PASS_MAX}	max. number of significant characters in a password
{PATH_MAX}	max. number of characters in a path-name
{PID_MAX}	max. value for a process-ID
{PIPE_BUF}	max. number bytes atomic in write to a pipe
{PIPE_MAX}	max. number of bytes written to a pipe in a write
{PROC_MAX}	max. number of simultaneous processes, system wide
{SHRT_MAX}	max. decimal value of a `short`
{STD_BLK}	number of bytes in a physical I/O block
{SYS_NMLN}	number of characters in string returned by `uname`
{SYS_OPEN}	max. number of files open on system
{TMP_MAX}	max. number of unique names generated by `tmpnam`
{UID_MAX}	max. value for a user-ID or group-ID
{USI_MAX}	max. decimal value of an `unsigned`
{WORD_BIT}	number of bits in a `word` or `int`
{CHAR_MIN}	min. integer value of a `char`
{INT_MIN}	min. decimal value of an `int`
{LONG_MIN}	min. decimal value of a `long`
{SHRT_MIN}	min. decimal value of a `short`

parent-process-ID

The parent-process-ID of a process is the process-ID of its creator. A new process is created by a currently active-process [see FORK(BA_OS)].

path-name and **path-prefix**
In a C program, a path-name is a null-terminated character-string starting with an optional slash (/), followed by zero or more directory-names separated by slashes, optionally followed by a file-name. A null string is undefined and may be considered an error.

More precisely, a path-name is a null-terminated character-string as follows:

```
<path_name>::=<file_name>|<path_prefix><file_name>|/|.|..
<path_prefix>::=<rtprefix>|/<rtprefix>|empty
<rtprefix>::=<dirname>/|<rtprefix><dirname>/
```

where `<file_name>` is a string of 1 to {NAME_MAX} significant characters other than slash and null, and `<dirname>` is a string of 1 to {NAME_MAX} significant characters (other than slash and null) that names a directory. The result of names not produced by the grammar are undefined.

If a path-name begins with a slash, the path search begins at the root-directory. Otherwise, the search begins from the current-working-directory.

A slash by itself names the root-directory. The meanings of . and .. are defined under **directory**.

process-group-ID
Each active-process is a member of a process-group. The process-group is uniquely identified by a positive-integer, called the process-group-ID, which is the process-ID of the group-leader (see below). This grouping permits the signaling of related processes [see KILL(BA_OS)].

process-group-leader
A process group leader is any process whose process-group-ID is the same as its process-ID. Any process may detach itself from its current process-group and become a new process-group-leader by calling the SETPGRP(BA_OS) routine. A process inherits the process-group-ID of the process that created it [see FORK(BA_OS) and EXEC(BA_OS)].

process-ID
Each active-process in the system is uniquely identified by a positive-integer called a process-ID. The range of this ID is from 0 to {PID_MAX}. By convention, process-ID 0 and 1 are reserved for special system-processes.

real-user-ID and **real-group-ID**
Each user allowed on the system is identified by a positive-integer called a real-user-ID. Each user is also a member of a group. The group is identified by a positive-integer called the real-group-ID.

An active-process has a real-user-ID and real-group-ID that are set to the real-user-ID and real-group-ID, respectively, of the user responsible for the creation of the process. They can be reset with the SETUID(BA_OS) and SETGID(BA_OS) routines, respectively.

root-directory and **current-working-directory**
Each process has associated with it a concept of a root-directory and a current-working-directory for the purpose of resolving path searches. The root-directory of a process need not be the root-directory of the root file system.

special-processes
All special-processes are system-processes (e.g., a system's process-scheduler). At least process-IDs 0 and 1 are reserved for special-processes.

stdio-routines
A set of routines described as Standard I/O (*stdio*) routines constitute an efficient, user-level I/O buffering scheme. The complete set of Standard I/O, *stdio* routines is shown below [see also the definition of **stdio-stream** below]. Detailed component definitions of each can be found in either **Chapter 5**, the system service (BA_OS) routines or **Chapter 6**, the general library (BA_LIB) routines.

(BA_OS) `clearerr`, `fclose`, `fdopen`, `feof`, `ferror`, `fileno`, `fflush`, `fopen`, `fread`, `freopen`, `fseek`, `ftell`, `fwrite`, `popen`, `pclose`, `rewind`.

(BA_LIB) `ctermid`, `fgetc`, `fgets`, `fprintf`, `fputc`, `fputs`, `fscanf`, `getchar`, `gets`, `getw`, `printf`, `putc`, `putchar`, `puts`, `putw`, `scanf`, `setbuf`, `setvbuf`, `tempnam`, `tmpnam`, `ungetc`, `vprintf`. `vfprintf`. `vsprintf`.

The Standard I/O routines and constants are declared in the `<stdio.h>` header file and need no further declaration. The following *functions* are implemented as macros and must not be redeclared: `getc`, `getchar`, `putc`, `putchar`, `ferror`, `feof`, `clearerr`, and `fileno`. The macros `getc` and `putc` handle characters quickly. The macros `getchar` and `putchar`, and the higher-level routines `fgetc`, `fgets`, `fprintf`, `fputc`, `fputs`, `fread`, `fscanf`, `fwrite`, `gets`, `getw`, `printf`, `puts`, `putw`, and `scanf` all use or act as if they use `getc` and `putc`; they can be freely intermixed.

The `<stdio.h>` header file also defines three symbolic constants used by the *stdio* routines:

The defined constant `NULL` designates a nonexistent *null* pointer.

The integer constant `EOF` is returned upon end-of-file or error by most integer functions that deal with streams (see the individual component definitions for details).

The integer constant `BUFSIZ` specifies the size of the *stdio* buffers used by the particular implementation.

Any application-program that uses the *stdio* routines must include the `<stdio.h>` header file.

stdio-stream

A file with associated *stdio* buffering is called a *stream.* A stream is a pointer to a type `FILE` defined by the `<stdio.h>` header file. The FOPEN(BA_OS) routine creates certain descriptive data for a stream and returns a pointer that identifies the stream in all further transactions with other *stdio* routines.

Most *stdio* routines manipulate either a stream created by the function `fopen` or one of three streams that are associated with three files that are expected to be open in the Base System [see TERMIO(BA_ENV)]. These three streams are declared in the `<stdio.h>` header file:

`stdin`	the standard input file.
`stdout`	the standard output file.
`stderr`	the standard error file.

Output streams, with the exception of the standard error stream `stderr`, are by default buffered if the output refers to a file and line-buffered if the output refers to a terminal. The standard error output stream `stderr` is by default unbuffered. When an output stream is unbuffered, information is queued for writing on the destination file or terminal as soon as written; when it is buffered, many characters are saved up and written as a block. When it is line-buffered, each line of output is queued for writing on the destination terminal as soon as the line is completed (that is, as soon as a new-line character is written or terminal input is requested). The SETBUF(BA_LIB) routines may be used to change the stream's buffering strategy.

super-user

A process is recognized as a super-user process and is granted special privileges if its effective-user-ID is `0`.

tty-group-ID

Each active-process can be a member of a terminal-group that shares a control terminal [see DEVTTY(BA_ENV)] and is identified by a positive-integer called the tty-group-ID. This grouping is used to terminate a group of related processes upon termination of one of the processes in the group [see EXIT(BA_OS) and SIGNAL(BA_OS)].

Chapter 5
Environment

NAME

console — system console interface

SYNOPSIS

`/dev/console`

DESCRIPTION

`/dev/console` is a generic name given to the system console. It is usually linked to a particular machine-dependent special file, and provides a basic I/O interface to the system console through the *termio* interface [see TERMIO(BA_ENV)].

SEE ALSO

TERMIO(BA_ENV).

LEVEL

Level 1.

NAME

null – the null file

SYNOPSIS

`/dev/null`

DESCRIPTION

Data written on a null special file are discarded.

Read operations from a null special file always return 0 bytes.

Output of a command is written to the special file `/dev/null` when the command is executed for its side effects and not for its output.

LEVEL

Level 1.

NAME

tty — controlling terminal interface

SYNOPSIS

`/dev/tty`

DESCRIPTION

The file `/dev/tty` is, in each process, a synonym for the control-terminal associated with the process group of that process, if any. It is useful for programs that wish to be sure of writing messages on the terminal no matter how output has been redirected [see SYSTEM(BA_OS)]. It can also be used for programs that demand the name of a file for output when typed output is desired and as an alternative to identifying what terminal is currently in use.

APPLICATION USAGE

Normally, application programs should not need to use this file interface. The standard input, standard output and standard error files should be used instead. These file are accessed through the `stdin`, `stdout` and `stderr` *stdio* interfaces [see **stdio-stream** in **Chapter 4 — Definitions**].

SEE ALSO

TERMIO(BA_ENV).

LEVEL

Level 1.

NAME

errors — error code and condition definitions

SYNOPSIS

```
#include <errno.h>

extern int errno;
```

DESCRIPTION

The numerical value represented by the symbolic name of an error condition is assigned to the external variable `errno` for errors that occur when executing a system service routine or general library routine.

The component definitions given in **Chapter 6 — OS Service Routines** and **Chapter 7 — General Library Routines**, list possible error conditions for each routine and the meaning of the error in that *context*. The order in which possible errors are listed is not significant and does not imply precedence. The value of `errno` should be checked only *after* an error has been indicated; that is, when the return value of the component indicates an error, and the component definition specifies that `errno` will be set. The `errno` value 0 is reserved; no error condition will be equal to zero. An application that checks the value of `errno` must include the `<errno.h>` header file.

Additional error conditions may be defined by Extensions to the Base System or by particular implementations.

The following list describes the *general* meaning of each error:

`E2BIG`	Argument list too long An argument list longer than {ARG_MAX} bytes was presented to a member of the EXEC(BA_OS) family of routines.
`EACCES`	Permission denied An attempt was made to access a file in a way forbidden by the protection system.
`EAGAIN`	Resource temporarily unavailable, try again later, For example, the FORK(BA_OS) routine failed because the system's process table is full.
`EBADF`	Bad file number Either a file-descriptor refers to no open file, or a read (respectively, write) request was made to a file that is open only for writing (respectively, reading).
`EBUSY`	Device or resource busy An attempt was made to mount a device that was already mounted or an attempt was made to dismount a device on which there is an active file (open file, current directory, mounted-on file, active text segment). It will also occur if an attempt is made to enable accounting when it is already enabled. The device or resource is currently unavailable.

`ECHILD`	No child processes The WAIT(BA_OS) routine was executed by a process that had no existing or unwaited-for child processes.
`EDEADLK`	Deadlock avoided The request would have caused a deadlock; the situation was detected and avoided.
`EDOM`	Math argument The argument of a function in the math package is out of the domain of the function.
`EEXIST`	File exists An existing file was mentioned in an inappropriate context (e.g., a call to the LINK(BA_OS) routine).
`EFAULT`	Bad address The system encountered a hardware fault in attempting to use an argument of a routine. For example, `errno` potentially may be set to `EFAULT` any time a routine that takes a pointer argument is passed an invalid address, if the system can detect the condition. Because systems will differ in their ability to reliably detect a bad address, on some implementations passing a bad address to a routine will result in undefined behavior.
`EFBIG`	File too large The size of a file exceeded the maximum file size, {FCHR_MAX} [see ULIMIT(BA_OS)].
`EINTR`	Interrupted system service An asynchronous signal (such as interrupt or quit), which the user has elected to catch, occurred during a system service routine. If execution is resumed after processing the signal, it will appear as if the interrupted routine returned this error condition.
`EINVAL`	Invalid argument Some invalid argument (e.g., dismounting a non-mounted device; mentioning an undefined signal in a call to the SIGNAL(BA_OS) or KILL(BA_OS) routine). Also set by math routines.
`EIO`	I/O error Some physical I/O error has occurred. This error may, in some cases, occur on a call following the one to which it actually applies.
`EISDIR`	Is a directory An attempt was made to write on a directory.
`EMFILE`	Too many open files in a process No process may have more than {OPEN_MAX} file descriptors open at a time.

`EMLINK`	Too many links An attempt to make more than the maximum number of links, {LINK_MAX}, to a file.
`ENFILE`	Too many open files in the system The system file table is full (i.e., {SYS_OPEN} files are open, and temporarily no more *opens* can be accepted).
`ENODEV`	No such device An attempt was made to apply an inappropriate operation to a device (e.g., read a write-only device).
`ENOENT`	No such file or directory A file name is specified and the file should exist but doesn't, or one of the directories in a path-name does not exist.
`ENOEXEC`	Exec format error A request is made to execute a file which, although it has the appropriate permissions, does not start with a valid format.
`ENOLCK`	No locks available There are no more locks available. The system lock table is full.
`ENOMEM`	Not enough space During execution of an EXEC(BA_OS) routine, a program asks for more space than the system is able to supply. This is not a temporary condition; the maximum space size is a system parameter. The error may also occur if the arrangement of text, data, and stack segments requires too many segmentation registers, or if there is not enough swap space during execution of the FORK(BA_OS) routine.
`ENOSPC`	No space left on device While writing an ordinary file or creating a directory entry, there is no free space left on the device.
`ENOTBLK`	Block device required A non-block file was mentioned where a block device was required (e.g., in a call to the MOUNT(BA_OS) routine).
`ENOTDIR`	Not a directory A non-directory was specified where a directory is required (e.g. in a path-prefix or as an argument to the CHDIR(BA_OS) routine).
`ENOTTY`	Not a character device A call was made to the IOCTL(BA_OS) routine specifying a file that is not a special character device.
`ENXIO`	No such device or address I/O on a special file refers to a subdevice which does not exist, or exists beyond the limits of the device. It may also occur when, for example, a tape drive is not on-line or no disk pack is loaded on a drive.

`EPERM`	No permission match Typically this error indicates an attempt to modify a file in some way forbidden except to its owner or super-user. It is also returned for attempts by ordinary users to do things allowed only to the super-user.
`EPIPE`	Broken pipe A write on a pipe for which there is no process to read the data. This condition normally generates a signal; the error is returned if the signal is ignored.
`ERANGE`	Result too large The value of a function in the math package is not representable within machine precision.
`EROFS`	Read-only file system An attempt to modify a file or directory was made on a device mounted read-only.
`ESPIPE`	Illegal seek A call to the LSEEK(BA_OS) routine was issued to a pipe.
`ESRCH`	No such process No process can be found corresponding to that specified by `pid` in the KILL(BA_OS) or PTRACE(KE_OS) routine.
`ETXTBSY`	Text file busy An attempt was made to execute a pure-procedure program that is currently open for writing. Also an attempt to open for writing a pure-procedure program that is being executed.
`EXDEV`	Cross-device link A link to a file on another device was attempted.

APPLICATION USAGE

Because a few routines may not have an error return value, an application may set `errno` to zero, call the routine, and then check `errno` again to see if an error has occurred.

LEVEL

Level 1.

NAME

envvar — environmental variables

DESCRIPTION

When a process begins execution, the EXEC(BA_OS) routines make available an array of strings called the *environment* [see also SYSTEM(BA_OS)]. By convention, these strings have the form `variable=value`, for example, `PATH=/bin/usr/bin`. These environmental variables provide a way to make information about an end-user's environment available to programs. The following environmental variables can be used by applications and are expected to be set in the target run-time environment.

Variable	*Use*
`HOME`	Full path-name of the user's home-directory, the user's initial-working-directory [see PASSWD(BA_ENV)].
`PATH`	Colon-separated ordered list of path-names that determine the search sequence used in locating files [see SYSTEM(BA_OS)].
`TERM`	The kind of terminal for which output is prepared. This information is used by applications that may exploit special capabilities of the terminal.
`TZ`	Time-zone information. `TZ` must be a three-letter, local time-zone abbreviation, followed by a number (an optional minus sign, for time-zones east of Greenwich, followed by a series of digits) that is the difference in hours between this time-zone and Greenwich Mean Time. This may be followed by an optional three-letter daylight local time-zone. For example, `EST5EDT` for Eastern Standard, Eastern Daylight Savings Time.

Other variables might be set in a particular environment but are not required to be included in the Base System.

SEE ALSO

EXEC(BA_OS), SYSTEM(BA_OS), FILSYS(BA_ENV).

FUTURE DIRECTIONS

The number in `TZ` will be defined as an optional minus sign followed by two hour digits and two minute digits, `hhmm`, in order to represent fractional time-zones.

LEVEL

Level 1.

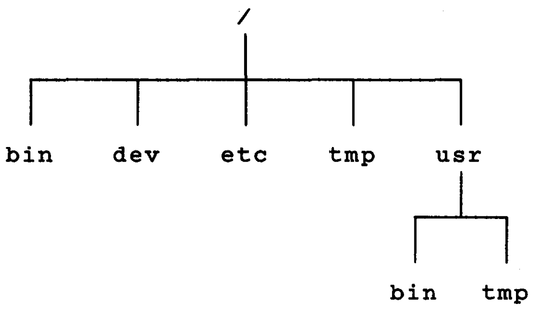
NAME

file system — directory tree structure

DESCRIPTION

Directory Tree Structure

Below is a diagram of the minimal directory tree structure expected to be on any System V operating system.



The following guidelines apply to the contents of these directories:

- `/bin`, `/dev`, `/etc`, and `/tmp` are primarily for the use of the system. Most applications should never *create* files in any of these directories, though they may read and execute them. Applications, as well as the system, can use `/usr/bin` and `/usr/tmp`.
- `/bin` holds executable system commands (utilities), if any.
- `/dev` holds special device files.
- `/etc` holds system data files, such as `/etc/passwd`.
- `/tmp` holds temporary files created by utilities in `/bin` and by other system processes.
- `/usr/bin` holds (user-level) executable application and system commands.
- `/usr/tmp` holds temporary files created by applications and the system.

Some Extensions to the Base System will have additional requirements on the tree structure when the Extension is installed on a system. Directory tree requirements specific to an Extension will be identified when the Extension is defined in detail.

System Data Files

The Base System Definition specifies only these system-resident data files:

```
/etc/passwd
/etc/profile
```

The /etc/passwd and /etc/profile files are owned by the system and are readable but not writable by ordinary users.

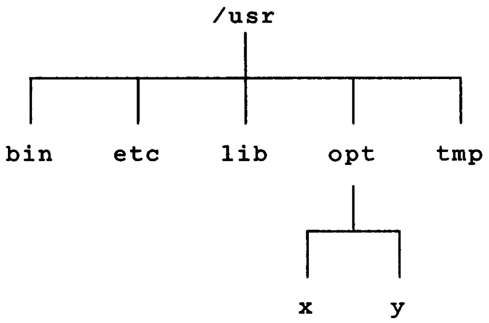
The format and contents of /etc/passwd are defined on PASSWD(BA_ENV). This is a generally useful file, readable by applications, that makes available to application programs some basic information about end-users on a system. It has one entry for each user. Minimally, each user's entry contains a string that is the name by which the user is known on the system, a numerical user-ID, and the home-directory or initial-working-directory of the user.

Conventionally, the information in this file is used during the initialization of the environment for a particular user. However, the /etc/passwd file is also useful as a standardly formatted database of information about users, which can be used independently of the mechanisms that maintain the data file.

The /etc/profile file may contain a string assignment of the PATH and TZ variables defined in ENVVAR(BA_ENV).

FUTURE DIRECTIONS

The following directory structure and guidelines are proposed for applications ("add-ons") that are to be installed on a system:



- /usr/etc would hold data and log files for commands in /usr/bin.
- /usr/lib would hold any executable files for commands in /usr/bin.
- /usr/opt would hold sub-directories for each add-on to hold data files private to the add-on (e.g., add-on x)
- /usr/opt/x would hold files and/or directories private to add-on x, /usr/opt/y would hold files and/or directories private to add-on y.

LEVEL

Level 1.

NAME

passwd — password file

SYNOPSIS

`/etc/passwd`

DESCRIPTION

The file `/etc/passwd` contains the following information for each user:

name
encrypted password (may be empty)
numerical user-ID
numerical group-ID (may be empty)
free field
initial-working-directory
program to use as command interpreter (may be empty)

This ASCII file resides in directory `/etc`. It has general read permission and can be used, for example, to map *numerical user-IDs* to *names*.

Each field within each user's entry is separated from the next by a colon. Fields 2, 4, and 7 may be empty. However, if they are not empty, they must be used for their stated purpose. Field 5 is a free field that is implementation-specific. Fields beyond 7 are also free but may be standardized in the future. Each user's entry is separated from the next by a newline.

The *name* is a character string that identifies a user. Its composition should follow the same rules used for file-names.

By convention, the last element in the path-name of the initial-working-directory is typically *name.*

SEE ALSO

CRYPT(BA_LIB).

LEVEL

Level 1.

NAME

termio — general terminal interface

SYNOPSIS

```
#include <termio.h>

ioctl(fildes, request, arg)
struct termio *arg;

ioctl(fildes, request, arg)
int arg;
```

DESCRIPTION

System V supports a general interface for asynchronous communications ports that is hardware-independent. The remainder of this section discusses the common features of this interface.

When a terminal file is opened, it normally causes the process to wait until a connection is established. Typically, these files are opened by the system initialization process and become the *standard input*, *standard output*, and *standard error* files [see **stdio-stream** in **Chapter 4 — Definitions**]. The very first terminal file opened by the process-group-leader but not already associated with a process-group becomes the *control-terminal* for that process-group. The control-terminal plays a special role in handling quit and interrupt signals [see below]. The control-terminal is inherited by a new process during a FORK(BA_OS) or EXEC(BA_OS) operation. A process can break this association by changing its process-group with the SETPGRP(BA_OS) routine.

A terminal associated with one of these files ordinarily operates in full-duplex mode. This means characters may be typed at any time, even while output is occurring. Characters are only lost when the system's character input buffers become completely full, or when an input line exceeds {MAX_CHAR}, the maximum allowable number of input characters. When the input limit is reached, all the saved characters may be thrown away without notice.

Normally, terminal input is processed in units of lines. A line is delimited by the new-line (ASCII LF) character, end-of-file (ASCII EOT) character, or end-of-line character. This means that a program attempting to read will be suspended until an entire line has been typed. Also, no matter how many characters may be requested in a read, at most one line will be returned. It is not, however, necessary to read a whole line at once; any number of characters may be requested in a read, even one, without losing information.

Some characters have special meaning when input. For example, during input, *erase* and *kill* processing is normally done. The **ERASE** character erases the last character typed, except that it will not erase beyond the beginning of the line. Typically, the default **ERASE** character is the character #. The **KILL** character kills (deletes) the entire input line, and optionally outputs a new-line character. Typically, the default **KILL** character is the character @. Both characters operate on a key-stroke basis independently of any backspacing or tabbing.

Special Characters.
Some characters have special functions on input. These functions and their typical default character values are summarized below:

INTR	(Typically, rubout or **ASCII DEL**) generates an *interrupt* signal, which is sent to all processes with the associated control-terminal. Normally, each such process is forced to terminate, but arrangements may be made either to ignore the signal or to receive a trap to an agreed-upon location [see SIGNAL(BA_OS)].
QUIT	(Typically, control-\ or **ASCII FS**) generates a *quit* signal. Its treatment is identical to the interrupt signal except that, unless a receiving process has made other arrangements, it will not only be terminated but the abnormal termination routines will be executed.
ERASE	(Typically, the character #) erases the preceding character. It will not erase beyond the start of a line, as delimited by an **EOF**, **EOL** or **NL** character.
KILL	(Typically, the character @) deletes the entire line, as delimited by an **EOF**, **EOL** or **NL** character.
EOF	(Typically, control-d or **ASCII EOT**) may be used to generate an **EOF**, from a terminal. When received, all the characters waiting to be read are immediately passed to the program, without waiting for a new-line, and the **EOF** is discarded. Thus, if there are no characters waiting, which is to say the **EOF** occurred at the beginning of a line, zero characters will be passed back, which is the standard end-of-file indication.
NL	(**ASCII LF**) is the normal line delimiter. It can not be changed or escaped.
EOL	(Typically, **ASCII NUL**) is an additional line delimiter, like **NL**. It is not normally used.
STOP	(Typically, control-s or **ASCII DC3**) is used to temporarily suspend output. It is useful with CRT terminals to prevent output from disappearing before it can be read. While output is suspended, **STOP** characters are ignored and not read.
START	(Typically, control-q or **ASCII DC1**) is used to resume output suspended by a **STOP** character. While output is not suspended, **START** characters are ignored and not read. The **START/STOP** characters can not be changed or escaped.

MIN	Used to control terminal I/O during raw mode (`ICANON` off) processing [see the **MIN/TIME Interaction** section below].
TIME	Used to control terminal I/O during raw mode (`ICANON` off) processing [see the **MIN/TIME Interaction** section below].

The **ERASE**, **KILL**, and **EOF** characters may be entered literally, and their special meaning escaped, by preceding them with the escape character \. In this case, no special function is performed. Also the escape character is not read as input.

When one or more characters are written, they are transmitted to the terminal as soon as previously-written characters have finished typing. Input characters are echoed by putting them in the output queue as they arrive. If a process produces characters more rapidly than they can be typed, it will be suspended when its output queue exceeds some limit. When the queue has drained down to some threshold, the program is resumed.

When a modem disconnect is detected, a *hang-up* signal, `SIGHUP`, is sent to all processes that have this terminal as the control-terminal. Unless other arrangements have been made, this signal causes the processes to terminate. If the hang-up signal is ignored, any subsequent read returns with an end-of-file indication. Thus, programs that read a terminal and test for end-of-file can terminate appropriately when hung up on.

IOCTL(BA_OS) Requests.
Several IOCTL(BA_OS) requests apply to terminal files and use the structure `termio` which is defined by the `<termio.h>` header file.

The primary IOCTL(BA_OS) requests to a terminal have the form:

```
ioctl(fildes, request, arg)
struct termio *arg;
```

The requests using this form are:

`TCGETA`	Get the parameters associated with the terminal and store in the structure `termio` referenced by `arg`.
`TCSETA`	Set the parameters associated with the terminal from the structure `termio` referenced by `arg`. The change is immediate.
`TCSETAW`	Wait for the output to drain before setting the new parameters. This form should be used when changing parameters that will affect output.
`TCSETAF`	Wait for the output to drain, then flush the input queue and set the new parameters.

Additional IOCTL(BA_OS) requests to a terminal have the form:

```
ioctl(fildes, request, arg)
int arg;
```

The requests using this form are:

`TCSBRK`	Wait for the output to drain. If `arg` is `0`, then send a break (zero bits for 0.25 seconds).
`TCXONC`	Start/stop control. If `arg` is `0`, suspend output; if `1`, restart suspended output.
`TCFLSH`	Flush queues If `arg` is `0`, flush the input queue; if `1`, flush the output queue; if `2`, flush both the input and output queues.

The structure `termio` includes the following members:

```
unsigned short  c_iflag;      /* input modes */
unsigned short  c_oflag;      /* output modes */
unsigned short  c_cflag;      /* control modes */
unsigned short  c_lflag;      /* local modes */
char            c_line;       /* line-discipline */
unsigned char   c_cc[NCC];    /* control chars */
```

The special control-characters are defined by the array `c_cc`. The symbolic name `NCC` is the size of the control-character array and is also defined by the `<termio.h>` header file. The relative positions, subscript names and typical default values for each entry are as follows:

0	VINTR	ASCII DEL
1	VQUIT	ASCII FS
2	VERASE	#
3	VKILL	@
4	VEOF	ASCII EOT
4	VMIN	
5	VEOL	ASCII NUL
5	VTIME	
6	reserved	
7	reserved	

Input Modes.
The following values for the field `c_iflag` define the basic terminal input control:

`IGNBRK`	Ignore break condition. If `IGNBRK` is set, the break condition (a character framing error with data all zeros) is ignored, that is, not put on the input queue and therefore not read by any process. Otherwise, see `BRKINT`.

`BRKINT`	Signal interrupt on break. If `BRKINT` is set, the break condition will generate an interrupt signal and flush both the input and output queues.
`IGNPAR`	Ignore characters with parity errors. If `IGNPAR` is set, characters with other framing and parity errors are ignored.
`PARMRK`	Mark parity errors. If `PARMRK` is set, a character with a framing or parity error which is not ignored is read as the three-character sequence: `0377, 0, X`, where `0377, 0` is a two-character flag preceding each sequence and `X` is the data of the character received in error. To avoid ambiguity in this case, if `ISTRIP` is not set, a valid character of `0377` is read as `0377, 0377`. If `PARMRK` is not set, a framing or parity error which is not ignored is read as the character **ASCII NUL** (**ASCII** code `0`).
`INPCK`	Enable input parity check. If `INPCK` is set, input parity checking is enabled. If `INPCK` is not set, input parity checking is disabled allowing output parity generation without input parity errors.
`ISTRIP`	Strip character. If `ISTRIP` is set, valid input characters are first stripped to 7-bits, otherwise all 8-bits are processed.
`INLCR`	Map NL to **ASCII CR** on input. If `INLCR` is set, a received NL character is translated into a **ASCII CR** character.
`IGNCR`	Ignore **ASCII CR**. If `IGNCR` is set, a received **ASCII CR** character is ignored (not read).
`ICRNL`	Map **ASCII CR** to NL on input. If `ICRNL` is set, a received **ASCII CR** character is translated into a NL character.
`IUCLC`	Map upper-case to lower-case on input. If `IUCLC` is set, a received upper-case alphabetic character is translated into lower-case.
`IXON`	Enable start/stop output control. If `IXON` is set, start/stop output control is enabled. A received **STOP** character will suspend output and a received **START** character will restart output. All start/stop characters are ignored and not read.

`IXANY`	Enable any character to restart output. If `IXANY` is set, any input character, will restart output which has been suspended.
`IXOFF`	Enable start/stop input control. If `IXOFF` is set, the system will transmit **START/STOP** characters when the input queue is nearly empty/full.

The initial input control value is all bits clear.

Output Modes.
The following values for the field `c_oflag` define the system treatment of output:

`OPOST`	Postprocess output. If `OPOST` is set, output characters are post-processed as indicated by the remaining flags; otherwise characters are transmitted without change.
`OLCUC`	Map lower case to upper on output. If `OLCUC` is set, a lower-case alphabetic character is transmitted as the corresponding upper-case character. This function is often used in conjunction with `IUCLC`.
`ONLCR`	Map **NL** to **ASCII CR-NL** on output. If `ONLCR` is set, the **NL** character is transmitted as the **ASCII CR-NL** character pair.
`OCRNL`	Map **ASCII CR** to **NL** on output. If `OCRNL` is set, the **ASCII CR** character is transmitted as the **NL** character.
`ONOCR`	No **ASCII CR** output at column 0. If `ONOCR` is set, no **ASCII CR** character is transmitted when at column `0` (first position).
`ONLRET`	**NL** performs **ASCII CR** function. If `ONLRET` is set, the **NL** character is assumed to do the carriage-return function; the column pointer will be set to `0` and the delays specified for **ASCII CR** will be used. Otherwise the **NL** character is assumed to do just the line-feed function; the column pointer will remain unchanged. The column pointer is also set to `0` if the **ASCII CR** character is actually transmitted.
`OFILL`	Use fill-characters for delay. If `OFILL` is set, fill-characters will be transmitted for delay instead of a timed delay. This is useful for high baud-rate terminals that need only a minimal delay.
`OFDEL`	Fill is **ASCII DEL**, else **ASCII NUL**. If `OFDEL` is set, the fill-character is **ASCII DEL**, otherwise **ASCII NUL**.

The delay-bits specify how long transmission stops to allow for mechanical or other movement when certain characters are sent to the terminal. In all cases a value of 0 indicates no delay.

The actual delays depend on line-speed and system-load.

`NLDLY` New-line delay lasts about 0.10 seconds.
If `ONLRET` is set, the carriage-return delays are used instead of the new-line delays.

If `OFILL` is set, two fill-characters will be transmitted.

Select new-line delays:

`NL0`	New-Line character type 0
`NL1`	New-Line character type 1

`CRDLY` Carriage-return delay type 1 is dependent on the current column position, type 2 is about 0.10 seconds, and type 3 is about 0.15 seconds.

If `OFILL` is set, delay type 1 transmits two fill-characters, and type 2, four fill-characters.

Select carriage-return delays:

`CR0`	Carriage-return delay type 0
`CR1`	Carriage-return delay type 1
`CR2`	Carriage-return delay type 2
`CR3`	Carriage-return delay type 3

`TABDLY` Horizontal-tab delay type 1 is dependent on the current column position, type 2 is about 0.10 seconds, and type 3 specifies that tabs are to be expanded into spaces.

If `OFILL` is set, two fill-characters will be transmitted for any delay.

Select horizontal-tab delays:

`TAB0`	Horizontal-tab delay type 0
`TAB1`	Horizontal-tab delay type 1
`TAB2`	Horizontal-tab delay type 2
`TAB3`	Expand tabs to spaces.

`BSDLY` Backspace delay lasts about 0.05 seconds.

If `OFILL` is set, one fill-character will be transmitted.

Select backspace delays:

`BS0`	Backspace delay type 0
`BS1`	Backspace delay type 1

`VTDLY` Vertical-tab delay lasts about 2.0 seconds.

Select vertical-tab delays:

`VT0`	Vertical-tab delay type 0
`VT1`	Vertical-tab delay type 1

`FFDLY`	Form-feed delay lasts about 2.0 seconds.

Select form-feed delays:

`FF0`	Form-feed delay type 0
`FF1`	Form-feed delay type 1

The initial output control value is all bits clear.

Control Modes.
The following values for the field `c_cflag` define the hardware control of the terminal:

`CBAUD` Specify the baud-rate.
The zero baud-rate, `B0`, is used to hang up the connection. If `B0` is specified, the data-terminal-ready signal will not be asserted. Normally, this will disconnect the line. For any particular hardware, unsupported speed changes are ignored.

Select baud rate:

`B0`	`Hang up`
`B50`	`50 baud`
`B75`	`75 baud`
`B110`	`110 baud`
`B134`	`134.5 baud`
`B150`	`150 baud`
`B200`	`200 baud`
`B300`	`300 baud`
`B600`	`600 baud`
`B1200`	`1200 baud`
`B1800`	`1800 baud`
`B2400`	`2400 baud`
`B4800`	`4800 baud`
`B9600`	`9600 baud`
`B19200`	`19200 baud`
`B38400`	`38400 baud`

`CSIZE` Specify the character size in bits for both transmission and reception. This size does not include the parity-bit, if any.

Select character size:

`CS5`	5-bits
`CS6`	6-bits
`CS7`	7-bits
`CS8`	8-bits

`CSTOPB` Send two stop-bits, else one.
If `CSTOPB` is set, two stop-bits are used, otherwise one stop-bit. For example, at 110 baud, two stop-bits are normally used.

`CREAD` Enable receiver.
If `CREAD` is set, the receiver is enabled. Otherwise no characters will be received.

`PARENB` Enable parity.
If `PARENB` is set, parity generation and detection is enabled and a parity-bit is added to each character.

`PARODD` Specify odd parity, else even.
If parity is enabled, the `PARODD` flag specifies odd parity if set, otherwise even parity is used.

`HUPCL` Hang up on last close.
If `HUPCL` is set, the modem control lines fo the port will be lowered when the last process with the line open closes it or terminates. That is, the data-terminal-ready signal will not be asserted.

`CLOCAL` Local line, else dial-up.
If `CLOCAL` is set, the line is assumed to be a local, direct connection with no modem control. Otherwise modem control is assumed.

Under normal circumstances, an OPEN(BA_OS) operation will wait for the modem connection to complete. However, if the `O_NDELAY` flag is set, or `CLOCAL` is set, the OPEN(BA_OS) operation will return immediately without waiting for the connection. For those files on which the connection has not been established, or has been lost, and for which `CLOCAL` is not set, both READ(BA_OS) and WRITE(BA_OS) operations will return a zero character count. For the READ(BA_OS) operation, this is equivalent to an end-of-file condition. The initial hardware control value after the OPEN(BA_OS) operation is implementation-dependent.

Local Modes and Line Discipline.
The field `c_lflag` of the structure `termio` is used by the line-discipline to control terminal functions. The basic line-discipline, `c_line` set to `0`, provides the following:

`ISIG` Enable signals.
If `ISIG` is set, each input character is checked against the special control characters **INTR** and **QUIT**. If an input character matches one of these control characters, the function associated with that character is performed. If `ISIG` is not set, no checking is done. Thus these special input functions are possible only if `ISIG` is set. These functions may be disabled individually by changing the value of the control character to an unlikely or impossible value (e.g., `0377`).

`ICANON` Canonical input (**ERASE** and **KILL** processing).
If `ICANON` is set, canonical processing is enabled. This enables the **ERASE** and **KILL** edit functions, and the assembly of input characters into lines delimited by the **EOF**, **EOL** or **NL** characters. If `ICANON` is not set, read requests are satisfied directly from

the input queue. A read will not be satisfied until at least **MIN** characters have been received or the time-out value **TIME** has expired between characters [see the **MIN/TIME Interaction** section below]. This allows fast bursts of input to be read efficiently while still allowing single character input. The **MIN** and **TIME** values are stored in the position for the **EOF** and **EOL** characters, respectively. The time-value is expressed in units of 0.10 seconds.

`XCASE` Canonical upper/lower presentation.
If both `XCASE` and `ICANON` are set, an upper-case letter is input by preceding it with the character `\`, and is output preceded by the character `\`. In this mode, the following escape sequences are generated on output and accepted on input:

for:	**use:**
`	\'
|	\!
~	\^
{	\(
}	\)
\	\\

For example, `A` is input as `\a`, `\n` as `\\n`, and `\N` as `\\\n`.

`ECHO` Enable echo.
If `ECHO` is set, characters are echoed back to the terminal as received.

When `ICANON` is set, the following echo functions are possible:

`ECHOE` Echo the **ERASE** character as **ASCII BS-SP-BS**.
If both `ECHOE` and `ECHO` are set, the **ERASE** character is echoed as **ASCII BS-SP-BS**, which will clear the last character from a CRT screen.

If `ECHOE` is set but `ECHO` is not set, the **ERASE** character is echoed as **ASCII SP-BS**.

`ECHOK` Echo the NL character after the **KILL** character.
If `ECHOK` is set, the NL character will be echoed after the **KILL** character to emphasize that the line will be deleted. Note that an escape character preceding the **ERASE** character or the **KILL** character removes any special function.

`ECHONL` Echo the NL character.
If `ECHONL` is set, the NL character will be echoed even if `ECHO` is not set. This is useful for terminals set to local-echo (also called half-duplex). Unless escaped, the **EOF** character is not echoed. Because **ASCII EOT** is the default **EOF** character, this prevents terminals that respond to **ASCII EOT** from hanging up.

NOFLSH Disable flush after interrupt or quit.
If NOFLSH is set, the normal flush of the input and output queues associated with the quit and interrupt characters will not be done.

The initial line-discipline control value is all bits clear.

MIN/TIME Interaction.
MIN represents the minimum number of characters that should be received when the read is satisfied (i.e., the characters are returned to the user). TIME is a timer of 0.10 second granularity used to time-out bursty and short-term data transmissions. The four possible values for MIN and TIME and their interactions follow:

1. MIN > 0, TIME > 0. In this case, TIME serves as an inter-character timer activated after the first character is received, and reset upon receipt of each character. MIN and TIME interact as follows:

   As soon as one character is received the inter-character timer is started.

   If MIN characters are received before the inter-character timer expires the read is satisfied.

   If the timer expires before MIN characters are received the characters received to that point are returned to the user.

   A READ(BA_OS) operation will sleep until the MIN and TIME mechanisms are activated by the receipt of the first character; thus, at least one character must be returned.

2. MIN > 0, TIME = 0. In this case, because TIME = 0, the timer plays no role and only MIN is significant. A READ(BA_OS) operation is not satisfied until MIN characters are received.

3. MIN = 0, TIME > 0. In this case, because MIN = 0, TIME no longer serves as an inter-character timer, but now serves as a read timer that is activated as soon as the READ(BA_OS) operation is processed (in canon). A READ(BA_OS) operation is satisfied as soon as a single character is received or the timer expires, in which case, the READ(BA_OS) operation will not return any characters.

4. MIN = 0, TIME = 0. In this case, return is immediate. If characters are present, they will be returned to the user.

SEE ALSO

FORK(BA_OS), IOCTL(BA_OS), SETPGRP(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

Chapter 6
OS Service Routines

NAME

abort — generate an abnormal process termination

SYNOPSIS

```
int abort( )
```

DESCRIPTION

The function `abort` first closes all open files if possible, then causes a signal to be sent to the process. This invokes abnormal process termination routines, such as a core dump, which are implementation dependent.

APPLICATION USAGE

The signal sent by `abort` should not be caught or ignored by applications.

SEE ALSO

EXIT(BA_OS), SIGNAL(BA_OS).

FUTURE DIRECTIONS

The function `abort` will send the `SIGABRT` signal rather than the `SIGIOT` signal.

LEVEL

Level 1.

NAME

access — determine accessibility of a file

SYNOPSIS

```
int access(path, amode)
char *path;
int amode;
```

DESCRIPTION

The function `access` checks the named file for accessibility according to the bit-pattern contained in `amode`, using the real-user-ID in place of the effective-user-ID, and the real-group-ID or equivalent in place of the effective-group-ID.

The argument `path` points to a path-name naming the file.

The bit-pattern contained in `amode` is constructed as follows:

04	read
02	write
01	execute (search)
00	check existence of file

Thus, the argument `amode` should be the sum of the values of the access modes to be checked.

The owner of a file has permission checked with respect to the *owner* read, write, and execute mode bits. Members of the file's group other than the owner have permissions checked with respect to the *group* mode bits, and all others have permissions checked with respect to the *other* mode bits.

RETURN VALUE

If the requested access is permitted, the function `access` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `access` will fail and will set `errno` to:

ENOTDIR	if a component of the path-prefix is not a directory.
ENOENT	if the named file does not exist.
EACCES	if a component of the path-prefix denies search permission, or if the permission bits of the file mode do not permit the requested access.
EROFS	if write access is requested for a file on a read-only file system.
ETXTBSY	if write access is requested for a pure procedure (shared text) file that is being executed.

SEE ALSO

CHMOD(BA_OS), STAT(BA_OS).

FUTURE DIRECTIONS

`EINVAL` will be returned in `errno` if the argument `amode` is invalid.

The `<unistd.h>` header file will define the following symbolic constants for the argument `amode` to the function `access`:

Name	*Description*
`R_OK`	test for *read* permission.
`W_OK`	test for *write* permission.
`X_OK`	test for *execute* permission.
`F_OK`	test for existence of file.

LEVEL

Level 1.

NAME

alarm — set a process alarm clock

SYNOPSIS

```
unsigned alarm(sec)
unsigned sec;
```

DESCRIPTION

The function `alarm` instructs the alarm clock of the calling-process to send the signal `SIGALRM` to the calling-process after the number of real time seconds specified by `sec` have elapsed [see SIGNAL(BA_OS)].

Alarm requests are not stacked; successive calls reset the alarm clock of the calling-process.

If `sec` is `0`, any previously made alarm request is canceled.

The FORK(BA_OS) routine sets the alarm clock of a new process to `0`. A process created by the EXEC(BA_OS) family of routines inherits the time left on the old process's alarm clock.

RETURN VALUE

If successful, the function `alarm` will return the amount of time previously remaining in the alarm clock of the calling-process.

SEE ALSO

EXEC(BA_OS), FORK(BA_OS), PAUSE(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

chdir — change working directory

SYNOPSIS

```
int chdir(path)
char *path;
```

DESCRIPTION

The function `chdir` causes the named directory to become the current working directory and the starting point for path-searches for path-names not beginning with `/`.

The argument `path` points to the path-name of a directory.

RETURN VALUE

If successful, the function `chdir` will return 0; otherwise, it will return −1, the current-working-directory will be unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `chdir` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-name is not a directory.
`ENOENT`	if the named directory does not exist.
`EACCES`	if any component of the path-name denies search permission.

LEVEL

Level 1.

NAME

chmod — change mode of file

SYNOPSIS

```
int chmod(path, mode)
char *path;
int mode;
```

DESCRIPTION

The function `chmod` sets the access permission portion of the named file's mode according to the bit-pattern contained in the argument `mode`.

The argument `path` points to a path-name naming a file.

Access permission bits are interpreted as follows; the value of the argument `mode` should be the sum of the values of the desired permissions:

04000	Set user-ID on execution.
02000	Set group-ID on execution.
01000	Reserved.
00400	Read by owner.
00200	Write by owner.
00100	Execute (search if a directory) by owner.
00040	Read by group.
00020	Write by group.
00010	Execute (search) by group.
00004	Read by others (i.e., anyone else).
00002	Write by others.
00001	Execute (search) by others.

The effective-user-ID of the process must match the owner of the file or be super-user to change the mode of a file.

If the effective-user-ID of the process is not super-user and the effective-group-ID of the process does not match the group-ID of the file, mode bit 02000 (set group-ID on execution) is cleared. This prevents an ordinary user from making itself an effective member of a group to which it does not belong. Similarly, the CHOWN(BA_OS) routine clears the set-user-ID and set-group-ID bits when invoked by other than the super-user.

RETURN VALUE

If successful, the function `chmod` will return 0; otherwise, it will return −1, the file mode will be unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `chmod` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if the named file does not exist.
`EACCES`	if a component of the path-prefix denies search permission.
`EPERM`	if the effective-user-ID does not match the owner of the file and the effective-user-ID is not super-user.
`EROFS`	if the named file resides on a read-only file system.

SEE ALSO

CHOWN(BA_OS), MKNOD(BA_OS).

FUTURE DIRECTIONS

Symbolic constants defining the access permission bits will be added to the `<sys/stat.h>` header file and should be used to construct `mode`.

Enforcement-mode file and record-locking will be added:

> If the mode bit `02000` (set group-ID on execution) is set and the mode bit `01000` (execute or search by group) is not set, enforcement-mode file and record-locking will exist on an ordinary-file. This may affect future calls to OPEN(BA_OS), CREAT(BA_OS), READ(BA_OS) and WRITE(BA_OS) routines on this file.

LEVEL

Level 1.

NAME

chown — change owner and group of a file

SYNOPSIS

```
int chown(path, owner, group)
char *path;
int owner, group;
```

DESCRIPTION

The function `chown` sets the owner-ID and group-ID of the named file to the numeric values contained in `owner` and `group`, respectively.

The argument `path` points to a path-name naming a file.

Only processes with effective-user-ID equal to the file-owner or super-user may change the ownership of a file.

If the function `chown` is invoked successfully by other than the super-user, the set-user-ID and set-group-ID bits of the file mode, 04000 and 02000 respectively, will be cleared. (This prevents ordinary users from making themselves effectively other users or members of a group to which they don't belong.)

RETURN VALUE

If successful, the function `chown` will return `0`; otherwise, it will return `-1`, the owner and group of the named file will remain unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `chown` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if the named file does not exist.
`EACCES`	if a component of the path-prefix denies search permission.
`EPERM`	if the effective-user-ID does not match the owner of the file and the effective-user-ID is not super-user.
`EROFS`	if the named file resides on a read-only file system.

SEE ALSO

CHMOD(BA_OS).

LEVEL

Level 1.

NAME

close — close a file-descriptor

SYNOPSIS

```
int close(fildes)
int fildes;
```

DESCRIPTION

The function `close` closes the file-descriptor indicated by `fildes`.

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

All outstanding record-locks on the file indicated by `fildes` that are owned by the calling-process are removed.

RETURN VALUE

If successful, the function `close` will return `0`; otherwise, it will return `−1` and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `close` will fail and will set `errno` to:

`EBADF`	if `fildes` is not a valid open file-descriptor.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read and write files. Thus, an application that had used the FOPEN(BA_OS) *stdio* routine to open a file would use the corresponding FCLOSE(BA_OS) *stdio* routine rather than the CLOSE(BA_OS) routine.

The record and file locking features are an update that followed System V Release 1.0 and System V Release 2.0.

SEE ALSO

CREAT(BA_OS), DUP(BA_OS), EXEC(BA_OS), FCNTL(BA_OS), OPEN(BA_OS), PIPE(BA_OS).

LEVEL

Level 1.

NAME

creat — create a new file or rewrite an existing one

SYNOPSIS

```
int creat(path, mode)
char *path;
int mode;
```

DESCRIPTION

The function `creat` creates a new ordinary file or prepares to rewrite an existing file named by the path-name pointed to by `path`.

If the file exists, the length is truncated to 0, the mode and owner are unchanged, and the file is open for writing [see `O_WRONLY` in OPEN(BA_OS)]. If the file does not exist, the file's owner-ID is set to the effective-user-ID of the process; the group-ID of the file is set to the effective-group-ID of the process; and the access permission bits [see CHMOD(BA_OS)] of the file mode are set to the value of the argument `mode` modified as follows:

> The corresponding bits are ANDed with the complement of the process' file mode creation mask [see UMASK(BA_OS)]. Thus, the function `creat` clears each bit in the file mode whose corresponding bit in the file mode creation mask is set.

If successful, the function `creat` will return the file-descriptor and the file will be open for writing. A new file may be created with a `mode` that forbids writing. Even if the argument `mode` forbids writing, the function `creat` opens the file for writing.

The call `creat(path, mode)` is equivalent to the following [see OPEN(BA_OS)]:

```
open(path, O_WRONLY | O_CREAT | O_TRUNC, mode)
```

The file-pointer is set to the beginning of the file. The file-descriptor is set to remain open across calls to the EXEC(BA_OS) routines [see FCNTL(BA_OS)]. No process may have more than {OPEN_MAX} files open simultaneously.

RETURN VALUE

If successful, the function `creat` will return a non-negative integer, namely the file-descriptor; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `creat` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if a component of the path-name should exist but does not.
`EACCES`	if a component of the path-prefix denies search permission, or if the file does not exist and the directory in which the file is to be created does not permit writing, or if the file exists and write permission is denied.
`EROFS`	if the named file resides or would reside on a read-only file system.
`ETXTBSY`	if the file is a pure procedure (shared text) file that is being executed.
`EISDIR`	if the named file is an existing directory.
`EMFILE`	if {OPEN_MAX} file-descriptors are currently open in the calling-process.
`ENOSPC`	if the directory to contain the file cannot be extended.
`ENFILE`	if the system file table is full.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read and write files. In this case, the FOPEN(BA_OS) *stdio* routine should be used rather than the CREAT(BA_OS) routine.

SEE ALSO

CHMOD(BA_OS), CLOSE(BA_OS), DUP(BA_OS), FCNTL(BA_OS), LSEEK(BA_OS), OPEN(BA_OS), READ(BA_OS), UMASK(BA_OS), WRITE(BA_OS).

FUTURE DIRECTIONS

Symbolic constants defining the access permission bits will be defined by the `<sys/stat.h>` header file and should be used to construct `mode`.

Enforcement-mode file and record locking features will be added:

> The function `creat` will set `errno` to `EAGAIN` if the file exists, enforcement-mode file and record-locking is set and there are outstanding record-locks on the file [see CHMOD(BA_OS)].

LEVEL

Level 1.

NAME

dup — duplicate an open file-descriptor

SYNOPSIS

```
int dup(fildes)
int fildes;
```

DESCRIPTION

The function `dup` returns a new file-descriptor having the following in common with the original:

Same open file (or pipe).

Same file-pointer (i.e., both file-descriptors share one file-pointer).

Same access mode (read, write or read/write).

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

The new file-descriptor is set to remain open across calls to the EXEC(BA_OS) routines [see FCNTL(BA_OS)].

The file-descriptor returned is the lowest one available.

RETURN VALUE

If successful, the function `dup` will return a non-negative integer, namely the file-descriptor; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `dup` will fail and will set `errno` to:

`EBADF`	if `fildes` is not a valid open file-descriptor.
`EMFILE`	if {OPEN_MAX} file-descriptors are currently open in the calling-process.

SEE ALSO

CREAT(BA_OS), CLOSE(BA_OS), EXEC(BA_OS), FCNTL(BA_OS), OPEN(BA_OS), PIPE(BA_OS).

LEVEL

Level 1.

NAME

execl, execv, execle, execve, execlp, execvp — execute a file

SYNOPSIS

```
int execl(path, arg0, arg1, ... argn, (char *)0)
char *path, *arg0, *arg1, ... *argn;

int execv(path, argv)
char *path, *argv[];

int execle(path, arg0, arg1, ... argn, (char *)0, envp)
char *path, *arg0, *arg1, ... *argn, *envp[];

int execve(path, argv, envp)
char *path, *argv[], *envp[];

int execlp(file, arg0, arg1, ... argn, (char *)0)
char *file, *arg0, *arg1, ... *argn;

int execvp(file, argv)
char *file, *argv[];
```

DESCRIPTION

All forms of the function `exec` transform the calling-process into a new process. The new process is constructed from an ordinary, executable file called the *new-process-file*. This file consists of a header, a text segment, and a data segment. There can be no return from a successful `exec` because the calling-process image is overlaid by the new process image.

When a C program is executed, it is called as follows:

```
main(argc, argv, envp)
int argc;
char **argv, **envp;
```

where `argc` is the argument count, `argv` is an array of character pointers to the arguments themselves and `envp` is an array of character pointers to null-terminated strings that constitute the environment for the new process. The argument `argc` is conventionally at least one and the initial member of the array points to a string containing the name of the file.

The argument `path` points to a path-name that identifies the new-process-file. For `execlp` and `execvp`, the argument `file` points to the new-process-file. The path-prefix for this file is obtained by a search of the directories passed as the *environment* line `PATH=` [see ENVVAR(BA_ENV) and SYSTEM(BA_OS)].

The arguments `arg0, arg1, ... argn` are pointers to null-terminated character strings. These strings constitute the argument list available to the new process. By convention, at least `arg0` must be present and point to a string that is the same as `file` or `path` (or its last component).

The argument `argv` is an array of character pointers to null-terminated strings. These strings constitute the argument list available to the new process. By convention, `argv[0]` must point to a string that is the same as `file` or `path` (or its last component), and `argv` is terminated by a null pointer.

The argument `envp` is an array of character pointers to null-terminated strings. These strings constitute the environment for the new process, and `envp` is terminated by a null-pointer. For `execl` and `execv`, a pointer to the environment of the calling-process is made available in the global cell:

```
extern char **environ;
```

and it is used to pass the environment of the calling-process to the new process.

The file-descriptors open in the calling-process remain open in the new process, except for those whose *close-on-exec* flag is set [see FCNTL(BA_OS)]. For those file-descriptors that remain open, the file-pointer is unchanged.

Signals set to the default action (`SIG_DFL`) in the calling-process will be set to the default action in the new process. Signals set to be ignored (`SIG_IGN`) by the calling-process will be ignored by the new process. Signals set to be caught by the calling-process will be set to the default action in the new process [see SIGNAL(BA_OS)].

If the set-user-ID-on-execution mode bit of the new-process-file is set, the `exec` sets the effective-user-ID of the new process to the owner-ID of the new-process-file [see CHMOD(BA_OS)]. Similarly, if the set-group-ID mode bit of the new-process-file is set, the effective-group-ID of the new process is set to the group-ID of the new-process-file. The real-user-ID and real-group-ID of the new process remain the same as those of the calling-process. The effective-user-ID and group-ID of the new process are saved for use by the SETUID(BA_OS) routine.

The new process also inherits at least the following attributes from the calling-process:

process-ID
parent-process-ID
process-group-ID
tty-group-ID [see EXIT(BA_OS) and SIGNAL(BA_OS)]
time left until an alarm clock signal [see ALARM(BA_OS)]
current-working-directory
root-directory
file mode creation mask [see UMASK(BA_OS)]
file size limit [see ULIMIT(BA_OS)]
`utime`, `stime`, `cutime`, and `cstime` [see TIMES(BA_OS)]
(file-locks [see FCNTL(BA_OS) and LOCKF(BA_OS)])

RETURN VALUE

If the `exec` returns to the calling-process, an error has occurred; the `exec` will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the `exec` will return to the calling-process and will set `errno` to:

`ENOENT`	if one or more components of the path-name of the new-process-file do not exist.
`ENOTDIR`	if a component of the path-prefix of the new-process-file is not a directory.
`EACCES`	if a directory in the new-process-file's path-prefix denies search permission, or if the new-process-file is not an ordinary file [see MKNOD(BA_OS)], or if the new-process-file's mode denies execution permission.
`ENOEXEC`	if the `exec` is not an `execlp` or `execvp`, and the new-process-file has the appropriate access permission but is not a valid executable object.
`ETXTBSY`	if the new-process-file is a pure procedure (shared text) file that is currently open for writing by some process.
`ENOMEM`	if the new process image requires more memory than is allowed by the hardware or system-imposed maximum.
`E2BIG`	if the number of bytes in the new process image's argument list exceeds the system-imposed limit of {ARG_MAX} bytes.
`EFAULT`	if the new-process-file image is corrupted.

APPLICATION USAGE

Two interfaces for these functions are available. The list (`l`) versions: `execl`, `execle` and `execlp`, are useful when a known file with known arguments is being called. The arguments are the character-strings that are the file-name and the arguments. The variable (v) versions: `execv`, `execve` and `execvp`, are useful when the number of arguments is unknown in advance. The arguments are a file-name and a vector of strings containing the arguments.

If possible, applications should use the SYSTEM(BA_OS) routine, which is easier to use and supplies more functions, rather than the FORK(BA_OS) and EXEC(BA_OS) routines.

SEE ALSO

ALARM(BA_OS), EXIT(BA_OS), FORK(BA_OS), SIGNAL(BA_OS), TIMES(BA_OS), ULIMIT(BA_OS), UMASK(BA_OS).

LEVEL

Level 1.

NAME

exit, _exit — terminate process

SYNOPSIS

```
void exit(status)
int status;

void _exit(status)
int status;
```

DESCRIPTION

The function `exit` may cause cleanup actions before the process exits [see FCLOSE(BA_OS)]. The function `_exit` does not. The functions `exit` and `_exit` terminate the calling-process with the following consequences:

All of the file-descriptors open in the calling-process are closed.

If the parent-process of the calling-process is executing a WAIT(BA_OS) routine, it is notified of the calling-process's termination and the low-order eight bits (i.e., bits `0377`) of `status` are made available to it. If the parent is not waiting, the child's status will be made available to it when the parent subsequently executes the WAIT(BA_OS) routine.

If the parent-process of the calling-process is not executing a WAIT(BA_OS) routine, the calling-process is transformed into a zombie-process. A zombie-process is an inactive process that has no process space allocated to it, and it will be deleted at some later time when its parent executes the WAIT(BA_OS) routine.

Terminating a process by exiting does not terminate its children. The parent-process-ID of all of the calling-process's existing child-processes and zombie-processes is set to the process-ID of a special system-process. That is, these processes are inherited by a special system-process.

If the calling-process is a process-group-leader, and is associated with a controlling-terminal [see TERMIO(BA_ENV)], the `SIGHUP` signal is sent to each process that has a process-group-ID and tty-group-ID equal to that of the calling-process.

RETURN VALUE

Neither the function `exit` nor the function `_exit` will return a value.

APPLICATION USAGE

Normally applications should use `exit` rather than `_exit`.

SEE ALSO

SIGNAL(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

fclose, fflush — close or flush a stream

SYNOPSIS

```
#include <stdio.h>

int fclose(stream)
FILE *stream;

int fflush(stream)
FILE *stream;
```

DESCRIPTION

The function `fclose` causes any buffered data for the named `stream` to be written out, and the `stream` to be closed.

The function `fclose` is performed automatically for all open files upon calling the EXIT(BA_OS) routine.

The function `fflush` causes any buffered data for the named `stream` to be written to that file. The `stream` remains open.

RETURN VALUE

The functions `fclose` and `fflush` will return 0 for success, and `EOF` if any error (such as trying to write to a file that has not been opened for writing) was detected.

SEE ALSO

CLOSE(BA_OS), EXIT(BA_OS), FOPEN(BA_OS), SETBUF(BA_LIB).

LEVEL

Level 1.

NAME

fcntl — file control

SYNOPSIS

```
#include <fcntl.h>

int fcntl(fildes, cmd, arg)
int fildes, cmd;
```

DESCRIPTION

The function `fcntl` provides for control over open files.

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

The data type and value of `arg` are specific to the type of command specified by `cmd`. The symbolic names for commands and file status flags are defined by the `<fcntl.h>` header file.

The commands available are:

`F_DUPFD` Return a new file-descriptor as follows:

> Lowest numbered available file-descriptor greater than or equal to the argument `arg`.
>
> Same open file (or pipe) as the original file.
>
> Same file-pointer as the original file (i.e., both file-descriptors share one file-pointer).
>
> Same access-mode (*read*, *write* or *read/write*) [see ACCESS(BA_OS)].
>
> Same file status flags [see OPEN(BA_OS)].
>
> The close-on-exec flag associated with the new file-descriptor is set to remain open across calls to the EXEC(BA_OS) routines.

`F_GETFD` Get the close-on-exec flag associated with the file-descriptor `fildes`. If the low-order bit is 0 the file will remain open across calls to the EXEC(BA_OS) routines; otherwise, the file will be closed upon execution of any EXEC(BA_OS) routines.

`F_SETFD` Set the close-on-exec flag associated with `fildes` to the low-order bit of `arg` (0 or 1 as above).

`F_GETFL` Get `file` status flags:
`O_RDONLY`, `O_WRONLY`, `O_RDWR`, `O_NDELAY`, `O_APPEND`
[see OPEN(BA_OS)].

`F_SETFL` Set file status flags to `arg`. Only the flags `O_NDELAY` and `O_APPEND` may be set with `fcntl`.

The following commands are used for file-locking and record-locking (see also **APPLICATION USAGE** below). Locks may be placed on an entire file or segments of a file.

`F_GETLK` Get the first lock which blocks the lock description given by the variable of type `struct flock` (see below) pointed to by `arg`. The information retrieved overwrites the information passed to `fcntl` in the structure `flock`. If no lock is found that would prevent this lock from being created, then the structure is passed back unchanged except for the lock type which will be set to `F_UNLCK`.

NOTE: This command was added to `fcntl` following System V Release 1.0 and System V Release 2.0, and cannot be expected to be available in those releases.

`F_SETLK` Set or clear a file segment lock according to the variable of type `struct flock` (see below) pointed to by `arg`. `F_SETLK` is used to establish read (`F_RDLCK`) and write (`F_WRLCK`) locks, as well as remove either type of lock (`F_UNLCK`). `F_RDLCK`, `F_WRLCK`, and `F_UNLCK` are defined by the `<fcntl.h>` header file. If a read or write lock cannot be set, `fcntl` will return immediately with an error value of `-1`.

NOTE: This command was added to `fcntl` following System V Release 1.0 and System V Release 2.0, and cannot be expected to be available in those releases.

`F_SETLKW` This command is the same as `F_SETLK` except that if a read or write lock is blocked by other locks, the process will sleep until the segment is free to be locked.

NOTE: This command was added to `fcntl` following System V Release 1.0 and System V Release 2.0, and cannot be expected to be available in those releases.

The structure `flock` defined by the `<fcntl.h>` header file describes a lock. It describes the type (`l_type`), starting offset (`l_whence`), relative offset (`l_start`), size (`l_len`), and process-ID (`l_pid`):

```
short l_type;   /* F_RDLCK, F_WRLCK, F_UNLCK */
short l_whence; /* flag for starting offset */
long  l_start;  /* relative offset in bytes */
long  l_len;    /* if 0 then until EOF */
short l_pid;    /* returned with F_GETLK */
```

When a read-lock has been set on a segment of a file, other processes may also set read-locks on that segment or a portion of it. A read-lock prevents any other process from setting a write-lock on any portion of the protected area. The file-descriptor on which a read-lock is being placed must have been opened with read-access.

A write-lock prevents any other process from setting a read-lock or a write-lock on any portion of the protected area. Only one write-lock and no read-locks may exist for a given segment of a file at a given time. The file-descriptor on which a write-lock is being placed must have been opened with write-access.

The value of `l_whence` is `0`, `1` or `2` to indicate that the relative offset, `l_start` bytes, will be measured from the start of the file, current position or end of the file, respectively. The value of `l_len` is the number of consecutive bytes to be locked. The process-ID `l_pid` field is only used with `F_GETLK` to return the value for a blocking-lock.

Locks may start and extend beyond the current end of a file, but may not be negative relative to the beginning of the file. A lock may be set to always extend to the end of file by setting `l_len` to zero (`0`). If such a lock also has `l_start` set to zero (`0`), the whole file will be locked.

Changing or unlocking a segment from the middle of a larger locked segment leaves two smaller segments locked at each end of the originally locked segment. Locking a segment that is already locked by the calling-process causes the old lock type to be removed and the new lock type to take effect. All locks associated with a file for a given process are removed when a file-descriptor for that file is closed by that process or the process holding that file-descriptor terminates. Locks are not inherited by a child-process after executing the FORK(BA_OS) routine.

RETURN VALUE

If successful, the function `fcntl` will return a value that depends on `cmd` as follows:

`F_DUPFD`	a new file-descriptor.
`F_GETFD`	a value of flag (only the low-order bit is defined).
`F_SETFD`	a value other than −1.
`F_GETFL`	a value of file flags.
`F_SETFL`	a value other than −1.
`F_GETLK`	a value other than −1.
`F_SETLK`	a value other than −1.
`F_SETLKW`	a value other than −1.

If unsuccessful, the function `fcntl` will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `fcntl` will fail and will set `errno` to:

`EBADF`	if `fildes` is not a valid open file-descriptor.
`EMFILE`	if `cmd` is `F_DUPFD` and {OPEN_MAX} file-descriptors are currently open in the calling-process.
`EINVAL`	if `cmd` is `F_DUPFD` and `arg` is negative or greater than or equal to {OPEN_MAX}.
`EINVAL`	if `cmd` is `F_GETLK`, `F_SETLK` or `F_SETLKW` and `arg` or the data it points to is not valid.
`EACCES`	if `cmd` is `F_SETLK` the type of lock (`l_type`) is a read-lock (`F_RDLCK`) or write-lock (`F_WRLCK`) and the segment of a file to be locked is already write-locked by another process or the type is a write-lock and the segment of a file to be locked is already read-locked or write-locked by another process.
`ENOLCK`	if `cmd` is `F_SETLK` or `F_SETLKW`, the type of lock is a read-lock or write-lock and there are no more file-locks available (too many segments are locked).
`EDEADLK`	if `cmd` is `F_SETLKW`, the lock is blocked by some lock from another process and putting the calling-process to sleep, waiting for that lock to become free, would cause a deadlock.

APPLICATION USAGE

Because in the future the variable `errno` will be set to `EAGAIN` rather than `EACCES` when a section of a file is already locked by another process, portable application programs should expect and test for either value, for example:

```
flk->l_type = F_RDLCK;
if (fcntl(fd, F_SETLK, flk) == -1)
    if ((errno == EACCES) || (errno == EAGAIN))
        /*
         * section locked by another process,
         * check for either EAGAIN or EACCES
         * due to different implementations
         */
    else if ...
        /*
         * check for other errors
         */
```

The features of `fcntl` that deal with file and record locking are an update that followed System V Release 1.0 and System V Release 2.0.

SEE ALSO

CLOSE(BA_OS), EXEC(BA_OS), OPEN(BA_OS), LOCKF(BA_OS).

FUTURE DIRECTIONS

The error condition which currently sets `errno` to `EACCES` will instead set `errno` to `EAGAIN` [see also **APPLICATION USAGE** above].

Enforcement-mode file-locking and record locking will be added:

> If enforcement-mode file and record-locking is set and there are outstanding record-locks on the file, this may affect future calls to READ(BA_OS) and WRITE(BA_OS) routines on the file [see CHMOD(BA_OS)].

LEVEL

Level 1.

NAME

ferror, feof, clearerr, fileno — stream status inquiries

SYNOPSIS

```
#include <stdio.h>

int ferror(stream)
FILE *stream;

int feof(stream)
FILE *stream;

void clearerr(stream)
FILE *stream;

int fileno(stream)
FILE *stream;
```

DESCRIPTION

The function `ferror` determines if an I/O error has occurred when reading from or writing to the named `stream`.

The function `feof` determines if `EOF` has been detected when reading the named `stream`.

The function `clearerr` resets both the error and `EOF` indicator to false on the named `stream`. The `EOF` indicator is reset when the file pointer associated with `stream` is repositioned, e.g., by the FSEEK(BA_OS) or REWIND(BA_OS) routines, or can be reset with `clearerr`.

The function `fileno` gets the integer file-descriptor associated with the named `stream` [see OPEN(BA_OS)].

RETURN VALUE

The function `ferror` will return non-zero when an I/O error has previously occurred reading from or writing to the named `stream`; otherwise, the function `ferror` will return zero.

The function `feof` will return non-zero when `EOF` has previously been detected reading the named input `stream`; otherwise, the function `feof` will return zero.

The function `fileno` will return the integer file-descriptor number associated with the named `stream`.

APPLICATION USAGE

All of these functions are implemented as macros; they cannot be declared or redeclared.

The function `fileno` returns a file-descriptor that can be used with non-*stdio* routines, such as WRITE(BA_OS) and LSEEK(BA_OS) routines, to manipulate the associated file, but these routines are not recommended for use by application-programs.

SEE ALSO

OPEN(BA_OS), FOPEN(BA_OS).

LEVEL

Level 1.

NAME

fopen, freopen, fdopen — open a stream

SYNOPSIS

```
#include <stdio.h>

FILE *fopen(path, type)
char *path, *type;

FILE *freopen(path, type, stream)
char *path, *type;
FILE *stream;

FILE *fdopen(fildes, type)
int fildes;
char *type;
```

DESCRIPTION

The function `fopen` opens the file named by `path` and associates a stream with it [see **stream** in **Chapter 4 — Definitions**]. The function `fopen` returns a pointer to the `FILE` structure associated with the stream.

The function `freopen` substitutes the named file in place of the open `stream`. The original `stream` is closed, regardless of whether the open ultimately succeeds. The function `freopen` returns a pointer to the `FILE` structure associated with `stream`.

The function `freopen` is typically used to attach the preopened streams associated with `stdin`, `stdout` and `stderr` to other files. The standard error output stream `stderr` is by default unbuffered but use of the function `freopen` will cause it to become buffered or line-buffered.

The argument `path` points to a character-string that names the file to be opened.

The argument `type` is a character-string having one of the following values:

`r`	open for reading.
`w`	truncate or create for writing.
`a`	append; open for writing at the end of the file, or create for writing.
`r+`	open for update (reading and writing).
`w+`	truncate or create for update.
`a+`	append; open or create for update (appending) to the end of the file.

When a file is opened for update, both input and output may be done on the resulting `stream`. However, output may not be directly followed by input without an intervening call to the FSEEK(BA_OS) or REWIND(BA_OS) routine, and input may not be directly followed by output without an intervening call to the FSEEK(BA_OS) or REWIND(BA_OS) routine or an input operation which encounters end-of-file.

When a file is opened for append (i.e., when `type` is `a` or `a+`) it is impossible to overwrite information already in the file. The FSEEK(BA_OS) routine may be used to reposition the file-pointer to any position in the file, but when output is written to the file, the current file-pointer is disregarded. All output is written at the end of the file. For example, if two separate processes open the same file for append, each process may write to the file without overwriting output being written by the other, and the output from the two processes would be interleaved in the file.

The function `fdopen` associates a `stream` with a file-descriptor, `fildes`. The `type` of `stream` given to `fdopen` must agree with the mode of the already open file. File-descriptors are obtained from the routines which open files but do not return pointers to a `FILE` structure `stream`. Streams are necessary input for many of the *stdio* routines.

RETURN VALUE

The functions `fopen` and `freopen` return a `NULL` pointer if `path` cannot be accessed or if `type` is invalid or if the file cannot be opened.

The function `fdopen` will return a `NULL` pointer if `fildes` is not an open file-descriptor or if `type` is invalid or if the file cannot be opened.

The function `fopen` or the function `fdopen` may also fail if there are no free *stdio* streams.

ERRORS

When the file cannot be opened, the function `fopen` or the function `freopen` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix in `path` is not a directory.
`ENOENT`	if the named file does not exist or a component of the path-name should exist but does not.
`EACCES`	if a component of the path-prefix denies search permission or `type` permission is denied for the named file.
`EISDIR`	if the named file is a directory and `type` is write or read/write.
`EROFS`	if the named file resides on a read-only file system and `type` is write or read/write.
`ETXTBSY`	if the file is a pure procedure (shared text) file that is being executed and `type` is write or read/write.
`EINTR`	if a signal was caught during the open operation.

SEE ALSO

CREAT(BA_OS), DUP(BA_OS), OPEN(BA_OS), PIPE(BA_OS), FCLOSE(BA_OS), FSEEK(BA_OS).

LEVEL

Level 1.

NAME

fork — create a new process

SYNOPSIS

```
int fork( )
```

DESCRIPTION

The function `fork` creates a new process. The new process (child-process) is a copy of the calling-process (parent-process). This means the child-process inherits the following attributes from the parent-process:

environment
close-on-exec flag [see EXEC(BA_OS)]
signal-handling settings (i.e., `SIG_DFL`, `SIG_IGN`, *address*)
set-user-ID mode bit
set-group-ID mode bit
process-group-ID
tty-group-ID [see EXIT(BA_OS) and SIGNAL(BA_OS)]
current-working-directory
root-directory
file mode creation mask [see UMASK(BA_OS)]
file size limit [see ULIMIT(BA_OS)]

Additional attributes associated with an Extension to the Base System may be inherited from the parent-process [see, for example, **Part III — Kernel Extension Definition**].

The child-process differs from the parent-process as follows:

The child-process has a unique process-ID

The child-process has a different parent-process-ID (i.e., the process-ID of the parent-process).

The child-process has its own copy of the parent's file-descriptors. Each of the child-process's file-descriptors shares a common file-pointer with the corresponding file-descriptor of the parent-process.

The child-process's `utime`, `stime`, `cutime`, and `cstime` are set to `0`. The time left until an alarm clock signal is reset to `0`.

(File-locks set by the parent-process are not inherited by the child-process [see FCNTL(BA_OS) or LOCKF(BA_OS)]).

RETURN VALUE

If successful, the function `fork` will return `0` to the child-process and will return the process-ID of the child-process to the parent-process; otherwise, it will return `-1` to the parent-process, no child-process will be created and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `fork` will fail and will set `errno` to:

`EAGAIN`	if the system-imposed limit on the total number of processes under execution system-wide {PROC_MAX} or by a single user-ID {CHILD_MAX} would be exceeded.
`ENOMEM`	if the process requires more space than the system is able to supply.

APPLICATION USAGE

The function `fork` creates a new process that is a copy of the calling-process and both processes will run as system resources become available. Because the goal is typically to create a new process that is *different* from the parent-process (i.e., the goal is to start a new program running) often the child-process immediately calls an EXEC(BA_OS) routine to transform itself and start the new program.

If possible, applications should use the SYSTEM(BA_OS) routine, which is easier to use and supplies more functions, rather than the FORK(BA_OS) and EXEC(BA_OS) routines.

SEE ALSO

ALARM(BA_OS), EXEC(BA_OS), FCNTL(BA_OS), LOCKF(BA_OS), SIGNAL(BA_OS), TIMES(BA_OS), ULIMIT(BA_OS), UMASK(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

fread, fwrite — buffered input/output

SYNOPSIS

```
#include <stdio.h>

int fread(ptr, size, nitems, stream)
char *ptr;
int size, nitems;
FILE *stream;

int fwrite(ptr, size, nitems, stream)
char *ptr;
int size, nitems;
FILE *stream;
```

DESCRIPTION

The function `fread` reads into an array pointed to by `ptr` up to `nitems` items of data from the named input `stream`, where an item of data is a sequence of bytes (not necessarily terminated by a null byte) of length `size`. The function `fread` stops appending bytes if an end-of-file or error condition is encountered while reading `stream`, or if `nitems` items have been read. The function `fread` increments the data-pointer in `stream` to point to the byte following the last byte read if there is one [see FSEEK(BA_OS)]. The function `fread` does not change the contents of `stream`.

The function `fwrite` appends to the named output `stream` at most `nitems` items of data from the array pointed to by `ptr`. The function `fwrite` stops appending when it has appended `nitems` items of data or if an error condition is encountered on `stream`. The function `fwrite` does not change the contents of the array pointed to by `ptr`. The function `fwrite` increments the data-pointer in `stream` by the number of bytes written.

RETURN VALUE

If successful, both the function `fread` and the function `fwrite` will return the number of items read or written. If `size` or `nitems` is non-positive, no characters will be read or written and both `fread` and `fwrite` will return `0`.

APPLICATION USAGE

The argument `size` is typically `sizeof(*ptr)`, where the C operator `sizeof` gives the length of an item pointed to by `ptr`. If `ptr` points to a data type other than `char` it should be cast into a pointer to `char`.

The FERROR(BA_OS) or FEOF(BA_OS) routines must be used to distinguish between an error condition and an end-of-file condition.

SEE ALSO

FERROR(BA_OS), FOPEN(BA_OS), FSEEK(BA_OS), GETC(BA_LIB), GETS(BA_LIB), PRINTF(BA_LIB), PUTC(BA_LIB), PUTS(BA_LIB), READ(BA_OS), SCANF(BA_LIB). WRITE(BA_OS),

FUTURE DIRECTIONS

The type of the argument `size` to the functions `fread` and `fwrite` will be declared through the `typedef` facility in a header file as `size_t`.

LEVEL

Level 1.

NAME

fseek, rewind, ftell — reposition a file-pointer in a stream

SYNOPSIS

```
#include <stdio.h>

int fseek(stream, offset, whence)
FILE *stream;
long offset;
int whence;

void rewind(stream)
FILE *stream;

long ftell(stream)
FILE *stream;
```

DESCRIPTION

The function `fseek` sets the position of the next input or output operation on the `stream`. The new position is at the signed distance `offset` bytes from the beginning, from the current position, or from the end of the file, according as `whence` has the value `0`, `1`, or `2`.

The call `rewind(stream)` is equivalent to the following:

```
fseek(stream,0L,0)
```

except that the function `rewind` returns no value.

The functions `fseek` and `rewind` undo any effects of the UNGETC(BA_LIB) routine. After `fseek` or `rewind`, the next operation on a file opened for update may be either input or output.

The function `ftell` returns the offset of the current byte relative to the beginning of the file associated with the named `stream`. The offset is always measured in bytes.

RETURN VALUE

The function `fseek` will return non-zero for improper seeks; otherwise, the function `fseek` will return zero. An improper seek is, for example, an `fseek` on a file that has not been opened via the FOPEN(BA_OS) routine; on a device incapable of seeking, such as a terminal; or on a stream opened via the POPEN(BA_OS) routine.

SEE ALSO

LSEEK(BA_OS), FOPEN(BA_OS), POPEN(BA_OS), UNGETC(BA_LIB).

FUTURE DIRECTIONS

Symbolic constants for the values of `whence` will be defined by the `<unistd.h>` header file [see LSEEK(BA_OS)].

LEVEL

Level 1.

NAME

getcwd — get path-name of current working directory

SYNOPSIS

```
char *getcwd(buf, size)
char *buf;
int size;
```

DESCRIPTION

The function `getcwd` returns a pointer to the current directory path-name. The value of `size` must be at least two greater than the length of the path-name to be returned.

RETURN VALUE

If `size` is not large enough or if an error occurs in a lower-level function, the function `getcwd` will return `NULL` and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `getcwd` will fail and will set `errno` to:

`EINVAL`	if `size` is zero
`ERANGE`	if `size` not large enough to hold the path-name.

LEVEL

Level 1.

NAME

getpid, getpgrp, getppid — get process-ID, process-group-ID, and parent-process-ID

SYNOPSIS

```
int getpid( )

int getpgrp( )

int getppid( )
```

DESCRIPTION

The function `getpid` returns the process-ID of the calling-process.

The function `getpgrp` returns the process-group-ID of the calling-process.

The function `getppid` returns the parent-process-ID of the calling-process.

SEE ALSO

EXEC(BA_OS), FORK(BA_OS), SETPGRP(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

getuid, geteuid, getgid, getegid — get real-user-ID, effective-user-ID, real-group-ID, and effective-group-IDs

SYNOPSIS

```
unsigned short getuid( )

unsigned short geteuid( )

unsigned short getgid( )

unsigned short getegid( )
```

DESCRIPTION

The function `getuid` returns the real-user-ID of the calling-process.

The function `geteuid` returns the effective-user-ID of the calling-process.

The function `getgid` returns the real-group-ID of the calling-process.

The function `getegid` returns the effective-group-ID of the calling-process.

SEE ALSO

SETUID(BA_OS).

LEVEL

Level 1.

NAME

ioctl — control device

SYNOPSIS

```
int ioctl(fildes, request, arg)
int fildes, request;
```

DESCRIPTION

The function `ioctl` performs a variety of control functions on devices. This call passes the request to a device-driver to perform *device-specific* control functions.

NOTE: This control is not frequently used and the basic input/output operations are performed by the READ(BA_OS) and WRITE(BA_OS) routines.

The argument `fildes` is an open file-descriptor that refers to a device.

The argument `request` selects the control function to be performed and will depend on the device being addressed.

The argument `arg` represents additional information that is needed by this specific device to perform the requested function. The data type of `arg` depends upon the particular control request, but it is either an integer or a pointer to a device-specific data structure.

In addition to device-specific functions, there are generic functions that are provided by more than one device-driver, for example, the general terminal interface [see TERMIO(BA_ENV)].

RETURN VALUE

If successful, the function `ioctl` will return a value that depends upon the device control function, but must be an integer value; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `ioctl` will fail and will set `errno` to:

`EBADF`	if `fildes` is not a valid open file-descriptor.
`ENOTTY`	if `fildes` is not associated with a device-driver that accepts control functions.
`EINTR`	if a signal was caught during the `ioctl` operation.

The function `ioctl` will also fail if the device-driver detects an error. In this case, the error is passed through `ioctl` without change to the caller. A particular device-driver might not have all of the following error cases.

Under the following conditions, requests to standard device-drivers may fail and `errno` will be set to:

`EINVAL`	if `request` or `arg` are not valid for this device.
`EIO`	if some physical I/O error has occurred.
`ENXIO`	if `request` and `arg` are valid for this device-driver, but the service requested can not be performed on this particular sub-device.

SEE ALSO

The specific device reference documents and generic devices such as the general terminal interface [see TERMIO(BA_ENV)].

LEVEL

Level 1.

NAME

kill — send a signal to a process or a group of processes

SYNOPSIS

```
#include <signal.h>
int kill(pid, sig)
int pid, sig;
```

DESCRIPTION

The function `kill` sends a signal to a process or a group of processes.

The signal that is to be sent is specified by the argument `sig` and is either one from the list given in SIGNAL(BA_OS), or `0`. If `sig` is `0` (the null signal), error checking is performed but no signal is actually sent. This can be used to check the validity of `pid`.

The process or group of processes to which the signal is to be sent is specified by the argument `pid`. The argument `pid` specifies the processes to receive the signal as follows:

> If `pid` is greater than `0`, `sig` will be sent to the process whose process-ID is equal to `pid`.
>
> If `pid` is `0`, `sig` will be sent to all processes, excluding special system processes, whose process-group-ID is equal to the process-group-ID of the sender.
>
> If `pid` is negative but not `-1`, `sig` will be sent to all processes whose process-group-ID is equal to the absolute value of `pid`.
>
> If `pid` is `-1`, `sig` will be sent to all processes, excluding special system-processes.

Of the processes specified by `pid`, only those where the real-user-ID or effective-user-ID of the sending-process matches the real-user-ID or effective-user-ID of the receiving-process will be sent the signal, unless the effective-user-ID of the sending-process is super-user.

RETURN VALUE

If successful, the function `kill` will return `0`; otherwise, it will return `-1`, no signal will be sent and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `kill` will fail and will set `errno` to:

`EINVAL`	if `sig` is not a valid signal number or if `sig` is `SIGKILL` and `pid` is a special system-process.
`ESRCH`	if no process corresponding to `pid` can be found.
`EPERM`	if the user-ID of the sending-process is not super-user, and its real-user-ID (or effective-user-ID) does not match either the real-user-ID or effective-user-ID of the receiving-process.

SEE ALSO

GETPID(BA_OS), SETPGRP(BA_OS), SIGNAL(BA_OS).

FUTURE DIRECTIONS

EPERM will be returned in errno if sig is SIGKILL and pid is a special system-process.

LEVEL

Level 1.

NAME

link — link to a file

SYNOPSIS

```
int link(path1, path2)
char *path1, *path2;
```

DESCRIPTION

The function `link` creates a new link (directory entry) for the existing file.

The argument `path1` points to a path-name naming an existing file.

The argument `path2` points to a path-name naming the new directory entry to be created.

RETURN VALUE

If successful, the function `link` will return `0`; otherwise, it will return `-1`, no link will be created and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `link` will fail and will set `errno` to:

`ENOTDIR`	if a component of either path-prefix is not a directory.
`ENOENT`	if a component of either path-name should exist but does not.
`EACCES`	if a component of either path-prefix denies search permission, or if the requested link requires writing in a directory with a mode that denies write permission.
`EEXIST`	if the link named by `path2` exists.
`EPERM`	if the file named by `path1` is a directory and the effective-user-ID is not super-user.
`EXDEV`	if the link named by `path2` and the file named by `path1` are on different logical devices (file-systems) and the implementation does not permit cross-device links.
`EROFS`	if the requested link requires writing in a directory on a read-only file-system.
`EMLINK`	if the maximum number of links to a single file, {LINK_MAX}, would be exceeded.
`ENOSPC`	if the directory to contain the link cannot be extended.

SEE ALSO

UNLINK(BA_OS).

LEVEL

Level 1.

NAME

lockf — record locking on files

SYNOPSIS

```
#include <unistd.h>

int lockf(fildes, function, size)
int fildes, function;
long size;
```

DESCRIPTION

NOTE: The function `lockf` first became available following System V Release 1.0 and System V Release 2.0.

The function `lockf` will allow sections of a file to be locked. Calls to the function `lockf` from other processes which attempt to lock the locked file section will either return an error value or be put to sleep until the resource becomes unlocked. All the locks for a process are removed when the process terminates [see FCNTL(BA_OS) for more information about record-locking].

The argument `fildes` is an open file-descriptor. The file-descriptor must have been opened with write-only permission (`O_WRONLY`) or with read/write permission (`O_RDWR`) in order to establish a lock with this function call [see OPEN(BA_OS)].

The argument `function` is a control value which specifies the action to be taken. The permissible values for `function` are defined by the `<unistd.h>` header file as follows:

```
#define F_ULOCK 0 /* unlock locked sections */
#define F_LOCK  1 /* lock a section */
                  /* for exclusive use */
#define F_TLOCK 2 /* test and lock a section */
                  /* for exclusive use */
#define F_TEST  3 /* test section for locks */
                  /* by other processes */
```

`F_TEST` detects if a lock by another process is present on the specified section; `F_LOCK` and `F_TLOCK` both lock a section of a file if the section is available; `F_ULOCK` removes locks from a section of the file. All other values of `function` are reserved for future extensions and will result in an error return if they are not implemented.

The argument `size` is the number of contiguous bytes to be locked or unlocked. The resource to be locked or unlocked starts at the current offset in the file and extends forward for a positive size or backward for a negative size (the preceding bytes up to but not including the current offset). If `size` is `0`, the section from the current offset through the largest file offset {FCHR_MAX} is locked (i.e., from the current offset through the present or any future end-of-file). An area need not be allocated to the file in order to be locked as such locks may exist past the end-of-file.

The sections locked with F_LOCK or F_TLOCK may, in whole or in part, contain or be contained by a previously locked section for the same process. When this occurs, or if adjacent locked sections would occur, the sections are combined into a single locked section. If the request requires that a new element be added to the table of active locks and this table is already full, an error is returned, and the new section is not locked.

F_LOCK and F_TLOCK requests differ only by the action taken if the resource is not available. F_LOCK will cause the calling-process to sleep until the resource is available. F_TLOCK will cause the function to return a −1 and set errno to EACCES if the section is already locked by another process.

F_ULOCK requests may release (wholly or in part) one or more locked sections controlled by the process. Locked sections will be unlocked starting at the point of the file offset through size bytes or to the end of file if size is 0. When all of a locked section is not released (i.e., the beginning or end of the area to be unlocked falls within a locked section) the remaining portions of that section are still locked by the process. For example, releasing a center portion of a locked section will leave the portions of the section before and after it locked and requires an additional element in the table of active locks. If this table is full, an EDEADLK error is returned in errno and the requested section is not released.

A potential for deadlock occurs if a process controlling a locked resource is put to sleep by accessing another process's locked resource. Thus calls to the function lockf or the FCNTL(BA_OS) routine scan for a deadlock prior to sleeping on a locked resource. An error return is made if sleeping on the locked resource would cause a deadlock.

Sleeping on a resource is interrupted with any signal. The ALARM(BA_OS) routine may be used to provide a timeout facility in applications requiring it.

RETURN VALUE

If successful, the function lockf will return 0; otherwise, it will return −1 and errno will indicate the error.

ERRORS

The function lockf will fail and will set errno to:

EBADF	if fildes is not a valid open file-descriptor.
EACCES	if function is F_TLOCK or F_TEST and the section is already locked by another process.
EDEADLK	if function is F_LOCK and a deadlock would occur; also if function is F_LOCK, F_TLOCK or F_ULOCK and there are not enough entries in the system lock table to honor the request.

APPLICATION USAGE

Because in the future the variable `errno` will be set to `EAGAIN` rather than `EACCES` when a section of a file is already locked by another process, portable application programs should expect and test for either value, for example:

```
if (lockf(fd, F_TLOCK, siz) == -1)
    if ((errno == EAGAIN) || (errno == EACCES))
        /*
         * section locked by another process
         * check for either EAGAIN or EACCES
         * due to different implementations
         */
    else if ...
        /*
         * check for other errors
         */
```

File-locking and record-locking should not be used in combination with the FOPEN(BA_OS), FREAD(BA_OS), FWRITE(BA_OS), etc. *stdio* routines. Instead, the more primitive, non-buffered routines (e.g., the OPEN(BA_OS) routine) should be used. Unexpected results may occur in processes that do buffering in the user address space. The process may later read/write data which is/was locked. The *stdio* routines are the most common source of unexpected buffering.

SEE ALSO

CHMOD(BA_OS), CLOSE(BA_OS), CREAT(BA_OS), FCNTL(BA_OS), OPEN(BA_OS), READ(BA_OS), WRITE(BA_OS).

FUTURE DIRECTIONS

The error condition which currently sets `errno` to `EACCES` will instead set `errno` to `EAGAIN` [see also **APPLICATION USAGE** above].

Enforcement-mode file and record locking will be added:

Sections of a file will be locked with advisory-mode or enforcement-mode locks depending on the mode of the file [see CHMOD(BA_OS)]

LEVEL

Level 1.

NAME

lseek — move read/write file-pointer

SYNOPSIS

```
long lseek(fildes, offset, whence)
int fildes;
long offset;
int whence;
```

DESCRIPTION

The function `lseek` sets the file-pointer associated with `fildes` as follows:

> If `whence` is `0`, the function `lseek` will set the file-pointer equal to `offset` bytes.
>
> If `whence` is `1`, the function `lseek` will set the file-pointer equal to its current location plus `offset`.
>
> If `whence` is `2`, the function `lseek` will set the file-pointer equal to the length of the file plus `offset`.

If successful, the function `lseek` returns the resulting pointer location, as measured in bytes from the beginning of the file. The function `lseek` modifies the file-pointer and does not affect the physical device.

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

RETURN VALUE

If successful, the function `lseek` will return a file-pointer value; otherwise, it will return `−1`, the file-pointer will remain unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `lseek` will fail and will set `errno` to:

`EBADF`	if `fildes` is not an open file-descriptor.
`ESPIPE`	if `fildes` is associated with a pipe or FIFO.
`EINVAL`	if `whence` is not `0`, `1`, or `2`.

The significance of the file-pointer associated with a device incapable of seeking, such as a terminal, is undefined.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read, write and manipulate files. Thus, an application that had used the FOPEN(BA_OS) *stdio* routine to open a file would use the FSEEK(BA_OS) *stdio* routine rather than the function `lseek`.

The function `lseek` allows the file-pointer to be set beyond the existing data in the file. If data are later written at this point, subsequent reads in the gap between the previous end of data and the newly written data will return bytes of value 0 until data are written into the gap.

SEE ALSO

CREAT(BA_OS), DUP(BA_OS), FCNTL(BA_OS), OPEN(BA_OS).

FUTURE DIRECTIONS

The `<unistd.h>` header file will define the following symbolic constants for the argument `whence` to the `seek` and `lseek` functions:

Name	*Description*
`SEEK_SET`	set file-pointer to `offset`.
`SEEK_CUR`	set file-pointer to current plus `offset`.
`SEEK_END`	set file-pointer to `EOF` plus `offset`.

LEVEL

Level 1.

NAME

malloc, free, realloc, calloc, mallopt, mallinfo — fast main memory allocator

SYNOPSIS

```
#include <malloc.h>

char *malloc(size)
unsigned size;

void free(ptr)
char *ptr;

char *realloc(ptr, size)
char *ptr;
unsigned size;

char *calloc(nelem, elsize)
unsigned nelem, elsize;

int mallopt(cmd, value)
int cmd, value;

struct mallinfo mallinfo( )
```

DESCRIPTION

The function `malloc` and the function `free` provide a simple general-purpose memory allocation package.

The function `malloc` returns a pointer to a block of at least `size` bytes suitably aligned for any use.

The argument to the function `free` is a pointer to a block previously allocated by the function `malloc`; after the function `free` is performed this space is made available for further allocation.

Undefined results will occur if the space assigned by the function `malloc` is overrun or if an invalid value for `ptr` is passed to the function `free`.

The function `realloc` changes the size of the block pointed to by `ptr` to `size` bytes and returns a pointer to the (possibly moved) block. The contents will be unchanged up to the lesser of the new and old sizes.

The function `calloc` allocates space for an array of `nelem` elements of size `elsize`. The space is initialized to zeros.

Available in System V Release 2.0, the function `mallopt` plus the function `mallinfo` allow tuning the allocation algorithm at execution time.

The function `mallopt` initiates a mechanism that can be used to allocate small blocks of memory quickly. Using this scheme, a large-group (called a *holding-block*) of these small-blocks is allocated at one time. Then, each time a program requests a small amount of memory from `malloc` a pointer to one of the *pre-allocated* small-blocks is returned. Different holding-blocks are created for different sizes of small-blocks and are created when needed.

The function `mallopt` allows the programmer to set three parameters to maximize efficient small-block allocation for a particular application. The three parameters are:

> The value of `size` below which requests to `malloc` will be filled using the special small-block algorithm. Initially, this value, which will be called *maxfast*, is zero, which means that the small-block option is not normally in use by `malloc`.
>
> The number of small-blocks in a holding-block. If holding-blocks have many more small-blocks than the program is using, space will be wasted. If holding-blocks are too small, have too few small-blocks in each, performance gain is lost.
>
> The *grain* of small-block sizes. This value determines what range of small-block sizes will be considered to be the same size. This influences the number of separate holding-blocks allocated. For example, if *grain* were 16-bytes, all small-blocks of 16-bytes or less would belong to one holding-block and blocks from 17-bytes to 32-bytes would belong to another holding-block. Thus, if *grain* is too small space may be wasted because many holding-blocks may be created.

The values for the argument `cmd` to the function `mallopt` are:

`M_MXFAST`	Set *maxfast* to `value`. The algorithm allocates all blocks below the size of *maxfast* in large-groups and then doles them out very quickly. The default value for *maxfast* is `0`.
`M_NLBLKS`	Set *numlblks* to `value`. The above mentioned large-groups each contain *numlblks* blocks. The value for *numlblks* must be greater than `1`. The default value for *numlblks* is `100`.
`M_GRAIN`	Set *grain* to `value`. The sizes of all blocks smaller than *maxfast* are considered to be rounded up to the nearest multiple of *grain*. The value for *grain* must be greater than `0`. The default value for *grain* is the smallest number of bytes which will allow alignment of any data type. The `value` will be rounded up to a multiple of the default when *grain* is set.
`M_KEEP`	Preserve data in a freed-block until the next call to the function `malloc`, `realloc`, or `calloc`. This option is provided only for compatibility with the older version of the function `malloc` and is not recommended.

These `cmd` values are defined by the `<malloc.h>` header file.

The function `mallopt` may be called repeatedly, but the parameters may not be changed after the first small-block is allocated from a holding-block. If `mallopt` is called again after the first small-block is allocated using the small-block algorithm, it will return an error.

The function `mallinfo` can be used during a program development to determine the best settings of these parameters for a particular application. The function `mallinfo` must not be called until after some storage has been allocated using the function `malloc`. The function `mallinfo` provides information describing space usage. It returns the structure `mallinfo`, which includes the following members:

```
int arena;     /* total space in arena */
int ordblks;   /* number of ordinary-blocks */
int smblks;    /* number of small-blocks */
int hblkhd;    /* space in holding-block overhead */
int hblks;     /* number of holding-blocks */
int usmblks;   /* space in small-blocks in use */
int fsmblks;   /* space in free small-blocks */
int uordblks; /* space in ordinary-blocks in use */
int fordblks; /* space in free ordinary-blocks */
int keepcost; /* space penalty for keep option */
```

The structure `mallinfo` is defined by the `<malloc.h>` header file.

RETURN VALUE

Each of the allocation functions `malloc`, `realloc`, and `calloc` returns a pointer to space suitably aligned (after possible pointer coercion) for storage of any type of object.

The functions `malloc`, `realloc`, and `calloc` return a `NULL` pointer if `nbytes` is `0` or if there is not enough available memory. When the function `realloc` returns `NULL`, the block pointed to by `ptr` is left intact.

If the function `mallopt` is called after any allocation from a holding-block or if the arguments `cmd` or `value` are invalid, the function `mallopt` will return a non-zero value; otherwise, it will return `0`.

APPLICATION USAGE

The functions `mallopt` and `mallinfo` and the `<malloc.h>` header file first appeared in System V Release 2.0.

In System V Release 2.0, the developer can control whether the contents of the freed space are destroyed or left undisturbed (see the function `mallopt` above). In System V Release 1.0, the contents are left undisturbed.

Allocation time increases when many objects have been allocated and not freed. The additional System V Release 2.0 routines provide some flexibility in dealing with this.

LEVEL

Level 1.

NAME

mknod — make a directory, or a special or ordinary-file

SYNOPSIS

```
int mknod(path, mode, dev)
char *path;
int mode, dev;
```

DESCRIPTION

The function `mknod` creates a new file named by the path-name pointed to by the argument `path`.

The mode of the new file is initialized from the argument `mode`. Where the value of `mode` is interpreted as follows:

0170000 file type; one of the following:

0010000 FIFO-special
0020000 character-special
0040000 directory
0060000 block-special
0100000 or 0000000 ordinary-file

0004000 set user-ID on execution

0002000 set group-ID on execution

0001000 (reserved)

0000777 access permissions; constructed from the following:

0000400 read by owner
0000200 write by owner
0000100 execute (search on directory) by owner
0000070 read, write, execute (search) by group
0000007 read, write, execute (search) by others

The owner-ID of the file is set to the effective-user-ID of the process. The group-ID of the file is set to the effective-group-ID of the process.

Values of `mode` other than those above are undefined and should not be used. The owner, group and other permission bits of `mode` are modified by the process's file mode creation mask: the function `mknod` clears each bit whose corresponding bit in the process's file mode creation mask is set [see UMASK(BA_OS)].

If the argument `mode` indicates a block-special or character-special file, the argument `dev` is a configuration-dependent specification of a character or block I/O device. The value of `dev` is obtained from the `st_dev` field of the `stat` structure [see STAT(BA_OS)]. If `mode` does not indicate a block-special or character-special device, `dev` is ignored.

The function `mknod` may be invoked only by the super-user for file types other than FIFO-special.

RETURN VALUE

If successful, the function `mknod` will return 0; otherwise, it will return −1, the new file will not be created and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `mknod` will fail and will set `errno` to:

`EPERM`	if the effective-user-ID of the process is not super-user and the file type is not FIFO-special.
`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if a component of the path-prefix does not exist.
`EACCES`	if a component of the path-prefix denies search permission and the effective-user-ID of the process is not super-user.
`EROFS`	if the directory in which the file is to be created is located on a read-only file system.
`EEXIST`	if the named file exists.
`ENOSPC`	if the directory to contain the new file cannot be extended.

SEE ALSO

CHMOD(BA_OS), EXEC(BA_OS), STAT(BA_OS), UMASK(BA_OS).

LEVEL

Level 1.

NAME

mount — mount a file system

SYNOPSIS

```
int mount(spec, dir, rwflag)
char *spec, *dir;
int rwflag;
```

DESCRIPTION

The function `mount` requests that a removable file system contained on the block-special file identified by the argument `spec` be mounted on the directory identified by the argument `dir`.

The arguments `spec` and `dir` are pointers to path-names.

When the function `mount` succeeds, references to the file named by `dir` will refer to the root-directory on the mounted file system.

The low-order bit of the argument `rwflag` is used to control write permission on the mounted file system; if the bit is set to 1, writing is forbidden; otherwise, writing is permitted according to individual file accessibility.

The function `mount` may be invoked only by the super-user.

RETURN VALUE

If successful, the function `mount` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `mount` will fail and will set `errno` to:

EPERM	if the effective-user-ID is not super-user.
ENOENT	if any of the named files does not exist.
ENOTDIR	if a component of a path-prefix is not a directory.
ENOTBLK	if the device identified by `spec` is not block-special.
ENXIO	if the device identified by `spec` does not exist.
ENOTDIR	if `dir` is not a directory.
EBUSY	if `dir` is currently mounted on, is someone's current working directory, or is otherwise busy.
EBUSY	if the device identified by `spec` is currently mounted.
EBUSY	if there are no more mount-table entries.

APPLICATION USAGE

The function `mount` is not recommended for use by application-programs.

SEE ALSO

UMOUNT(BA_OS).

FUTURE DIRECTIONS

The external variable `errno` will be set to `EAGAIN` rather than `EBUSY` when the system mount-table is full.

Additional optional arguments will be added to the `mount` function. New bit-patterns will be added to the set of possible values of the argument `rwflag`. Some of these patterns will be used to indicate if an optional argument is present.

LEVEL

Level 1.

NAME

open — open for reading or writing

SYNOPSIS

```
#include <fcntl.h>

int open(path, oflag, mode)
char *path;
int oflag, mode;
```

DESCRIPTION

The function `open` opens a file-descriptor for the named file.

The argument `path` points to a path-name naming a file.

The function `open` sets the file status flags according to the value of the argument `oflag`. Symbolic names of flags are defined by the `<fcntl.h>` header file. The values of `oflag` are constructed by ORing flags from the following list (only one of the first three flags below may be used):

`O_RDONLY` Open for reading only.

`O_WRONLY` Open for writing only.

`O_RDWR` Open for reading and writing.

`O_NDELAY` This flag may affect subsequent reads and writes [see READ(BA_OS) and WRITE(BA_OS)].

When opening a FIFO with `O_RDONLY` or `O_WRONLY` set:

If `O_NDELAY` is set:

An `open` for reading-only will return without delay. An `open` for writing-only will return an error if no process currently has the file open for reading.

If `O_NDELAY` is clear:

An `open` for reading-only will block until a process opens the file for writing. An `open` for writing-only will block until a process opens the file for reading.

When opening a file associated with a communication line:

If `O_NDELAY` is set:

The `open` will return without waiting for carrier.

If `O_NDELAY` is clear:

The `open` will block until carrier is present.

`O_APPEND` If set, the file-pointer will be set to the end of the file prior to each write.

`O_CREAT`	If the file exists, this flag has no effect. Otherwise, the file is created, the owner-ID of the file is set to the effective-user-ID of the process, the group-ID of the file is set to the effective-group-ID of the process, and the access permission bits [see CHMOD(BA_OS)] of the file mode are set to the value of `mode` modified as follows [see CREAT(BA_OS)]: The corresponding bits are ANDed with the complement of the process's file mode creation mask [see UMASK(BA_OS)]. Thus, the function `open` clears each bit in the file mode whose corresponding bit in the file mode creation mask is set.
`O_TRUNC`	If the file exists, its length is truncated to 0 and the mode and owner are unchanged.
`O_EXCL`	If `O_EXCL` and `O_CREAT` are set, the function `open` will fail if the file exists.

The file pointer used to mark the current position within the file is set to the beginning of the file.

The new file-descriptor is the lowest-numbered file-descriptor available and is set to remain open across calls to the EXEC(BA_OS) routines [see FCNTL(BA_OS)].

RETURN VALUE

If successful, the function `open` will return an open file-descriptor; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `open` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if `O_CREAT` is not set and the named file does not exist, or a component of the path-name should exist but does not.
`EACCES`	if a component of the path-prefix denies search permission; or if the file does not exist and the directory that would contain the file does not permit writing.
`EACCES`	if the `oflag` permission is denied for the named file.
`EISDIR`	if the named file is a directory and the `oflag` permission is write or read/write.
`EROFS`	if the named file resides on a read-only file system and the `oflag` permission is write or read/write.
`EMFILE`	if {OPEN_MAX} file-descriptors are currently open in this process.

ENXIO	if the named file is a character-special or block-special file and the device associated with this special file does not exist; or if O_NDELAY is set, the named file is a FIFO, O_WRONLY is set and no process has the file open for reading.
ETXTBSY	if the file is a pure procedure (shared text) file that is being executed and oflag specifies write or read/write permission.
EEXIST	if O_CREAT and O_EXCL are set, and the named file exists.
EINTR	if a signal was caught during the open operation.
ENFILE	if the system file table is full, {SYS_OPEN} files are open in the system.
ENOSPC	if the directory to contain the file cannot be extended, the file does not exist, and O_CREAT is specified.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read and write files. Thus, applications should use the FOPEN(BA_OS) *stdio* routine rather than using the OPEN(BA_OS) routine.

SEE ALSO

CLOSE(BA_OS), CREAT(BA_OS), DUP(BA_OS), FCNTL(BA_OS), LSEEK(BA_OS), READ(BA_OS), WRITE(BA_OS).

FUTURE DIRECTIONS

Enforcement-mode file and record-locking features will be added:

The function open will set errno to EAGAIN if the file exists, enforcement-mode file and record-locking is set and there are outstanding record-locks on the file [see CHMOD(BA_OS)].

LEVEL

Level 1.

NAME

pause — suspend process until signal

SYNOPSIS

```
int pause( )
```

DESCRIPTION

The function `pause` suspends the calling-process until it receives a signal. The signal must be one that is not currently set to be ignored by the calling-process.

RETURN VALUE

If the signal causes termination of the calling-process, the function `pause` will not return. In case of error, the function `pause` will return −1 and `errno` will be set to `EINTR`.

ERRORS

Under the following conditions, the function `pause` will fail and will set `errno` to:

`EINTR`	if the signal is *caught* by the calling-process and control is returned from the signal-catching function, the calling-process resumes execution from the point of suspension.

SEE ALSO

ALARM(BA_OS), KILL(BA_OS), SIGNAL(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

pipe — create an interprocess channel

SYNOPSIS

```
int pipe(fildes)
int fildes[2];
```

DESCRIPTION

The function `pipe` creates an I/O mechanism called a *pipe* and returns two file-descriptors, `fildes[0]` and `fildes[1]`. The file associated with `fildes[0]` is opened for reading, the file associated with `fildes[1]` is opened for writing, and the `O_NDELAY` flag is cleared.

Up to {PIPE_MAX} bytes of data are buffered by the pipe before the writing-process is blocked. A read-only file-descriptor `fildes[0]` accesses the data written to `fildes[1]` on a first-in-first-out, FIFO, basis.

RETURN VALUE

If successful, the function `pipe` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `pipe` will fail and will set `errno` to:

`EMFILE`	if {OPEN_MAX}−1 or more file-descriptors are currently open for this process.
`ENFILE`	if more than {SYS_OPEN} files would be open in the system.

SEE ALSO

READ(BA_OS), WRITE(BA_OS).

LEVEL

Level 1.

NAME

popen, pclose — initiate pipe to/from a process

SYNOPSIS

```
#include <stdio.h>

FILE *popen(command, type)
char *command, *type;

int pclose(stream)
FILE *stream;
```

DESCRIPTION

The function `popen` creates a pipe between the calling program and the command to be executed.

The arguments to `popen` are pointers to null-terminated strings containing, respectively, a command line [see SYSTEM(BA_OS)] and an I/O mode, either `r` for reading or `w` for writing.

The function `popen` returns a stream pointer such that one can write to the standard input of the command, if the I/O mode is `w` by writing to the file `stream`; and one can read from the standard output of the command, if the I/O mode is `r` by reading from the file `stream`.

A stream opened by the function `popen` should be closed by the function `pclose`, which waits for the associated process to terminate and returns the exit status of the command.

Because open files are shared, a type `r` command may be used as an input filter and a type `w` command as an output filter.

RETURN VALUE

If files or processes cannot be created or if the `command` cannot be executed, the function `popen` will return a `NULL` pointer.

If `stream` is not associated with a *popened* command, the function `pclose` will return `-1`.

APPLICATION USAGE

The FSEEK(BA_OS) routine should not be used with a stream opened by the function `popen`.

SEE ALSO

FCLOSE(BA_OS), FOPEN(BA_OS), PIPE(BA_OS), SYSTEM(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

read — read from file

SYNOPSIS

```
int read(fildes, buf, nbyte)
int fildes;
char *buf;
unsigned nbyte;
```

DESCRIPTION

The function `read` attempts to read `nbyte` bytes from the file associated with `fildes` into the buffer pointed to by `buf`.

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

On devices capable of seeking, the `read` starts at a position in the file given by the file-pointer associated with `fildes`. Upon return from the function `read`, the file-pointer is incremented by the number of bytes actually read.

Devices that are incapable of seeking, such as terminals, always read from the current position. The value of a file-pointer associated with such a file is undefined.

If successful, the function `read` will return the number of bytes read and placed in the buffer; this number may be less than `nbyte` if the file is associated with a communication line [see IOCTL(BA_OS) and TERMIO(BA_ENV)], or if the number of bytes left in the file is less than `nbyte` bytes or if the file is a pipe or a special file. When an end-of-file has been reached, the function `read` will return `0`.

When attempting to read from an empty pipe (or FIFO):

> If the pipe is no longer open for writing, `0` will be returned indicating end-of-file.
>
> If `O_NDELAY` is clear, the read will block until data is written to the file or the file is no longer open for writing.

When attempting to read a file associated with a character-special file that has no data currently available:

> If `O_NDELAY` is clear, the read will block until data becomes available.

The function `read` reads data previously written to a file. If any portion of an ordinary-file prior to the end-of-file has not been written, the function `read` returns bytes with value `0`. For example, the LSEEK(BA_OS) routine allows the file-pointer to be set beyond the end of existing data in the file. If data are later written at this point, subsequent reads in the gap between the previous end of data and newly written data will return bytes with value `0` until data are written into the gap.

RETURN VALUE

If successful, the function `read` will return a non-negative integer indicating the number of bytes actually read; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

The function `read` will fail and will set `errno` to:

`EBADF`	if `fildes` is not a valid file-descriptor open for reading.
`EINTR`	if a signal was caught during the `read` operation.
`EIO`	if a physical I/O error has occurred.
`ENXIO`	if the device associated with the file-descriptor is a block-special or character-special file and the value of the file-pointer is out of range.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read and write files. Thus, an application that used the FOPEN(BA_OS) *stdio* routine to open a file should use the FREAD(BA_OS) *stdio* routine rather than the READ(BA_OS) routine to read it.

SEE ALSO

CREAT(BA_OS), DUP(BA_OS), FCNTL(BA_OS), IOCTL(BA_OS), OPEN(BA_OS), POPEN(BA_OS).

FUTURE DIRECTIONS

When no data are present at the time of the read, the function `read` on a pipe, FIFO, or *tty-line* with the `O_NDELAY` flag set will return −1, rather than 0, and `errno` will be set to `EAGAIN`.

Enforcement-mode file and record-locking will be added:

When attempting to read from an ordinary-file with enforcement-mode file and record-locking set [see CHMOD(BA_OS)], and the segment of the file to be read has a blocking write-lock (i.e., a write-lock owned by another process):

If `O_NDELAY` is set, the function `read` will return −1 and `errno` will be set to `EAGAIN`.

If `O_NDELAY` is clear, the function `read` will sleep until the blocking write-lock is removed.

The function `read` will fail and will set `errno` to:

`EAGAIN`	if enforcement-mode file-locking and record-locking was set, `O_NDELAY` was set, and there was a blocking write-lock.
`ENOLCK`	if the system record-lock table was full, so the read could not go to sleep until the blocking write-lock was removed.

LEVEL

Level 1.

NAME

setpgrp — set process-group-ID

SYNOPSIS

```
int setpgrp( )
```

DESCRIPTION

The function `setpgrp` sets the process-group-ID of the calling-process to the process-ID of the calling process and returns the new process-group-ID.

RETURN VALUE

If successful, the function `setpgrp` will return the new process-group-ID.

SEE ALSO

EXEC(BA_OS), FORK(BA_OS), GETPID(BA_OS), KILL(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

setuid, setgid — set user-ID and group-IDs

SYNOPSIS

```
int setuid(uid)
int uid;

int setgid(gid)
int gid;
```

DESCRIPTION

The function `setuid` is used to set the real-user-ID and effective-user-ID of the calling-process.

If the effective-user-ID of the calling-process is super-user, the real-user-ID and effective-user-ID are set to `uid`.

If the effective-user-ID of the calling-process is not super-user, but its real-user-ID is equal to `uid`, the effective-user-ID is set to `uid`.

If the effective-user-ID of the calling-process is not super-user, but the saved set-user-ID from an EXEC(BA_OS) routine is equal to `uid`, the effective-user-ID is set to `uid`.

The function `setgid` is used to set the real-group-ID and effective-group-ID of the calling-process.

If the effective-user-ID of the calling-process is super-user, the real-group-ID and effective-group-ID are set to `gid`.

If the effective-user-ID of the calling-process is not super-user, but its real-group-ID is equal to `gid`, the effective-group-ID is set to `gid`.

RETURN VALUE

If successful, the function `setuid` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

If successful, the function `setgid` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

The function `setuid` will fail and will set `errno` to:

`EPERM`	if the real-user-ID of the calling-process is not equal to `uid` and its effective-user-ID is not super-user.
`EINVAL`	if `uid` is out of range.

The function `setgid` will fail and will set `errno` to:

`EPERM`	if the real-group-ID of the calling-process is not equal to `gid` and its effective-user-ID is not super-user.
`EINVAL`	if `gid` is out of range.

SEE ALSO

EXEC(BA_OS), GETUID(BA_OS).

LEVEL

Level 1.

NAME

signal — specify what to do upon receipt of a signal

SYNOPSIS

```
#include <signal.h>

int (*signal(sig, func))()
int sig;
int (*func)();
```

DESCRIPTION

The function `signal` allows the calling-process to choose one of three ways in which it is possible to handle the receipt of a specific signal.

The argument `sig` specifies the signal and the argument `func` specifies the choice. The argument `sig` can be assigned any one of the following signals except `SIGKILL`:

`SIGHUP`	hangup
`SIGINT`	interrupt
`SIGQUIT`	quit*
`SIGILL`	illegal instruction (not reset when caught)*
`SIGTRAP`	trace trap (not reset when caught)*
`SIGFPE`	floating point exception*
`SIGKILL`	kill (cannot be caught or ignored)
`SIGSYS`	bad argument to routine*
`SIGPIPE`	write on a pipe with no one to read it
`SIGALRM`	alarm clock
`SIGTERM`	software termination signal
`SIGUSR1`	user-defined signal 1
`SIGUSR2`	user-defined signal 2

For portability, application-programs should use or catch *only* the signals listed above; other signals are hardware and implementation-dependent and may have very different meanings or results across systems (For example, the System V signals `SIGEMT`, `SIGBUS`, `SIGSEGV`, and `SIGIOT` are implementation-dependent and are not listed above). Specific implementations may have other implementation-dependent signals.

* The default action for these signals is an abnormal process termination. See `SIG_DFL`.

The argument `func` is assigned one of three values: `SIG_DFL`, `SIG_IGN`, or an *address* of a signal-catching function. The following actions are prescribed by these values:

`SIG_DFL` Terminate process upon receipt of a signal.

Upon receipt of the signal `sig`, the receiving process is to be terminated with all of the consequences outlined in EXIT(BA_OS). In addition, if `sig` is one of the signals marked with an asterisk above, implementation-dependent abnormal process termination routines, such as a core dump, may be invoked.

`SIG_IGN` Ignore signal.

The signal `sig` is to be ignored.

NOTE: The signal `SIGKILL` cannot be ignored.

address Catch signal.

Upon receipt of the signal `sig`, the receiving process is to execute the signal-catching function pointed to by `func`. The signal number `sig` will be passed as the only argument to the signal-catching function. Additional arguments may be passed to the signal-catching function for hardware-generated signals. Before entering the signal-catching function, the value of `func` for the caught signal will be set to `SIG_DFL` unless the signal is `SIGILL`, or `SIGTRAP`.

The function `signal` will not catch an invalid function argument, `func`, and results are undefined when an attempt is made to execute the function at the bad address.

Upon return from the signal-catching function, the receiving process will resume execution at the point at which it was interrupted, except for implementation defined signals where this may not be true.

When a signal to be caught occurs during a non-atomic operation such as a call to a READ(BA_OS), WRITE(BA_OS), OPEN(BA_OS), or IOCTL(BA_OS) routine on a slow device (such as a terminal); or occurs during a PAUSE(BA_OS) routine; or occurs during a WAIT(BA_OS) routine that does not return immediately, the signal-catching function will be executed and then the interrupted routine may return a −1 to the calling-process with `errno` set to `EINTR`.

NOTE: The signal `SIGKILL` cannot be caught.

A call to the function `signal` cancels a pending signal `sig` except for a pending `SIGKILL` signal.

RETURN VALUE

If successful, the function `signal` will return the previous value of the argument `func` for the specified signal `sig`; otherwise, it will return `(int(*)())-1` and `errno` will indicate the error.

ERRORS

The function `signal` will fail and will set `errno` to:

`EINVAL` if `sig` is an illegal signal number or `SIGKILL`.

APPLICATION USAGE

Signals may be sent by the system to an application-program (user-level process) or signals may be sent by one user-level process to another using the KILL(BA_OS) routine. An application-program can catch signals and specify the action to be taken using the SIGNAL(BA_OS) routine. The signals that a portable application-program may *send* are: `SIGKILL`, `SIGTERM`, `SIGUSR1`, and `SIGUSR2`.

For portability, application-programs should use only the symbolic names of signals rather than their values and use only the set of signals defined here. Specific implementations may have additional signals.

SEE ALSO

KILL(BA_OS), PAUSE(BA_OS), WAIT(BA_OS), SETJMP(BA_LIB).

FUTURE DIRECTIONS

`SIGABRT` will be added to the `<signal.h>` header file [see ABORT(BA_OS)].

A macro `SIG_ERR` will be defined by the `<signal.h>` header file to represent the return value `(int(*)())-1` of the function `signal` in case of error.

The end-user level utility KILL(BU_CMD) will be changed to use symbolic signal names rather than numbers.

In keeping with the proposed **ANSI X3J11** standard, the argument `func` will be declared as type pointer to a function returning `void`.

The following functions will be added to enhance the signal facility: `sigset`, `sighold`, `sigrelse`, `sigignore` and `sigpause`. These functions will give a calling-process control over the disposition of a specified signal that follows a signal that has been caught. When a signal has been caught, the system will hold (defer) a succeeding signal of the type specified should it occur. Similarly, processes will be able to establish critical regions of code where an incoming-signal is deferred so the critical region can be executed without losing the signal. Finally, a calling process will be able to suspend if a specified signal has not yet occurred.

LEVEL

Level 1.

NAME

sleep — suspend execution for interval

SYNOPSIS

```
unsigned sleep(seconds)
unsigned seconds;
```

DESCRIPTION

The function `sleep` suspends the current-process from execution for the number of seconds specified by the argument `seconds`. The actual suspension-time may be less than that requested for two reasons: (1) Because scheduled wakeups occur at fixed 1-second intervals (on the second, according to an internal clock) and (2) because any signal caught will terminate the `sleep` following execution of that signal-catching routine. Also, the suspension-time may be longer than requested by an arbitrary amount due to the scheduling of other activity in the system.

The function `sleep` sets an alarm signal and pauses until it (or some other signal) occurs. The previous state of the alarm signal is saved and restored. The calling-process may have set up an alarm signal before calling the function `sleep`. If the argument `seconds` exceeds the time until such an alarm signal would occur, the process sleeps only until the alarm signal would have occurred. The alarm signal-catching routine of the calling-process is executed just before the function `sleep` returns. But if the suspension-time is less than the time till such alarm, the prior alarm time remains unchanged.

RETURN VALUE

If successful, the function `sleep` will return the *unslept* amount (the requested time minus the time actually slept) in case the caller had an alarm set to go off earlier than the end of the requested suspension-time or premature arousal due to another caught signal; otherwise, the function `sleep` will return `0`.

SEE ALSO

ALARM(BA_OS), PAUSE(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

stat, fstat — get file status

SYNOPSIS

```
#include <sys/types.h>
#include <sys/stat.h>

int stat(path, buf)
char *path;
struct stat *buf;

int fstat(fildes, buf)
int fildes;
struct stat *buf;
```

DESCRIPTION

The function `stat` obtains information about the named file.

The argument `path` points to a path-name naming a file. Neither read, write, nor execute permission of the named file is required, but all directories listed in the path-name leading to the file must be searchable.

Similarly, the function `fstat` obtains information about an open file associated with the file-descriptor `fildes` [see **file-descriptor** in **Chapter 4 — Definitions**].

The argument `buf` is a pointer to a structure `stat` into which information is placed concerning the file.

The contents of the structure `stat` pointed to by `buf` include the following members:

```
ushort st_mode;  /* file mode */
ino_t  st_ino;   /* i-node number */
dev_t  st_dev;   /* file-system identifier */
dev_t  st_rdev;  /* device identifier, only */
                 /* for character-special */
                 /* or block-special files */
short  st_nlink; /* number of links */
ushort st_uid;   /* file owner user-ID */
ushort st_gid;   /* file group user-ID */
off_t  st_size;  /* file size in bytes */
time_t st_atime; /* time data last accessed */
time_t st_mtime; /* time data last modified */
time_t st_ctime; /* time file status last */
                 /* changed, in seconds since */
                 /* 00:00:00 GMT 1 Jan 70 */
```

`st_mode`	This field is the mode of the file as described in the MKNOD(BA_OS) routine.
`st_ino`	This field uniquely identifies the file in a given file-system. The pair of fields `st_ino` and `st_dev` uniquely identifies ordinary-files.
`st_dev`	This field uniquely identifies the file-system that contains the file. The value of the field may be used as input to the USTAT(BA_OS) routine to determine more information about this file-system. No other significance is associated with this value.
`st_rdev`	This field should not be used by application-programs. The field is valid only for block-special or character-special files and only has significance on the system where the file was configured.
`st_nlink`	This field should not be used by application-programs.
`st_size`	For ordinary-files, this field is the address of the end of the file. For pipes or FIFOs, this field is the count of the data currently in the file. For block-special or character-special files, this field is not defined.
`st_atime`	This field is the time when file-data was last accessed. The CREAT(BA_OS), LOCKF(BA_OS), MKNOD(BA_OS), PIPE(BA_OS), UTIME(BA_OS), and READ(BA_OS) routines change this field.
`st_mtime`	This field is the time when file-data was last modified. The CREAT(BA_OS), MKNOD(BA_OS), PIPE(BA_OS), UTIME(BA_OS), and WRITE(BA_OS) routines change this field.
`st_ctime`	This field is the time when file status was last changed. The CHMOD(BA_OS), CHOWN(BA_OS), CREAT(BA_OS), LINK(BA_OS), MKNOD(BA_OS), PIPE(BA_OS), UNLINK(BA_OS), UTIME(BA_OS), and WRITE(BA_OS) routines change this field.

The types `ushort`, `ino_t`, `time_t`, `dev_t`, and `off_t` are defined by the `<sys/types.h>` header file.

RETURN VALUE

If successful, both the function `stat` and the function `fstat` will return `0`. Otherwise, both the function `stat` and the function `fstat` will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `stat` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if the named file does not exist.
`EACCES`	if a component of the path-prefix denies search permission.

Under the following conditions, the function `fstat` will fail and will set `errno` to:

`EBADF`	if the argument `fildes` is not a valid open file-descriptor.

SEE ALSO

CHMOD(BA_OS), CHOWN(BA_OS), CREAT(BA_OS), LINK(BA_OS), MKNOD(BA_OS), PIPE(BA_OS), READ(BA_OS), TIME(BA_OS), UNLINK(BA_OS), UTIME(BA_OS), WRITE(BA_OS).

LEVEL

Level 1.

NAME

stime — set time

SYNOPSIS

```
int stime(tp)
long *tp;
```

DESCRIPTION

The function `stime` sets the system time and date. The argument `tp` points to the value of time as measured in seconds from 00:00:00 GMT January 1, 1970.

RETURN VALUE

If successful, the function `stime` will return `0`; otherwise, it will return `-1` and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `stime` will fail and will set `errno` to:

`EPERM`	if the effective-user-ID of the calling-process is not super-user.

SEE ALSO

TIME(BA_OS).

LEVEL

Level 1.

NAME

sync — update super-block

SYNOPSIS

```
void sync( )
```

DESCRIPTION

The function `sync` causes all information in transient memory that updates a file-system to be written out to the file-system. This includes modified super-blocks, modified i-nodes, and delayed block I/O.

The function `sync` should be used by programs which examine a file-system.

The writing, although scheduled, is not necessarily complete upon return from the function `sync`.

APPLICATION USAGE

The function `sync` is not recommended for use by application-programs.

LEVEL

Level 1.

NAME

system — issue a command

SYNOPSIS

```
#include <stdio.h>

int system(string)
char *string;
```

DESCRIPTION

The function `system` causes the argument `string` to be given as input to a command interpreter and execution process. That is, the argument `string` is interpreted as a command, and then the command is executed.

Commands

A *blank* is a tab or a space.

A *word* is a sequence of characters excluding blanks.

A *parameter name* is a sequence of letters, digits, or underscores beginning with a letter or underscore. A *parameter* is a parameter name, a digit, or any of the characters `?`, `$`, or `!`.

A *simple-command* is a sequence of non-blank words separated by blanks. The first word specifies the path-name or file-name of the command to be executed. Except as specified below, the remaining words are passed as arguments to the invoked command. The command name is passed as argument `0` [see EXEC(BA_OS)]. The *value* of a simple-command is its exit status if it terminates normally, or (octal) `200`+*status* if it terminates abnormally [see WAIT(BA_OS)].

A *pipeline* is a sequence of two or more simple-commands separated by the character `|`. The standard output of each simple-command (except the last simple-command in the sequence) is connected by a PIPE(BA_OS) routine to the standard input of the next simple-command. Each simple-command is run as a separate process; the command execution process waits for the last simple-command to terminate. The exit status of a pipeline is the exit status of the last command.

A *command* is either a simple-command or a *list* enclosed in parentheses: `(` *list* `)`. Unless otherwise stated, the value returned by a command is that of the last simple-command executed in the command.

A *list* is a command or a pipeline or a sequence of commands and pipelines separated by the characters `;` or `&` or the character-pairs `&&` or `||`. Of these, the characters `;` and `&`, which have equal precedence, have a precedence lower than that of the character-pairs `&&` and `||`, which have equal precedence. A *list* may optionally be terminated by the characters `;` or `&`.

A series of commands and/or pipelines separated by the character `;` are executed sequentially, while commands and pipelines terminated by the character `&` are executed asynchronously.

The character-pairs `&&` or `||` cause the command or pipeline following it to be executed only if the preceding pipeline returns a zero (non-zero) exit status. An arbitrarily long sequence of new-lines may appear in a *list*, instead of the character `;`, to delimit commands.

Comments

A word beginning with the character `#` causes that word and all the following characters up to a new-line to be ignored.

Command Substitution

The standard output from a command bracketed by grave-accents (the character `` ` ``) may be used as part or all of a word; trailing new-lines are removed.

Parameter Substitution

The character `$` is used to introduce substitutable keyword-parameters.

`$`{*parameter*}	The value, if any, of the *parameter* is substituted. The braces are required only when *parameter* is followed by a letter, digit, or underscore that is not to be interpreted as part of its name.

Keyword-parameters (also known as variables) may be assigned values by writing:

parameter-name = *value*

The following parameters are automatically set:

Parameter	*Description*
?	The decimal value returned by the last synchronously executed command in this call to `system`.
$	The process-number of this process.
!	The process-number of the last background command invoked in this call to `system`.

The following parameters are used by the command execution process:

Parameter	*Description*
`HOME`	The initial working (home) directory, initially set from the 6th-field in the `/etc/passwd` file [see PASSWD(BA_ENV)].
`PATH`	The search path for commands (see **Execution** below).

Blank Interpretation

After parameter and command substitution, the results of substitution are scanned for internal field separator characters (*space*, *tab* and *new-line*) and split into distinct arguments where such characters are found. Explicit null arguments (`""` or `''`) are retained. Implicit null arguments (those resulting from parameters that have no values) are removed.

File Name Generation

Following substitution, each word in the command is scanned for the characters `*`, `?`, and `[`. If one of these characters appears the word is regarded as a *pattern*. The word is replaced with alphabetically sorted file names that match the pattern. If no file name is found that matches the pattern, the word is left unchanged. The character `.` at the start of a file name or immediately following the character `/`, as well as the character `/` itself, must be matched explicitly.

Parameter	*Description*
`*`	Matches any string, including the null string.
`?`	Matches any single character.
`[...]`	Matches any one of the enclosed characters. A pair of characters separated by the character `–` matches any character lexically between the pair, inclusive. If the first character following the opening `[` is the character `!` any character **not** enclosed is matched.

Quoting

The following characters have special meaning and cause termination of a word unless enclosed in quotation marks as explained below:

`;  &  (  )  |  <  >` *new-line space tab*

A character may be *quoted* (i.e., made to stand for itself) by preceding it with the character `\`. The character-pair `\`*new-line* is ignored. All characters enclosed between a pair of single quote marks (`' '`), except a single quote, are quoted. Inside double quote marks (`" "`), parameter and command substitution occurs and the character `\` quotes the characters `\`, `*`, `"`, and `$`.

Input/Output

Before a command is executed, its input and output may be redirected using a special notation. The following may appear anywhere in a simple-command, or may precede or follow a command and are **not** passed on to the invoked command; substitution occurs before word or digit is used:

Notation	*Description*
<*word*	Use file *word* as standard input (file-descriptor `0`).
>*word*	Use file *word* as standard output (file-descriptor `1`). If the file does not exist it is created; otherwise, it is truncated to zero length.
>>*word*	Use file *word* as standard output. If the file exists, output is appended to it (by first seeking to the end-of-file); otherwise, the file is created.
<&*digit*	Use the file associated with file-descriptor *digit* as standard input. Similarly for the standard output using >&*digit*.
`<&-`	The standard input is closed. Similarly for the standard output using `>&-`.

If a digit precedes any of the above, the digit specifies the file-descriptor to be associated with the file (instead of the default `0` or `1`). For example:

```
... 2>&1
```

associates file descriptor `2` with the file currently associated with file descriptor `1`.

The order in which redirections are specified is significant. Redirections are evaluated left-to-right. For example:

```
... 1>xxx 2>&1
```

first associates file-descriptor `1` with file *xxx*. It associates file-descriptor `2` with the file associated with file-descriptor `1` (i.e., *xxx*). If the order of redirections were reversed, file-descriptor `2` would be associated with the terminal (assuming file-descriptor `1` had been) and file-descriptor `1` would be associated with file *xxx*.

If a command is followed by the character `&` the default standard input for the command is the empty file `/dev/null`. Otherwise, the environment for the execution of a command contains the file-descriptors of the invoking process as modified by input/output specifications.

Environment
The *environment* [see EXEC(BA_OS)] is a list of parameter name-value pairs passed to an executed program in the same way as a normal argument list. On invocation, the environment is scanned and a parameter is created for each name found, giving it the corresponding value.

The environment for any simple-command may be augmented by prefixing it with one or more assignments to parameters. For example:

```
TERM=450 cmd;
```

Signals
The `SIGINT` and `SIGQUIT` signals for an invoked command are ignored if the command is followed by the character `&`; otherwise signals have the values inherited by the command execution process from its parent.

Execution
The above substitutions are carried out each time a command is executed. A new process is created and an attempt is made to execute the command via the EXEC(BA_OS) routines.

The parameter `PATH` defines the search path for the directory containing the command. The character `:` separates path-names. The default path is `:/bin:/usr/bin` (specifying the current directory, `/bin`, and `/usr/bin`, in that order). NOTE: The current directory is specified by a null path-name, which can appear immediately after the equal sign or between the colon delimiters anywhere else in the path-list. If the command name contains the character `/` the search path is not used. Otherwise, each directory in the path is searched for an executable file.

Conventionally, the function `system` has been implemented with the Bourne shell, SH(BU_CMD) [see **Volume II: Part II — Basic Utilities Extension Definition: Chapter 5 — Commands and Utilities**]. The current definition of the function `system` is not intended to preclude that or its implementation by another command interpreter that provides the minimum functionality described here. Of course, any implementation may provide a superset of the functionality described.

RETURN VALUE

If successful, the function `system` will return the exit status of the last simple-command executed. Errors, such as syntax errors, cause a non-zero return value and execution of the command is abandoned.

FILES

`/dev/null`

APPLICATION USAGE

If possible, applications should use the the function `system`, which is easier to use and supplies more functions, rather than the FORK(BA_OS) and EXEC(BA_OS) routines.

SEE ALSO

DUP(BA_OS), EXEC(BA_OS), FORK(BA_OS), PIPE(BA_OS), SIGNAL(BA_OS), ULIMIT(BA_OS), UMASK(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

time — get time

SYNOPSIS

```
long time((long *) 0)

long time(tloc)
long *tloc;
```

DESCRIPTION

The function `time` returns the value of time in seconds since 00:00:00 GMT, January 1, 1970.

As long as the argument `tloc` is not a null-pointer, the return value is also stored in the location to which the argument `tloc` points.

The actions of the function `time` are undefined if the argument `tloc` points to an invalid address.

RETURN VALUE

If successful, the function `time` will return the value of time; otherwise, it will return −1.

SEE ALSO

STIME(BA_OS).

LEVEL

Level 1.

NAME

times — get process and child-process elapsed times

SYNOPSIS

```
#include <sys/types.h>
#include <sys/times.h>

long times(buffer)
struct tms *buffer;
```

DESCRIPTION

The function `times` fills the structure pointed to by the argument `buffer` with time-accounting information. The action of the function `time` is undefined if the argument `buffer` points to an illegal address.

The following are the contents of the structure `tms`, which is defined by the `<sys/times.h>` header file to include:

```
time_t    tms_utime;
time_t    tms_stime;
time_t    tms_cutime;
time_t    tms_cstime;
```

This information comes from the calling-process and each of its terminated child-processes for which it has executed a WAIT(BA_OS) routine. All times are defined in units of 1/{CLK_TCK}'s of a second.

The value of `tms_utime` is the CPU time used while executing instructions in the user-space of the calling-process.

The value of `tms_stime` is the CPU time used by the system on behalf of the calling-process.

The value of `tms_cutime` is the sum of the `tms_utime` and `tms_cutime` of the child-processes.

The value of `tms_cstime` is the sum of the `tms_stime` and `tms_cstime` of the child-processes.

The type `time_t` is defined by the `<sys/types.h>` header file.

RETURN VALUE

If successful, the function `times` will return the elapsed real time, in units of 1/{CLK_TCK}'s of a second, since an arbitrary point in the past (e.g., system start-up time). This point does not change from one invocation of the function `times` to another. When the function `times` fails, it will return −1.

SEE ALSO

EXEC(BA_OS), FORK(BA_OS), TIME(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

ulimit — get and set user limits

SYNOPSIS

```
long ulimit(cmd, newlimit)
int cmd;
long newlimit;
```

DESCRIPTION

The function `ulimit` provides for control over process limits.

Values available for the argument `cmd` are:

1 Get the file size limit of the process. The limit is in units of 512-byte blocks and is inherited by child-processes. Files of any size can be read.

2 Set the file size limit of the process equal to `newlimit`. Any process may decrease this limit, but only a process with an effective-user-ID of super-user may increase the limit.

RETURN VALUE

If successful, the function `ulimit` will return a non-negative value; otherwise, it will return `-1`, the limit will be unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `ulimit` will fail and will set `errno` to:

`EPERM` if a process with an effective-user-ID other than super-user attempts to increase its file size limit.

SEE ALSO

WRITE(BA_OS).

LEVEL

Level 1.

NAME

umask — set and get file creation mask

SYNOPSIS

```
int umask(cmask)
int cmask;
```

DESCRIPTION

The function `umask` sets the process's file mode creation mask [see CREAT(BA_OS)] equal to the argument `cmask` and returns the previous value of the mask. Only the owner, group, other permission bits of the argument `cmask` and the file mode creation mask are used.

RETURN VALUE

If successful, the function `umask` will return the previous value of the file mode creation mask.

SEE ALSO

CHMOD(BA_OS), CREAT(BA_OS), MKNOD(BA_OS), OPEN(BA_OS).

LEVEL

Level 1.

NAME

umount — unmount a file system

SYNOPSIS

```
int umount(spec)
char *spec;
```

DESCRIPTION

The function `umount` requests that a previously mounted file system contained on the block-special device identified by the argument `spec` be unmounted.

The argument `spec` is a pointer to a path-name. After unmounting the file-system, the directory upon which the file-system was mounted reverts to its ordinary interpretation.

The function `umount` may be invoked only by the super-user.

RETURN VALUE

If successful, the function `umount` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `umount` will fail and will set `errno` to:

`EPERM`	if the process's effective-user-ID is not super-user.
`ENXIO`	if the device identified by `spec` does not exist.
`ENOTDIR`	if a component of the path-prefix is not a directory.
`ENOENT`	if the named file does not exist.
`ENOTBLK`	if the device identified by `spec` is not block-special.
`EINVAL`	if the device identified by `spec` is not mounted.
`EBUSY`	if a file on the device identified by `spec` is busy.

APPLICATION USAGE

The function `umount` is not recommended for use by application-programs.

SEE ALSO

MOUNT(BA_OS).

LEVEL

Level 1.

NAME

uname — get name of current operating system

SYNOPSIS

```
#include <sys/utsname.h>

int uname(name)
struct utsname *name;
```

DESCRIPTION

The function uname stores information identifying the current operating system in the structure pointed to by the argument name.

The function uname uses the structure defined by the <sys/utsname.h> header file whose members include:

```
char   sysname[{SYS_NMLN}];
char   nodename[{SYS_NMLN}];
char   release[{SYS_NMLN}];
char   version[{SYS_NMLN}];
char   machine[{SYS_NMLN}];
```

The function uname returns a null-terminated character string naming the current operating system in the character array sysname.

Similarly, the character array nodename contains the name that the system is known by on a communications network.

The members release and version further identify the operating system.

The member machine contains a standard name that identifies the hardware that the operating system is running on.

RETURN VALUE

If successful, the function uname will return a non-negative value; otherwise, it will return −1 and errno will indicate the error.

LEVEL

Level 1.

NAME

unlink — remove directory entry

SYNOPSIS

```
int unlink(path)
char *path;
```

DESCRIPTION

The function `unlink` removes the directory entry named by the path-name pointed to by the argument `path`. When all links to a file have been removed and no process has the file open, the space occupied by the file is freed and the file ceases to exist. If one or more processes have the file open when the last link is removed, space occupied by the file is not released until all references to the file have been closed.

RETURN VALUE

If successful, the function `unlink` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `unlink` will fail and will set `errno` to:

`ENOTDIR`	if a component of the path prefix is not a directory.
`ENOENT`	if the named file does not exist.
`EACCES`	if a component of the path-prefix denies search permission.
`EACCES`	if the directory containing the link to be removed denies write permission.
`EPERM`	if the named file is a directory and the effective-user-ID of the process is not super-user.
`EBUSY`	if the entry to be unlinked is the mount point for a mounted file system.
`ETXTBSY`	if the entry to be unlinked is the last link to a pure procedure (shared text) file that is being executed.
`EROFS`	if the directory entry to be unlinked is part of a read-only file system.

SEE ALSO

CLOSE(BA_OS), LINK(BA_OS), OPEN(BA_OS).

LEVEL

Level 1.

NAME

ustat — get file system statistics

SYNOPSIS

```
#include <sys/types.h>
#include <ustat.h>

int ustat(dev, buf)
int dev;
struct ustat *buf;
```

DESCRIPTION

The function `ustat` returns information about a mounted file system.

The argument `dev` is a device number identifying a device containing a mounted file-system. The value of `dev` is obtained from the field `st_dev` of the structure `stat` [see STAT(BA_OS)].

The argument `buf` is a pointer to a `ustat` structure that includes the following elements:

```
daddr_t f_tfree;     /* total free blocks */
ino_t   f_tinode;    /* number of free i-nodes */
char    f_fname[6];  /* file-system name or null */
char    f_fpack[6];  /* file-system pack or null */
```

The last two fields, `f_fname` and `f_fpack` may not have significant information on all systems, and, in that case, will contain the null character.

RETURN VALUE

If successful, the function `ustat` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `ustat` will fail and will set `errno` to:

`EINVAL` if `dev` is not the device number of a device containing a mounted file-system.

SEE ALSO

STAT(BA_OS).

LEVEL

Level 1.

NAME

utime — set file access and modification times

SYNOPSIS

```
#include <sys/types.h>

int utime(path, times)
char *path;
struct utimbuf *times;
```

DESCRIPTION

The function `utime` sets the access and modification times of the named file.

The argument `path` points to a path-name naming a file.

If the argument `times` is `NULL`, the access and modification times of the file are set to the current time. A process must be the owner of the file or have write permission to use the function `utime` in this manner.

If the argument `times` is not `NULL`, `times` is interpreted as a pointer to a structure `utimbuf` (see below) and the access and modification times are set to the values contained in the designated structure. Only the owner of the file or the super-user may use the function `utime` this way.

The times in the structure `utimbuf` are measured in seconds since 00:00:00 GMT Jan. 1, 1970.

The structure `utimbuf` must be defined as:

```
struct utimbuf {
        time_t actime;  /* access time */
        time_t modtime; /* modification time */
};
```

The function `utime` will also cause the time of the last file status change (`st_ctime`) to be updated [see STAT(BA_OS)]. The type `time_t` is defined by the `<sys/types.h>` header file.

RETURN VALUE

If successful, the function `utime` will return 0; otherwise, it will return −1 and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `utime` will fail and will set `errno` to:

`ENOENT`	if the named file does not exist.
`ENOTDIR`	if a component of the path-prefix is not a directory.
`EACCES`	if a component of the path-prefix denies search permission.
`EPERM`	if the effective-user-ID is not super-user and not the owner of the file and the argument `times` is not `NULL`.

`EACCES`	if the effective-user-ID is not super-user and not the owner of the file and the argument `times` is `NULL` and write access is denied.
`EROFS`	if the file-system containing the file is mounted read-only.

APPLICATION USAGE

The structure `utimbuf` must be declared by the application-program. The declaration is shown above.

SEE ALSO

STAT(BA_OS).

LEVEL

Level 1.

NAME

wait — wait for child-process to stop or terminate

SYNOPSIS

```
int wait(stat_loc)
int *stat_loc;

int wait((int *)0)
```

DESCRIPTION

The function `wait` suspends the calling-process until one of the immediate children terminates. If a child-process terminated prior to the call on the function `wait`, return is immediate.

If the argument `stat_loc` (taken as an integer) is non-zero, 16-bits of information called *status* are stored in the low-order 16-bits of the location pointed to by `stat_loc`. The status can be used to differentiate between stopped and terminated child-processes and if the child-process terminated, status identifies the cause of termination and passes useful information to the parent. This is accomplished in the following manner:

> If the child-process terminated due to a call to the EXIT(BA_OS) routine, the low-order 8-bits of status will be zero and the next 8-bits will contain the low-order 8-bits of the argument that the child-process passed to the EXIT(BA_OS) routine.
>
> If the child-process terminated due to a signal, the low-order 7-bits (i.e., bits 177) will contain the number of the signal that caused the termination. In addition, if abnormal process termination routines [see SIGNAL(BA_OS)] were successfully completed then the low-order eighth-bit (i.e., bit 200) will be set. The next 8-bits of status will be zero.

If a parent process terminates without waiting for its child-processes to terminate, a special system process inherits the child-processes [see EXIT(BA_OS)].

The function `wait` will fail and its actions are undefined if the argument `stat_loc` points to an illegal address.

RETURN VALUE

If the function `wait` returns due to the receipt of a signal, it will return −1 to the calling-process and will set `errno` to `EINTR`.

If the function `wait` returns due to a terminated child-process, it will return the process-ID of the child-process to the calling-process; otherwise, it will return immediately with a value of −1 and `errno` will indicate the error.

ERRORS

The function `wait` will fail and will set `errno` to:

`ECHILD` if the calling-process has no existing unwaited-for child-processes.

SEE ALSO

EXEC(BA_OS), EXIT(BA_OS), FORK(BA_OS), PAUSE(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

write — write on a file

SYNOPSIS

```
int write(fildes, buf, nbyte)
int fildes;
char *buf;
unsigned nbyte;
```

DESCRIPTION

The function `write` attempts to write `nbyte` bytes from the buffer pointed to by the argument `buf` to the file associated with the argument `fildes`.

The argument `fildes` is an open file-descriptor [see **file-descriptor** in **Chapter 4 — Definitions**].

On devices capable of seeking, the actual writing of data proceeds from the position in the file indicated by the file-pointer associated with the argument `fildes`. Upon returning from the function `write`, the file-pointer is incremented by the number of bytes actually written.

On devices incapable of seeking, such as a terminal, writing always takes place starting at the current position. The value of a file-pointer associated with such a device is undefined [see OPEN(BA_OS)].

If the `O_APPEND` flag of the file status flags is set, the file-pointer will be set to the end of the file prior to each `write` operation.

If a `write` requests that more bytes be written than there is room for (e.g., beyond the user process's file size limit [see ULIMIT(BA_OS)] or the physical end of a medium), only as many bytes as there is room for will be written. For example, suppose there is space for 20 bytes more in a file before reaching a limit. A `write` of 512-bytes will return 20-bytes. The next `write` of a non-zero number of bytes will give a failure return (except as noted for pipes and FIFOs below).

If a `write` to a pipe (or FIFO) of {PIPE_BUF} bytes or less is requested and less than `nbytes` bytes of free space is available in the pipe, one of the following will occur:

> If the `O_NDELAY` flag is clear, the process will block until at least `nbytes` of space is available in the pipe and then the `write` will take place, or
>
> If the `O_NDELAY` flag is set, the process will not block and the function `write` will return `0`.

A `write` request of greater than {PIPE_BUF} bytes to a pipe (or FIFO) will behave differently.

If a `write` to a pipe (or FIFO) of more than {PIPE_BUF} bytes is requested, one of the following will occur:

> If the `O_NDELAY` flag is clear, the process will block if the pipe is full. As space becomes available in the pipe, the data from the `write` request will be written piecemeal — in multiple smaller amounts until the request is fulfilled. Thus, data from a `write` request of more than {PIPE_BUF} bytes may be interleaved on arbitrary byte boundaries with data written by other processes.
>
> If the `O_NDELAY` flag is set and the pipe is full, the process will not block and the function `write` will return `0`.
>
> If the `O_NDELAY` flag is set and the pipe is not full, the process will not block and as much data as will currently fit in the pipe will be written and the function `write` will return the number of bytes written. In this case, only part of the data are written, but what data are written will not be interleaved with data from other processes.

In contrast to `write` requests of more than {PIPE_BUF} bytes, data from a `write` request of {PIPE_BUF} bytes or less will never be interleaved in the pipe with data from other processes.

RETURN VALUE

If successful, the function `write` will return the number of bytes actually written; otherwise, it will return `−1`, the file-pointer will remain unchanged and `errno` will indicate the error.

ERRORS

Under the following conditions, the function `write` will fail and will set `errno` to:

`EBADF` if `fildes` is not a valid file descriptor open for writing.

`EPIPE` and `SIGPIPE` signal if an attempt is made to write to a pipe that is not open for reading by any process.

`EFBIG` if an attempt was made to write a file that exceeds the process's file size limit or the system's maximum file size [see ULIMIT(BA_OS)].

`EINTR` if a signal was caught during the `write` operation.

`ENOSPC` if there is no free space remaining on the device containing the file.

`EIO` if a physical I/O error has occurred.

`ENXIO` if the device associated with the file-descriptor is a block-special or character-special file and the file-pointer value is out of range.

APPLICATION USAGE

Normally, applications should use the *stdio* routines to open, close, read and write files. Thus, if an application had used the FOPEN(BA_OS) *stdio* routine to open a file, it would use the FWRITE(BA_OS) *stdio* routine rather than the WRITE(BA_OS) routine to write it.

Because they are not atomic, `write` requests of `nbytes` greater than {PIPE_BUF} bytes to a pipe (or FIFO) should only be used when just two cooperating processes, one reader and one writer, are using a pipe.

SEE ALSO

CREAT(BA_OS), DUP(BA_OS), LSEEK(BA_OS), OPEN(BA_OS), PIPE(BA_OS), ULIMIT(BA_OS).

FUTURE DIRECTIONS

Enforcement-mode file and record-locking will be added:

A `write` to an ordinary-file will be blocked if enforcement-mode file and record-locking is set, and there is a record-lock owned by another process on the segment of the file to be written.

If `O_NDELAY` is not set, the `write` will sleep until the blocking record-lock is removed.

Under the following conditions, the function `write` will fail and will set `errno` to:

`EAGAIN`	if enforcement-mode file-locking and record-locking was set, `O_NDELAY` was set and there was a blocking record-lock.
`EDEADLK`	if the `write` was going to sleep and cause a deadlock situation to occur.
`ENOLCK`	if the system record-lock table was full, so the `write` could not go to sleep until the blocking record-lock was removed.

LEVEL

Level 1.

Chapter 7
General Library Routines

NAME

abs — return integer absolute value

SYNOPSIS

```
int abs(i)
int i;
```

DESCRIPTION

The function `abs` returns the absolute value of its integer operand.

APPLICATION USAGE

In two-complement representation, the absolute value of the negative integer with largest magnitude {INT_MIN} is undefined. Some implementations may catch this as an error but others may ignore it.

SEE ALSO

FLOOR(BA_LIB).

LEVEL

Level 1.

NAME

j0, j1, jn, y0, y1, yn — Bessel functions

SYNOPSIS

```
#include <math.h>

double j0(x)
double x;

double j1(x)
double x;

double jn(n, x)
int n;
double x;

double y0(x)
double x;

double y1(x)
double x;

double yn(n, x)
int n;
double x;
```

DESCRIPTION

The functions `j0` and `j1` return Bessel functions of **x** of the first kind of orders 0 and 1 respectively.

The function `jn` returns the Bessel function of **x** of the first kind of order `n`.

The functions `y0` and `y1` return Bessel functions of **x** of the second kind of orders 0 and 1 respectively.

The function **yn** returns the Bessel function of **x** of the second kind of order `n`.

For the functions `y0`, `y1` and **yn**, the argument **x** must be positive.

RETURN VALUE

Non-positive arguments cause `y0`, `y1` and **yn** to return the value `-HUGE` and to set `errno` to `EDOM`. In addition, a message indicating argument `DOMAIN` error is printed on the standard error output.

Arguments too large in magnitude cause the functions `j0`, `j1`, `y0` and `y1` to return zero and to set `errno` to `ERANGE`. In addition, a message indicating `TLOSS` error is printed on the standard error output [see MATHERR(BA_LIB)].

APPLICATION USAGE

These error-handling procedures may be changed with the MATHERR(BA_LIB) routine.

SEE ALSO

MATHERR(BA_LIB).

LEVEL

Level 1.

NAME

bsearch — binary search on a sorted table

SYNOPSIS

```
char *bsearch(key, base, nel, width,  compar)
char *key;
char *base;
unsigned nel, width;
int (*compar)( );
```

DESCRIPTION

The function `bsearch` is a binary search routine. It returns a pointer into a table indicating where a datum may be found. The table must be previously sorted in increasing order according to a user-provided comparison function, `compar` [see QSORT(BA_OS)].

The argument `key` points to a datum instance to be sought in the table.

The argument `base` points to the element at the base of the table.

The argument `nel` is the number of elements in the table.

The argument `width` is the size of an element in bytes.

The argument `compar` is the name of the comparison function, which is called with two arguments of type `char` that point to the elements being compared. The `compar` function must return an integer less than, equal to or greater than zero, as the first argument is to be considered less than, equal to or greater than the second.

RETURN VALUE

A `NULL` pointer is returned if the key cannot be found in the table.

APPLICATION USAGE

The pointers to the key and the element at the base of the table, `key` and `base`, should be of type pointer-to-element and cast to type pointer-to-character.

The comparison function need not compare every byte, so arbitrary data may be contained in the elements in addition to the values being compared.

Although declared as type pointer-to-character, the value returned should be cast into type pointer-to-element.

EXAMPLE

The following example searches a table containing pointers to nodes consisting of a string and its length. The table is ordered alphabetically on the string in the node pointed to by each entry.

This code fragment reads in strings; it either finds the corresponding node and prints out the string and its length or it prints an error message.

```
#include <stdio.h>
#include <search.h>

#define TABSIZE 1000

struct node {                     /* these are in the table */
    char *string;
    int length;
};
struct node table[TABSIZE];      /* table to be searched */
    . . .
{
    struct node *node_ptr, node;
  int node_compare( );          /* routine to compare 2 nodes */
  char str_space[20];           /* space to read string into */
      . . .
      node.string = str_space;
    while (scanf("%s", node.string) != EOF) {
        node_ptr = (struct node *)bsearch((char *)(&node),
          (char *)table, TABSIZE,
          sizeof(struct node), node_compare);
        if (node_ptr != NULL) {
            (void)printf("string = %20s, length = %d\n",
              node_ptr->string, node_ptr->length);
        } else {
            (void) printf("not found: %s\n", node.string);
        }
    }
}
/*
    This routine compares two nodes based on an
    alphabetical ordering of the string field.
*/
int node_compare(node1, node2)
struct node *node1, *node2;
{
    return strcmp(node1->string, node2->string);
}
```

SEE ALSO

HSEARCH(BA_LIB), LSEARCH(BA_LIB), QSORT(BA_LIB), TSEARCH(BA_LIB).

LEVEL

Level 1.

NAME

clock — report CPU time used

SYNOPSIS

```
long clock( )
```

DESCRIPTION

The function `clock` returns the amount of CPU time (in microseconds) used since the first call to the function `clock`. The time reported is the sum of the user and system times of the calling-process and its terminated child-processes for which it has executed the WAIT(BA_OS) or SYSTEM(BA_OS) routine.

APPLICATION USAGE

The value returned by `clock` is defined in microseconds for compatibility with systems that have CPU clocks with much higher resolution.

SEE ALSO

TIMES(BA_OS), WAIT(BA_OS), SYSTEM(BA_OS).

LEVEL

Level 1.

NAME

toupper, tolower, _toupper, _tolower, toascii — translate characters

SYNOPSIS

```
#include <ctype.h>

int toupper(c)
int c;

int tolower(c)
int c;

int _toupper(c)
int c;

int _tolower(c)
int c;

int toascii(c)
int c;
```

DESCRIPTION

The functions `toupper` and `tolower` have as domain the range of the GETC(BA_LIB) routine: the integers from `-1` through `255`. If the argument of `toupper` represents a lower-case letter, the result is the corresponding upper-case letter. If the argument of `tolower` represents an upper-case letter, the result is the corresponding lower-case letter. All other arguments in the domain are returned unchanged.

The macros `_toupper`, `_tolower`, and `_toascii` are defined by the `<ctype.h>` header file. The macros `_toupper` and `_tolower` accomplish the same thing as `toupper` and `tolower` but have restricted domains and are faster. The macro `_toupper` requires a lower-case letter as its argument; its result is the corresponding upper-case letter. The macro `_tolower` requires an upper-case letter as its argument; its result is the corresponding lower-case letter. Arguments outside the domain cause undefined results.

The macro `toascii` yields its argument with all bits turned off that are not part of a standard ASCII character; it is intended for compatibility with other systems.

SEE ALSO

CTYPE(BA_LIB), GETC(BA_LIB).

LEVEL

Level 1.

NAME

crypt, setkey, encrypt — generate string encoding

SYNOPSIS

```
char *crypt(key, salt)
char *key, *salt;

void setkey(key)
char *key;

void encrypt(block, edflag)
char *block;
int edflag;
```

DESCRIPTION

The function `crypt` is a string-encoding function.

The argument `key` is a string to be encoded. The argument `salt` is a two-character string chosen from the set `[a-zA-Z0-9.]`; this string is used to perturb the encoding algorithm, after which the string that `key` points to is used as the key to repeatedly encode a constant string. The returned value points to the encoded string. The first two characters are the salt itself.

The functions `setkey` and `encrypt` provide (rather primitive) access to the encoding algorithm. The argument to the entry `setkey` is a character array of length 64 containing only the characters with numerical value `0` and `1`. If this string is divided into groups of 8, the low-order bit in each group is ignored; this gives a 56-bit key. This is the key that will be used with the above mentioned algorithm to encode the string `block` with the function `encrypt`.

The argument to the entry `encrypt` is a character array of length 64 containing only the characters with numerical value `0` and `1`. The argument array is modified in place to a similar array representing the bits of the argument after having been subjected to the encoding algorithm using the key set by `setkey`.

If the argument `edflag` is zero, the argument is encoded.

APPLICATION USAGE

The return value of the function `crypt` points to static data that are overwritten by each call.

LEVEL

Level 1.

Optional: the functions `crypt`, `setkey` and `encrypt` may not be present in all implementations of the Base System.

NAME

ctermid — generate file name for terminal

SYNOPSIS

```
#include <stdio.h>

char *ctermid(s)
char *s;
```

DESCRIPTION

The function `ctermid` generates the path-name of the controlling terminal for the current process and stores it in a string.

If the argument `s` is a `NULL` pointer, the string is stored in an internal static area which will be overwritten at the next call to `ctermid`. The address of the static area is returned. Otherwise, `s` is assumed to point to a character array of at least `L_ctermid` elements; the path name is placed in this array and the value of `s` is returned. The constant `L_ctermid` is defined by the `<stdio.h>` header file.

APPLICATION USAGE

The difference between the TTYNAME(BA_LIB) routine and the function `ctermid` is that the TTYNAME(BA_LIB) routine must be passed a file-descriptor and returns the name of the terminal associated with that file-descriptor, while the function `ctermid` returns a string (e.g., `/dev/tty`) that will refer to the terminal if used as a file-name. Thus the TTYNAME(BA_LIB) routine is useful only if the process already has at least one file open to a terminal.

SEE ALSO

TTYNAME(BA_LIB).

LEVEL

Level 1.

NAME

ctime, localtime, gmtime, asctime, tzset — convert date and time to string

SYNOPSIS

```
#include <time.h>

char *ctime(clock)
long *clock;

struct tm *localtime(clock)
long *clock;

struct tm *gmtime(clock)
long *clock;

char *asctime(tm)
struct tm *tm;

extern long timezone;

extern int daylight;

extern char *tzname[2];

void tzset()
```

DESCRIPTION

The function `ctime` converts a long integer, pointed to by `clock`, representing the time in seconds since 00:00:00 GMT, January 1, 1970 [see TIME(BA_OS)] and returns a pointer to a 26-character string in the following form:

```
Sun Sep 16 01:03:52 1973
```

All the fields have constant width.

The functions `localtime` and `gmtime` return pointers to the structure `tm`, described below:

> The function `localtime` corrects for the time-zone and possible Daylight Savings Time.
>
> The function `gmtime` converts directly to Greenwich Mean Time (GMT), which is the time the system uses.

The function `asctime` converts a `tm` structure to a 26-character string, as shown in the above example, and returns a pointer to the string.

Declarations of all the functions, the external variables and the `tm` structure are in the `<time.h>` header file. The structure `tm` includes the following members:

```
int tm_sec;    /* number of seconds past */
               /* the minute (0-59) */
int tm_min;    /* number of minutes past */
               /* the hour (0-59) */
int tm_hour;   /* current hour (0-23) */
int tm_mday;   /* day of month (1-31) */
int tm_mon;    /* month of year (0-11) */
int tm_year;   /* current year -1900 */
int tm_wday;   /* day of week (Sunday=0) */
int tm_yday;   /* day of year (0-365) */
int tm_isdst; /* daylight savings time flag */
```

The value of `tm_isdst` is non-zero if Daylight Savings Time is in effect.

The external `long` variable `timezone` contains the difference, in seconds, between GMT and local standard time (in EST, `timezone` is `5*60*60`); the external variable `daylight` is non-zero only if the standard USA Daylight Savings Time conversion should be applied. The program compensates for the peculiarities of this conversion in 1974 and 1975; if necessary, a table for these years can be extended.

If an environment variable named `TZ` is present, `asctime` uses the contents of the variable to override the default time-zone. The value of `TZ` must be a three-letter time-zone name, followed by an optional minus sign (for zones east of Greenwich) and a series of digits representing the difference between local time and Greenwich Mean Time in hours; this is followed by an optional three-letter name for a daylight time-zone. For example, the setting for New Jersey would be `EST5EDT`. The effects of setting `TZ` are thus to change the values of the external variables `timezone` and `daylight`. In addition, the time-zone names contained in the external variable

```
char *tzname[2] = { "EST", "EDT" };
```

are set from the environment variable `TZ`. The function `tzset` sets these external variables from `TZ`; the function `tzset` is called by `asctime` and may also be called explicitly by the user.

APPLICATION USAGE

The return values point to static data whose content is overwritten by each call.

SEE ALSO

TIME(BA_OS), GETENV(BA_LIB).

FUTURE DIRECTIONS

The argument `clock` to the functions `ctime`, `localtime` and `gmtime` will be defined by the `<sys/types.h>` header file as pointer to `time_t`.

The number in `TZ` will be defined as an optional minus sign followed by two hour-digits and two minute-digits, `hhmm`, to represent fractional time-zones.

LEVEL

Level 1.

NAME

isalpha, isupper, islower, isdigit, isxdigit, isalnum, isspace, ispunct, isprint, isgraph, iscntrl, isascii — classify characters

SYNOPSIS

```
#include <ctype.h>

int isalpha(c)
int c;

int isupper(c)
int c;

int islower(c)
int c;

int isdigit(c)
int c;

int isxdigit(c)
int c;

int isalnum(c)
int c;

int isspace(c)
int c;

int ispunct(c)
int c;

int isprint(c)
int c;

int isgraph(c)
int c;

int iscntrl(c)
int c;

int isascii(c)
int c;
```

DESCRIPTION

These macros, which are defined by the `<ctype.h>` header file, classify character-coded integer values. Each is a predicate returning non-zero for true, zero for false. The function `isascii` is defined on all integer values; the rest are defined only where `isascii` is true and on the single non-ASCII value `EOF`, which is defined by the `<stdio.h>` header file and represents end-of-file.

`isalpha`	c is a letter.
`isupper`	c is an upper-case letter.
`islower`	c is a lower-case letter.
`isdigit`	c is a digit `[0-9]`.

`isxdigit`	c is a hexadecimal digit `[0-9]`, `[A-F]` or `[a-f]`.
`isalnum`	c is an alphanumeric (letter or digit).
`isspace`	c is a space, tab, carriage-return, new-line, vertical-tab or form-feed.
`ispunct`	c is a punctuation mark (neither control nor alpha-numeric nor space).
`isprint`	c is a printing character, **ASCII** code `040` (space) through `0176` (tilde).
`isgraph`	c is a printing character, like `isprint` except false for space.
`iscntrl`	c is a delete character (`0177`) or an ordinary control-character (less than `040`).
`isascii`	c is an **ASCII** character, code between `0` and `0177` inclusive.

RETURN VALUE

If the argument to any of these macros is not in the domain of the function, the result is undefined.

SEE ALSO

FOPEN(BA_OS), **ASCII character set** in **Chapter 4 — Definitions.**

LEVEL

Level 1.

NAME

drand48, erand48, lrand48, nrand48, mrand48, jrand48, srand48, seed48, lcong48 — generate uniformly distributed pseudo-random numbers

SYNOPSIS

```
double drand48( )

double erand48(xsubi)
unsigned short xsubi[3];

long lrand48( )

long nrand48(xsubi)
unsigned short xsubi[3];

long mrand48( )

long jrand48(xsubi)
unsigned short xsubi[3];

void srand48(seedval)
long seedval;

unsigned short *seed48(seed16v)
unsigned short seed16v[3];

void lcong48(param)
unsigned short param[7];
```

DESCRIPTION

This family of functions generates pseudo-random numbers using the well-known linear congruential algorithm and 48-bit integer arithmetic.

Functions `drand48` and `erand48` return non-negative double-precision floating-point values uniformly distributed over the interval $[0.0,1.0)$.

Functions `lrand48` and `nrand48` return non-negative long integers uniformly distributed over the interval $[0,2^{31})$.

Functions `mrand48` and `jrand48` return signed long integers uniformly distributed over the interval $[-2^{31},2^{31})$.

Functions `srand48`, `seed48` and `lcong48` are initialization entry points, one of which should be invoked before either `drand48`, `lrand48` or `mrand48` is called. (Although it is not recommended practice, constant default initializer values will be supplied automatically if `drand48`, `lrand48` or `mrand48` is called without a prior call to an initialization entry point.) Functions `erand48`, `nrand48` and `jrand48` do not require an initialization entry point to be called first.

All the routines work by generating a sequence of 48-bit integer values, X_i, according to the linear congruential formula:

$$X_{n+1} = (aX_n + c)_{mod\, m} \quad n \geq 0$$

The parameter $m = 2^{48}$; hence 48-bit integer arithmetic is performed. Unless `lcong48` has been invoked, the multiplier value a and the addend value c are given by:

$$a = 5DEECE66D_{16} = 273673163155_8$$
$$c = B_{16} = 13_8$$

The value returned by any of the functions `drand48`, `erand48`, `lrand48`, `nrand48`, `mrand48` or `jrand48` is computed by first generating the next 48-bit X_i in the sequence. Then the appropriate number of bits, according to the type of data item to be returned, are copied from the high-order (leftmost) bits of X_i and transformed into the returned value.

The functions `drand48`, `lrand48` and `mrand48` store the last 48-bit X_i generated in an internal buffer; that is why they must be initialized prior to being invoked. The functions `erand48`, `nrand48` and `jrand48` require the calling program to provide storage for the successive X_i values in the array specified as an argument when the functions are invoked. That is why these routines do not have to be initialized; the calling program merely has to place the desired initial value of X_i into the array and pass it as an argument. By using different arguments, functions `erand48`, `nrand48` and `jrand48` allow separate modules of a large program to generate several **independent** streams of pseudo-random numbers. In other words, the sequence of numbers in each stream will **not** depend upon how many times the routines have been called to generate numbers for the other streams.

The initializer function `srand48` sets the high-order 32-bits of X_i to the {LONG_BIT} bits contained in its argument. The low-order 16-bits of X_i are set to the arbitrary value $330E_{16}$.

The initializer function `seed48` sets the value of X_i to the 48-bit value specified in the argument array. In addition, the previous value of X_i is copied into a 48-bit internal buffer, used only by `seed48`, and a pointer to this buffer is the value returned by `seed48`.

The initialization function `lcong48` allows the user to specify the initial X_i, the multiplier value a and the addend value c. Argument array elements `param[0-2]` specify X_i, `param[3-5]` specify the multiplier a, and `param[6]` specifies the 16-bit addend c. After `lcong48` has been called, a subsequent call to either `srand48` or `seed48` will restore the *standard* multiplier and addend values, a and c, specified on the previous page.

APPLICATION USAGE

The pointer returned by `seed48`, which can just be ignored if not needed, is useful if a program is to be restarted from a given point at some future time. Use the pointer to get at and store the last X_i value and then use this

SEE ALSO

RAND(BA_LIB).

LEVEL

Level 1.

NAME

erf, erfc — error function and complementary error function

SYNOPSIS

```
#include <math.h>

double erf(x)
double x;

double erfc(x)
double x;
```

DESCRIPTION

The function `erf` returns the error function of `x`, defined as follows:

$$\frac{2}{\sqrt{\pi}}\int_0^x e^{-t^2}dt$$

APPLICATION USAGE

The function `erfc` is provided because of the extreme loss of relative accuracy if `erf(x)` is called for large `x` and the result subtracted from `1.0`.

SEE ALSO

EXP(BA_LIB).

LEVEL

Level 1.

NAME

exp, log, log10, pow, sqrt — exponential, logarithm, power, square root functions

SYNOPSIS

```
#include <math.h>

double exp(x)
double x;

double log(x)
double x;

double log10(x)
double x;

double pow(x, y)
double x, y;

double sqrt(x)
double x;
```

DESCRIPTION

The function `exp` returns e^{x}.

The function `log` returns the natural logarithm of x. The value of x must be positive.

The function `log10` returns the logarithm base ten of x. The value of x must be positive.

The functions `pow` returns x^{y}. If x is zero, y must be positive. If x is negative, y must be an integer.

The function `sqrt` returns the non-negative square root of x. The value of x may not be negative.

RETURN VALUE

The function `exp` returns `HUGE` when the correct value would overflow or 0 when the correct value would underflow and sets `errno` to `ERANGE`.

The functions `log` and `log10` `return` `−HUGE` and set `errno` to `EDOM` when x is non-positive. A message indicating `DOMAIN` error (or `SING` error when x is 0) is printed on the standard error output.

The function `pow` returns 0 and sets `errno` to `EDOM` when x is 0 and y is non-positive, or when x is negative and y is not an integer. In these cases a message indicating `DOMAIN` error is printed on the standard error output. When the correct value for `pow` would overflow or underflow, `pow` returns `±HUGE` or 0 respectively and sets `errno` to `ERANGE`.

The function `sqrt` returns 0 and sets `errno` to `EDOM` when x is negative. A message indicating `DOMAIN` error is printed on the standard error output.

APPLICATION USAGE

These error-handling procedures may be changed with the MATHERR(BA_LIB) routine.

SEE ALSO

HYPOT(BA_LIB), MATHERR(BA_LIB), SINH(BA_LIB).

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file. This macro will call a function which will either return $+\infty$ on a system supporting the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

The function `exp` will return `HUGE_VAL` when the correct value overflows.

The functions `log` and `log10` will return `-HUGE_VAL` when `x` is not positive.

The function `sqrt` will return `-0` when the value of `x` is `-0`.

The return value of `pow` will be negative `HUGE_VAL` when an illegal combination of input arguments is passed to `pow`.

LEVEL

Level 1.

NAME

floor, ceil, fmod, fabs — floor, ceiling, remainder, absolute value functions

SYNOPSIS

```
#include <math.h>

double floor(x)
double x;

double ceil(x)
double x;

double fmod(x, y)
double x, y;

double fabs(x)
double x;
```

DESCRIPTION

The function `floor` returns the largest integer (as a double-precision number) not greater than `x`.

The function `ceil` returns the smallest integer not less than `x`.

The function `fmod` returns the floating-point remainder of the division of `x` by `y`, zero if `y` is zero or if `x/y` would overflow. Otherwise the number is f with the same sign as `x`, such that $x = iy + f$ for some integer i, and $|f| < |y|$.

The function `fabs` returns the absolute value of `x`, i.e., $|x|$.

SEE ALSO

ABS(BA_LIB).

FUTURE DIRECTIONS

The function `fmod` will return `x` if `y` is zero or if `x/y` would overflow.

LEVEL

Level 1.

NAME

frexp, ldexp, modf — manipulate parts of floating-point numbers

SYNOPSIS

```
double frexp(value, eptr)
double value;
int *eptr;

double ldexp(value, exp)
double value;
int exp;

double modf(value, iptr)
double value, *iptr;
```

DESCRIPTION

Every non-zero number can be written uniquely as $x*2^n$, where the *mantissa* (fraction) x is in the range $0.5 \leqslant |x| < 1.0$ and the *exponent* n is an integer. The function `frexp` returns the mantissa of a `double value` and stores the exponent indirectly in the location pointed to by `eptr`. If `value` is `0`, both results returned by `frexp` are `0`.

The function `ldexp` returns the quantity `value`$*2^{\text{exp}}$.

The function `modf` returns the fractional part of `value` and stores the integral part indirectly in the location pointed to by `iptr`. Both the fractional and integer parts have the same sign as `value`.

RETURN VALUE

If `ldexp` would cause overflow, ±`HUGE` is returned (according to the sign of `value`) and `errno` is set to `ERANGE`.

If `ldexp` would cause underflow, `0` is returned and `errno` is set to `ERANGE`.

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file This macro will call a function which will either return $+\infty$ on a system supporting the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

The return value of `ldexp` will be ±`HUGE_VAL` (according to the sign of `value`) in case of overflow.

LEVEL

Level 1.

NAME

ftw — walk a file tree

SYNOPSIS

```
#include <ftw.h>

int ftw(path, fn, param)
char *path;
int (*fn)( );
int param;
```

DESCRIPTION

The function `ftw` recursively descends the directory hierarchy rooted in `path`. For each object in the hierarchy, the function `ftw` calls a user-defined function `fn` passing it three arguments. The first argument passed is a character pointer to a null-terminated string containing the name of the object. The second argument passed to `fn` is a pointer to a `stat` structure [see STAT(BA_OS)] containing information about the object, and the third argument passed is an integer flag. Possible values of the flag, defined by the `<ftw.h>` header file, are `FTW_F` for a file, `FTW_D` for a directory, `FTW_DNR` for a directory that cannot be read and `FTW_NS` for an object for which `stat` could not successfully be executed. If the integer is `FTW_DNR`, descendants of that directory will not be processed. If the integer is `FTW_NS`, the contents of the `stat` structure are undefined.

The function `ftw` visits a directory before visiting any of its descendants.

The function `ftw` uses one file-descriptor for each level in the tree. The argument `param` limits the number of file-descriptors so used. The argument `param` should be in the range of 1 to {OPEN_MAX}. The function `ftw` will run more quickly if `param` is at least as large as the number of levels in the tree.

RETURN VALUE

The tree traversal continues until the tree is exhausted, an invocation of `fn` returns a nonzero value or some error is detected within `ftw` (such as an I/O error). If the tree is exhausted, the function `ftw` returns `0`. If the function `fn` returns a non-zero value, the function `ftw` stops its tree traversal and returns whatever value was returned by the function `fn`.

If the function `ftw` encounters an error other than `EACCES` (see `FTW_DNR` and `FTW_NS` above), it returns −1 and `errno` is set to the type of error. The external variable `errno` may contain the error values that are possible when a directory is opened [see OPEN(BA_OS)] or when the STAT(BA_OS) routine is executed on a directory or file.

APPLICATION USAGE

Because the function `ftw` is recursive, it is possible for it to terminate with a memory fault when applied to very deep file structures.

SEE ALSO

STAT(BA_OS), MALLOC(BA_OS).

LEVEL

Level 1.

NAME

gamma — log gamma function

SYNOPSIS

```
#include <math.h>

double gamma(x)
double x;

extern int signgam;
```

DESCRIPTION

The function `gamma` returns $\ln(|\Gamma(x)|)$, where $\Gamma(x)$ is defined as:

$$\int_0^\infty e^{-t} t^{x-1} dt$$

The sign of $\Gamma(x)$ is returned in the external integer `signgam`. The argument x may not be a non-positive integer.

The following C program fragment might be used to calculate Γ:

```
if ((y = gamma(x)) > LN_MAXDOUBLE)
    error();
y = signgam * exp(y);
```

RETURN VALUE

For non-positive integer arguments `HUGE` is returned, and `errno` is set to `EDOM`. A message indicating `SING` error is printed on the standard error output [see MATHERR(BA_LIB)].

If the correct value would overflow, `gamma` returns `HUGE` and sets `errno` to `ERANGE`.

APPLICATION USAGE

These error-handling procedures may be changed with the MATHERR(BA_LIB) routine.

SEE ALSO

EXP(BA_LIB), MATHERR(BA_LIB).

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file. This macro will call a function which will either return $+\infty$ on a system supporting the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

If the correct value overflows, `gamma` will return `HUGE_VAL`.

LEVEL

Level 1.

NAME

getc, getchar, fgetc, getw — get character or word from a stream

SYNOPSIS

```
#include <stdio.h>

int getc(stream)
FILE *stream;

int getchar( )

int fgetc(stream)
FILE *stream;

int getw(stream)
FILE *stream;
```

DESCRIPTION

The function `getc` returns the next character (i.e., byte) from the named input `stream` as an integer. It also moves the file pointer, if defined, ahead one character in `stream`. The macro `getchar` is defined as `getc(stdin)`. Both `getc` and `getchar` are macros.

The function `fgetc` behaves like `getc` but is a function rather than a macro. The function `fgetc` runs more slowly than `getc` but it takes less space per invocation and its name can be passed as an argument to a function.

The function `getw` returns the next word (i.e., integer) from the named input `stream`. The function `getw` increments the associated file pointer, if defined, to point to the next word. The size of a word is the size of an integer and varies from machine to machine. The function `getw` assumes no special alignment in the file.

RETURN VALUE

These functions return the constant `EOF` at end-of-file or upon an error. Because `EOF` is a valid integer, the FERROR(BA_OS) routine should be used to detect `getw` errors.

APPLICATION USAGE

If the integer value returned by `getc`, `getchar` or `fgetc` is stored into a character variable and then compared against the integer constant `EOF`, the comparison may never succeed because sign-extension of a character on widening to integer is machine-dependent.

Because of possible differences in word length and byte ordering, files written using `putw` are machine-dependent and may not be read using `getw` on a different processor.

Because it is implemented as a macro, `getc` treats incorrectly a `stream` argument with side effects. In particular, `getc(*f++)` does not work sensibly. The function `fgetc` should be used instead.

SEE ALSO

FCLOSE(BA_OS), FERROR(BA_OS), FOPEN(BA_OS), FREAD(BA_OS), GETS(BA_LIB), PUTC(BA_LIB), SCANF(BA_LIB).

LEVEL

Level 1.

NAME

getenv — return value for environment name

SYNOPSIS

```
char *getenv(name)
char *name;
```

DESCRIPTION

The function `getenv` searches the environment list for a string of the form `name = value` and returns a pointer to the `value` in the current environment if such a string is present. Otherwise a `NULL` pointer is returned.

SEE ALSO

EXEC(BA_OS), SYSTEM(BA_OS), PUTENV(BA_LIB).

LEVEL

Level 1.

NAME

getopt — get option letter from argument vector

SYNOPSIS

```
int getopt(argc, argv, optstring)
int argc;
char *argv[ ], *optstring;

extern char *optarg;
extern int optind, opterr;
```

DESCRIPTION

The function `getopt` is a command-line parser. It returns the next option letter in `argv` that matches a letter in `optstring`.

The function `getopt` places in `optind` the `argv` index of the next argument to be processed. The external variable `optind` is initialized to 1 before the first call to the function `getopt`.

The argument `optstring` is a string of recognized option letters; if a letter is followed by a colon, the option is expected to have an argument that may or may not be separated from it by white space.

The variable `optarg` is set to point to the start of the option argument on return from `getopt`.

When all options have been processed (i.e., up to the first non-option argument), the function `getopt` returns `EOF`. The special option `--` may be used to delimit the end of the options; `EOF` will be returned and `--` will be skipped.

RETURN VALUE

The function `getopt` prints an error message on `stderr` and returns a question-mark (`?`) when it encounters an option letter not included in `optstring`. Setting `opterr` to a 0 will disable this error message.

EXAMPLE

The following code fragment shows how one might process the arguments for a command that can take the mutually exclusive options a and b and the options f and o, both of which require arguments:

```
main (argc, argv)
int argc;
char *argv [ ];
{
    int c;
    int bflg, aflg, errflg;
    char *ifile;
    char *ofile;
    extern char *optarg;
    extern int optind;
    . . .
    while ((c = getopt(argc, argv, "abf:o:")) != EOF)
        switch (c) {
        case 'a': if (bflg)
                      errflg++;
                  else
                      aflg++;
                  break;
        case 'b': if (aflg)
                      errflg++;
                  else
                      bproc( );
                  break;
        case 'f': ifile = optarg;
                  break;
        case 'o': ofile = optarg;
                  break;
        case '?': errflg++;
        }
    if (errflg) {
        fprintf(stderr, "usage: . . . ");
        exit(2);
    }
    for ( ; optind < argc; optind++) {
        if (access(argv[optind], 4)) {
    . . .
}
```

FUTURE DIRECTIONS

The function getopt will be enhanced to enforce all rules of the System V Command Syntax Standard (see below). All *new* System V commands will conform to the command syntax standard described here. Existing commands will migrate toward the new standard if they do not already meet it. Applications whose user-interface is command-like may want to be consistent with the syntax standard.

The following rules comprise the System V standard for command-line syntax:

RULE 1:	Command names must be between two and nine characters.
RULE 2:	Command names must include lower-case letters and digits only.
RULE 3:	Option names must be a single character in length.
RULE 4:	All options must be delimited by the – character.
RULE 5:	Options with no arguments may be grouped behind one delimiter.
RULE 6:	The first option-argument following an option must be preceded by white space.
RULE 7:	Option arguments cannot be optional.
RULE 8:	Groups of option arguments following an option must be separated by commas or separated by white space and quoted.
RULE 9:	All options must precede operands on the command line.
RULE 10:	The characters –– may be used to delimit the end of the options.
RULE 11:	The order of options relative to one another should not matter.
RULE 12:	The order of operands may matter and position-related interpretations should be determined on a command-specific basis.
RULE 13:	The – character preceded and followed by white space should be used only to mean standard input.

The function `getopt` is the command-line parser that will enforce the rules of this command syntax standard.

LEVEL

Level 1.

NAME

gets, fgets — get a string from a stream

SYNOPSIS

```
#include <stdio.h>

char *gets(s)
char *s;

char *fgets(s, n, stream)
char *s;
int n;
FILE *stream;
```

DESCRIPTION

The function `gets` reads characters from the standard input stream, `stdin`, into the array pointed to by `s` until a new-line character is read or an end-of-file condition is encountered. The new-line character is discarded and the string is terminated with a null character.

The function `fgets` reads characters from the `stream` into the array pointed to by `s` until `n-1` characters are read or a new-line character is read and transferred to `s` or an end-of-file condition is encountered. The string is then terminated with a null character.

RETURN VALUE

If end-of-file is encountered and no characters have been read, no characters are transferred to `s` and a `NULL` pointer is returned. If a read error occurs, such as trying to use these functions on a file that has not been opened for reading, a `NULL` pointer is returned. Otherwise `s` is returned.

APPLICATION USAGE

Reading too long a line through `gets` may cause `gets` to fail. The use of `fgets` is recommended.

SEE ALSO

FERROR(BA_OS), FOPEN(BA_OS), FREAD(BA_OS), GETC(BA_LIB), SCANF(BA_LIB).

LEVEL

Level 1.

NAME

hsearch, hcreate, hdestroy — manage hash search tables

SYNOPSIS

```
#include <search.h>

ENTRY *hsearch(item, action)
ENTRY item;
ACTION action;

int hcreate(nel)
unsigned nel;

void hdestroy( )
```

DESCRIPTION

The function `hsearch` is a hash-table search routine. It returns a pointer into a hash table indicating the location at which an entry can be found. The comparison function used by `hsearch` is the function `strcmp` [see STRING(BA_LIB)].

The argument `item` is a structure of type `ENTRY` (defined by the `<search.h>` header file) containing two character pointers: `item.key` pointing to the comparison key and `item.data` pointing to any other data to be associated with that key. (Pointers to types other than `char` should be cast to pointer-to-character.)

The argument `action` is a member of an enumeration type `ACTION`, defined by the `<search.h>` header file, indicating the disposition of the entry if it cannot be found in the table.

`ENTER` indicates that the item should be inserted in the table at an appropriate point. Given a duplicate of an existing item, the new item is not entered, and `hsearch` returns a pointer to the existing item.

`FIND` indicates that no entry should be made. Unsuccessful resolution is indicated by the return of a `NULL` pointer.

The function `hcreate` allocates sufficient space for the table and must be called before `hsearch` is used. The value of `nel` is an estimate of the maximum number of entries that the table will contain. This number may be adjusted upward by the algorithm in order to obtain certain mathematically favorable circumstances.

The function `hdestroy` destroys the search table and may be followed by another call to `hcreate`.

RETURN VALUE

The function `hsearch` returns a `NULL` pointer if either the action is `FIND` and the item could not be found or the action is `ENTER` and the table is full.

The function `hcreate` returns 0 if it cannot allocate sufficient space for the table.

APPLICATION USAGE

The functions `hsearch` and `hcreate` use the MALLOC(BA_OS) routine to allocate space.

EXAMPLE

The example reads in strings followed by two numbers and stores them in a hash table. It then reads in strings and finds the entry in the table and prints it.

```
#include <stdio.h>
#include <search.h>

struct info {           /* these are in the table */
    int age, room;      /* apart from the key. */
};
#define NUM_EMPL 5000   /* # of elements in the table */

main( )
{
    /* space for strings */
    char string_space[NUM_EMPL*20];
    /* space for employee info */
    struct info info_space[NUM_EMPL];
    /* next avail space for strings */
    char *str_ptr = string_space;
    /* next avail space for info */
    struct info *info_ptr = info_space;
    ENTRY item, *found_item, *hsearch( );
    char name_to_find[30];  /* name to look for in table */
    int i = 0;

    /* create table */
    (void) hcreate(NUM_EMPL);
    while (scanf("%s%d%d", str_ptr, &info_ptr->age,
        &info_ptr->room) != EOF && i++ < NUM_EMPL) {
        /* put info in structure, and structure in item */
        item.key = str_ptr;
        item.data = (char *)info_ptr;
        str_ptr += strlen(str_ptr) + 1;
        info_ptr++;
        /* put item into table */
        (void) hsearch(item, ENTER);
    }
    /* access table */
    item.key = name_to_find;
    while (scanf("%s", item.key) != EOF) {
        if ((found_item = hsearch(item, FIND)) != NULL) {
        /* if item is in the table */
        (void) printf("found %s, age = %d, room = %d\n",
            found_item->key,
            ((struct info *)found_item->data)->age,
            ((struct info *)found_item->data)->room);
        } else {
        (void) printf("no such employee %s\n",
            name_to_find)
        }
    }
}
```

SEE ALSO

MALLOC(BA_OS), BSEARCH(BA_LIB), LSEARCH(BA_LIB), STRING(BA_LIB), TSEARCH(BA_LIB).

FUTURE DIRECTIONS

The restriction of having only one hash search table active at any given time will be removed.

LEVEL

Level 1.

NAME

hypot — Euclidean distance function

SYNOPSIS

```
#include <math.h>

double hypot(x, y)
double x, y;
```

DESCRIPTION

The function `hypot` returns `sqrt(x * x + y * y)`, taking precautions against unwarranted overflows.

RETURN VALUE

When the correct value would overflow, `hypot` returns `HUGE` and sets `errno` to `ERANGE`.

These error-handling procedures may be changed with the function defined by the MATHERR(BA_LIB) routine.

SEE ALSO

MATHERR(BA_LIB).

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file. This macro will call a function which will either return +∞ on a system supporting the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

The function `hypot` will return `HUGE_VAL` when the correct value overflows.

LEVEL

Level 1.

NAME

lsearch, lfind — linear search and update

SYNOPSIS

```
#include <search.h>

char *lsearch(key, base, nelp, width, compar)
char *key;
char *base;
unsigned *nelp;
unsigned width;
int (*compar)( );

char *lfind(key, base, nelp, width, compar)
char *key;
char *base;
unsigned *nelp;
unsigned width;
int (*compar)( );
```

DESCRIPTION

The function `lsearch` is a linear search routine. It returns a pointer into a table indicating where a datum may be found. If the datum does not occur, it is added at the end of the table. The value of `key` points to the datum to be sought in the table. The value of `base` points to the first element in the table. The value of `nelp` points to an integer containing the current number of elements in the table. The value of `width` is the size of an element in bytes. The variable pointed to by `nelp` is incremented if the datum is added to the table. The value of `compar` is the name of the comparison function which the user must supply (`strcmp`, for example). It is called with two arguments that point to the elements being compared. The function must return zero if the elements are equal and non-zero otherwise.

The function `lfind` is the same as `lsearch` except that if the datum is not found, it is not added to the table. Instead, a `NULL` pointer is returned.

RETURN VALUE

If the searched for datum is found, both the functions `lsearch` and `lfind` return a pointer to it. Otherwise, the function `lfind` returns `NULL` and the function `lsearch` returns a pointer to the newly added element.

APPLICATION USAGE

The function `lfind` was added to System V in System V Release 2.0.

The pointers to the key and the element at the base of the table should be of type pointer-to-element and cast to type pointer-to-character.

The comparison function need not compare every byte, so arbitrary data may be contained in the elements in addition to the values being compared.

Although declared as type pointer-to-character, the value returned should be cast into type pointer-to-element.

Space for the table must be managed by the application-program. Undefined results can occur if there is not enough room in the table to add a new item.

EXAMPLE

This fragment will read in ≤ `TABSIZE` strings of length ≤ `ELSIZE` and store them in a table, eliminating duplicates.

```
#include <stdio.h>
#include <search.h>

#define TABSIZE 50
#define ELSIZE 120

    char line[ELSIZE], tab[TABSIZE][ELSIZE], *lsearch( );
    unsigned nel = 0;
    int strcmp( );
    . . .
    while (fgets(line, ELSIZE, stdin) != NULL &&
        nel < TABSIZE)
            (void) lsearch(line, (char *)tab, &nel,
                ELSIZE, strcmp);
    . . .
```

SEE ALSO

BSEARCH(BA_LIB), HSEARCH(BA_LIB), TSEARCH(BA_LIB).

FUTURE DIRECTIONS

A `NULL` pointer will be returned by the function `lsearch` with `errno` set appropriately, if there is not enough room in the table to add a new item.

LEVEL

Level 1.

NAME

matherr — error-handling function

SYNOPSIS

```
#include <math.h>

int matherr(x)
struct exception *x;
```

DESCRIPTION

The function `matherr` is invoked by math library routines when errors are detected. Users may define their own procedures for handling errors, by including a function named `matherr` in their programs. The function `matherr` must be of the form described above. When an error occurs, a pointer to the `exception` structure `x` will be passed to the user-supplied `matherr` function. This structure, which is defined by the `<math.h>` header file, includes the following members:

```
int type;
char *name;
double arg1, arg2, retval;
```

The element `type` is an integer describing the type of error that has occurred from the following list defined by the `<math.h>` header file:

`DOMAIN`	argument domain error.
`SING`	argument singularity.
`OVERFLOW`	overflow range error.
`UNDERFLOW`	underflow range error.
`TLOSS`	total loss of significance.
`PLOSS`	partial loss of significance.

The element `name` points to a string containing the name of the routine that incurred the error. The elements `arg1` and `arg2` are the first and second arguments with which the routine was invoked.

The element `retval` is set to the default value that will be returned by the routine unless the user's `matherr` function sets it to a different value.

If the user's `matherr` function returns non-zero, no error message will be printed, and `errno` will not be set.

If the function `matherr` is not supplied by the user, the default error-handling procedures, described with the math library routines involved, will be invoked upon error. These procedures are also summarized in the table below. In every case, `errno` is set to `EDOM` or `ERANGE` and the program continues.

ERRORS

DEFAULT ERROR HANDLING PROCEDURES

	Types of Errors					
type	DOMAIN	SING	OVERFLOW	UNDERFLOW	TLOSS	PLOSS
errno	EDOM	EDOM	ERANGE	ERANGE	ERANGE	ERANGE
BESSEL:	–	–	–	–	M, 0	*
y0, y1, yn (arg ≤ 0)	M, −H	–	–	–	–	–
EXP:	–	–	H	0	–	–
LOG, LOG10:						
(arg < 0)	M, −H	–	–	–	–	–
(arg = 0)	–	M, −H	–	–	–	–
POW:	–	–	±H	0	–	–
neg ** non-int 0 ** non-pos	M, 0	–	–	–	–	–
SQRT:	M, 0	–	–	–	–	–
GAMMA:	–	M, H	H	–	–	–
HYPOT:	–	–	H	–	–	–
SINH:	–	–	±H	–	–	–
COSH:	–	–	H	–	–	–
SIN, COS, TAN:	–	–	–	–	M, 0	*
ASIN, ACOS, ATAN2:	M, 0	–	–	–	–	–

ABBREVIATIONS

*	As much as possible of the value is returned.
M	Message is printed (EDOM error).
H	HUGE is returned.
−H	−HUGE is returned.
±H	HUGE or −HUGE is returned.
0	0 is returned.

EXAMPLE

```
#include <math.h>

int matherr(x)
register struct exception *x;
{
    switch (x->type) {
    case DOMAIN:
        /* change sqrt to return sqrt(-arg1), not 0 */
        if (!strcmp(x->name, "sqrt")) {
            x->retval = sqrt(-x->arg1);
            return (0);  /* print message and set errno */
        }
    case SING:
        /* SING or other DOMAIN errs, print message and abort */
        fprintf(stderr, "domain error in %s\n", x->name);
        abort();
    case PLOSS:
        /* print detailed error message */
        fprintf(stderr, "loss of significance in %s(%g) = %g\n",
            x->name, x->arg1, x->retval);
        return (1);   /* take no other action */
    }
    return (0); /* all other errors, execute default procedure */
}
```

FUTURE DIRECTIONS

The math functions which return HUGE or ±HUGE on overflow will return HUGE_VAL or ±HUGE_VAL respectively.

LEVEL

Level 1.

NAME

memccpy, memchr, memcmp, memcpy, memset — memory operations

SYNOPSIS

```
#include <memory.h>

char *memccpy(s1, s2, c, n)
char *s1, *s2;
int c, n;

char *memchr(s, c, n)
char *s;
int c, n;

int memcmp(s1, s2, n)
char *s1, *s2;
int n;

char *memcpy(s1, s2, n)
char *s1, *s2;
int n;

char *memset(s, c, n)
char *s;
int c, n;
```

DESCRIPTION

These functions operate as efficiently as possible on memory areas (arrays of characters bounded by a count, not terminated by a null character). They do not check for the overflow of any receiving memory area.

The function `memccpy` copies characters from memory area `s2` into `s1`, stopping after the first occurrence of character `c` has been copied or after `n` characters have been copied, whichever comes first. It returns a pointer to the character after the copy of `c` in `s1`, or a `NULL` pointer if `c` was not found in the first `n` characters of `s2`.

The function `memchr` returns a pointer to the first occurrence of character `c` in the first `n` characters of memory area `s`, or a `NULL` pointer if `c` does not occur.

The function `memcmp` compares its arguments, looking at the first `n` characters only. It returns an integer less than, equal to or greater than `0`, according as `s1` is lexicographically less than, equal to or greater than `s2`.

The function `memcpy` copies `n` characters from memory area `s2` to `s1`. It returns `s1`.

The function `memset` sets the first `n` characters in memory area `s` to the value of character `c`. It returns `s`.

APPLICATION USAGE

All these functions are defined by the `<memory.h>` header file.

The function `memcmp` uses native character comparison. The sign of the value returned when one of the characters has its high-order bit set is implementation-dependent.

Character movement is performed differently in different implementations. Thus overlapping moves may be unpredictable.

SEE ALSO

STRING(BA_LIB).

FUTURE DIRECTIONS

The declarations in the `<memory.h>` header file will be moved to the `<string.h>` header file.

LEVEL

Level 1.

NAME

mktemp — make a unique file name

SYNOPSIS

```
char *mktemp(template)
char *template;
```

DESCRIPTION

The function `mktemp` replaces the contents of the string pointed to by `template` by a unique file name and returns `template`. The string in `template` should look like a file name with six trailing `X`s; `mktemp` will replace the `X`s with a letter and the current process-ID. The letter will be chosen so that the resulting name does not duplicate an existing file.

RETURN VALUE

The function `mktemp` returns the pointer `template`. If a unique name cannot be created, `template` will point to a null string.

SEE ALSO

GETPID(BA_OS), TMPFILE(BA_LIB), TMPNAM(BA_LIB).

FUTURE DIRECTIONS

A `NULL` pointer will be returned if a unique name cannot be created.

LEVEL

Level 1.

NAME

perror — system error messages

SYNOPSIS

```
void perror(s)
char *s;

extern int errno;

extern char *sys_errlist[ ];

extern int sys_nerr;
```

DESCRIPTION

The function `perror` produces a message on the standard error output describing the last error encountered during a call to a function.

The string pointed to by the argument `s` is printed first, then a colon and a blank, then the message and a new-line. To be of most use, the argument string should include the name of the program that incurred the error.

The error number is taken from the external variable `errno`, which is set when errors occur but not cleared when successful calls are made.

If given a null-string, the function `perror` prints only the message and a new-line.

The array of message strings `sys_errlist` is provided to make messages consistent. The variable `errno` can be used as an index in this array to get the message string without the new-line. The external variable `sys_nerr` is the largest message number provided for in the array; it should be checked because new error codes may be added to the system before they are added to the array.

FUTURE DIRECTIONS

New error handling routines will be added to support the System V Error Message Standard as a tool for application-developers to use. The System V Error Message Standard is designed to apply to: firmware/diagnostics, the operating system, networks, System V commands, languages and, when appropriate, applications. All *new* System V error messages will follow the standard, and existing error messages will be modified over time. The standard System V error message as seen by the end-user may have up to five informational elements:

Element	*Description*
LABEL	source of the error.
SEVERITY	one of at least 4 severity codes.
PROBLEM	description of the problem.
ACTION	error-recovery action.
TAG	unique error message identifier.

Each element is described in more detail below.

The standard specifies the information that is important in error recovery. It does not specify the format in which the information is delivered. For example, if a system had a graphical user interface, the **LABEL** might be presented as an icon. An operating system error message meeting the standard information requirements is shown below. Here, **OS** is the **LABEL**, **HALT** is the **SEVERITY**, **Timeout Table Overflow** is the **PROBLEM**, **See Administration Manual** is the **ACTION**, and **OS-136** is the **TAG**.

```
OS: HALT: Timeout Table Overflow.
   TO FIX: See Administration Manual. OS-136
```

The standard allows systematic omission of one or more elements in specific environments that do not need them for successful error recovery. For example, while operating system errors need all five elements, a firmware error message can omit the **ACTION** because an expert service person is typically the user of this message and the **ACTION** may be too long to store in firmware. Software that obviously puts the user in a special environment (e.g., a spread-sheet program) where the user will only see errors from that environment may omit the **LABEL**. Because a primary use of the **TAG** is for reporting or to point to on-line documentation, it may be omitted when appropriate (e.g., when there is no on-line documentation).

LABEL This element of the message identifies the error source (e.g., OS, UUCP, application-program-name, etc.) and could double as a pointer to documentation.

SEVERITY This element of the message indicates the consequences of the error for the user. Four levels of severity (which can be expanded by system builders who want additional distinctions) are outlined below.

HALT	signifies that the processor, OS, application, or database is corrupted and that processing should be stopped immediately to rectify the problem. This severity signifies an emergency.
ERROR	signifies that a condition that may soon interfere with resource use has occurred. This severity alerts the user that some corrective action is needed.
WARNING	signifies an aberrant condition (e.g., stray hardware interrupt, free file space is low) that should be monitored, but requires no immediate action.
INFO	simply provides some information about a user request or about the state of the system (e.g., a printer taken off-line).

PROBLEM This element of the message clearly describes the error condition. In much of today's software, this element is the only one provided in the message.

ACTION This element of the message describes the first step to be taken in the error-recovery process. For OS errors, this section of the message might be one of five standard strings: **See Hardware Vendor**, **See Software Vendor**, **See Administrator Procedure**, **See Operator Procedure**, or **See Manual**. These strings should be clearly identified as action to be taken (e.g., by preceding them with the prefix: **TO FIX:**).

TAG This is a unique identifier for the message, used both internally and to obtain online documentation for the message *on those systems that have capacity* to store such information.

LEVEL

Level 2: January 1, 1985.

NAME

printf, fprintf, sprintf — print formatted output

SYNOPSIS

```
#include <stdio.h>

int printf(format [ , arg ]...)
char *format;

int fprintf(stream, format [ , arg ]...)
FILE *stream;
char *format;

int sprintf(s, format [ , arg ]...)
char *s, *format;
```

DESCRIPTION

The function `printf` places output on the standard output stream `stdout`.

The function `fprintf` places output on the named output `stream`.

The function `sprintf` places output, followed by the null character (`\0`) in consecutive bytes starting at `*s`. It is the user's responsibility to ensure that enough storage is available. Each function returns the number of characters transmitted (not including the `\0` in the case of `sprintf`) or a negative value if an output error was encountered.

Each of these functions converts, formats and prints its `args` under control of the `format`. The `format` is a character-string that contains three types of objects defined below:

1. plain-characters that are simply copied to the output stream;
2. escape-sequences that represent non-graphic characters; and
3. conversion-specifications.

The following escape-sequences produce the associated action on display devices capable of the action:

`\b` Backspace.
Moves the printing position to one character before the current position, unless the current position is the start of a line.

`\f` Form Feed.
Moves the printing position to the initial printing position of the next logical page.

`\n`	New line. Moves the printing position to the start of the next line.
`\r`	Carriage return. Moves the printing position to the start of the current line.
`\t`	Horizontal tab. Moves the printing position to the next implementation-defined horizontal tab position on the current line.
`\v`	Vertical tab. Moves the printing position to the start of the next implementation-defined vertical tab position.

Each conversion specification is introduced by the character `%`. After the character `%`, the following appear in sequence:

Zero or more *flags*, which modify the meaning of the conversion specification.

An optional string of decimal digits to specify a minimum *field width*. If the converted value has fewer characters than the field width, it will be padded on the left (or right, if the left-adjustment flag (–), described below, has been given) to the field width.

A *precision* that gives the minimum number of digits to appear for the `d`, `o`, `u`, `x`, or `X` conversions (the field is padded with leading zeros), the number of digits to appear after the decimal point for the `e` and `f` conversions, the maximum number of significant digits for the `g` conversion; or the maximum number of characters to be printed from a string in `s` conversion. The precision takes the form of a period (`.`) followed by a decimal digit string; a null digit string is treated as zero.

An optional `l` (ell) to specify that a following `d`, `o`, `u`, `x` or `X` conversion character applies to a long integer `arg`. An `l` before any other conversion character is ignored.

A conversion character (see below) that indicates the type of conversion to be applied.

A *field width* or *precision* may be indicated by an asterisk (`*`) instead of a digit string. In this case, an integer `arg` supplies the field width or precision. The `arg` that is actually converted is not fetched until the conversion letter is seen, so the `args` specifying field width or precision must appear `before` the `arg` (if any) to be converted.

The *flag* characters and their meanings are:

−	The result of the conversion will be left-justified within the field.
+	The result of a signed conversion will always begin with a sign (+ or −).
blank	If the first character of a signed conversion is not a sign, a blank will be prepended to the result. This means that if the blank and + flags both appear, the blank flag will be ignored.
#	The value is to be converted to an *alternate form*. For `c`, `d`, `s` and `u` conversions, the flag has no effect. For `o` conversion, it increases the precision to force the first digit of the result to be a zero. For `x` or `X` conversion, a non-zero result will have `0x` or `0X` prepended to it. For `e`, `E`, `f`, `g` and `G` conversions, the result will always contain a decimal point, even if no digits follow the point (normally, a decimal point appears in the result of these conversions only if a digit follows it). For `g` and `G` conversions, trailing zeroes will *not* be removed from the result as they normally are.

Each conversion character results in fetching zero or more `args`. The results are undefined if there are insufficient `args` for the format. If the format is exhausted while `args` remain, the excess `args` are ignored.

The conversion characters and their meanings are:

d,o,u,x,X	The integer `arg` is converted to signed decimal (`d`), unsigned octal (`o`), unsigned decimal (`u`) or unsigned hexadecimal notation (`x` and `X`). The `x` conversion uses the letters `abcdef` and the `X` conversion uses the letters `ABCDEF`. The *precision* component of `arg` specifies the minimum number of digits to appear. If the value being converted can be represented in fewer digits than the specified minimum, it will be expanded with leading zeroes. The default precision is `1`. The result of converting a zero value with a precision of `0` is a null string.
f	The float or double `arg` is converted to decimal notation in the style `[−]ddd.ddd`, where the number of digits after the decimal point is equal to the *precision* specification. If the *precision* is omitted from `arg`, six digits are output; if the *precision* is explicitly `0`, no decimal point appears.
e,E	The float or double `arg` is converted to the style `[−]d.ddde±dd`, where there is one digit before the decimal point and the number of digits after it is equal to the precision. When the precision is missing, six digits are produced; if the precision is `0`, no decimal point appears. The `E` conversion character will produce a number with `E` instead of `e` introducing the exponent.

The exponent always contains at least two digits. However, if the value to be printed is greater than or equal to `1E+100`, additional exponent digits will be printed as necessary.

`g,G` The float or double `arg` is printed in style `f` or `e` (or in style `E` in the case of a `G` conversion character), with the precision specifying the number of significant digits. The style used depends on the value converted: style `e` will be used only if the exponent resulting from the conversion is less than −4 or greater than the precision. Trailing zeroes are removed from the result. A decimal point appears only if it is followed by a digit.

`c` The character `arg` is printed.

`s` The `arg` is taken to be a string (character pointer) and characters from the string are printed until a null character (`\0`) is encountered or the number of characters indicated by the *precision* specification of `arg` is reached. If the precision is omitted from `arg`, it is taken to be infinite, so all characters up to the first null character are printed. A `NULL` value for `arg` will yield undefined results.

`%` Print a `%`; no argument is converted.

If the character after the `%` is not a valid conversion character, the results of the conversion are undefined.

In no case does a non-existent or small field width cause truncation of a field; if the result of a conversion is wider than the field width, the field is simply expanded to contain the conversion result. Characters generated by `printf` and `fprintf` are printed as if the PUTC(BA_LIB) routine had been called.

RETURN VALUE

The functions `printf`, `fprintf`, and `sprintf` return the number of characters transmitted, or return −1 if an error was encountered.

EXAMPLE

To print a date and time in the form `Sunday, July 3, 10:02`, where `weekday` and `month` are pointers to null-terminated strings:

```
printf("%s, %s %d, %d:%.2d",
        weekday, month, day, hour, min);
```

To print π to 5 decimal places:

```
printf("pi = %.5f", 4 * atan(1.0));
```

SEE ALSO

PUTC(BA_LIB), SCANF(BA_LIB), FOPEN(BA_OS).

FUTURE DIRECTIONS

The function `printf` will make available character string representations for ∞ and "not a number" (NaN: a symbolic entity encoded in floating point format) to support the **IEEE P754** standard.

LEVEL

Level 1.

NAME

putc, putchar, fputc, putw — put character or word on a stream

SYNOPSIS

```
#include <stdio.h>

int putc(c, stream)
int c;
FILE *stream;

int putchar(c)
int c;

int fputc(c, stream)
int c;
FILE *stream;

int putw(w, stream)
int w;
FILE *stream;
```

DESCRIPTION

The function `putc` writes the character `c` onto the output `stream` at the position where the file-pointer, if defined, is pointing.

The function `putchar(c)` is defined as follows:

```
putc(c, stdout)
```

Both `putc` and `putchar` are macros.

The function `fputc` behaves like `putc`, but is a function rather than a macro. The function `fputc` runs more slowly than `putc` but it takes less space per invocation and its name can be passed as an argument to a function.

The function `putw` writes the word (i.e., integer) `w` to the output `stream` (where the file-pointer, if defined, is pointing). The size of a word is the size of an integer and varies from machine to machine. The function `putw` neither assumes nor causes special alignment in the file.

RETURN VALUE

On success, `putc`, `fputc`, and `putchar` each return the value they have written. On failure, they return the constant `EOF`. This will occur if the file `stream` is not open for writing or if the output file cannot be grown. The function `putw` returns non-zero when an error has occurred; otherwise the function returns `0`.

APPLICATION USAGE

Because it is implemented as a macro, `putc` incorrectly treats the argument `stream` when it has side-effects. In particular, the following call may not work as expected:

```
putc(c, *f++);
```

The function `fputc` should be used instead.

Because of possible differences in word length and byte ordering, files written using the function `putw` are machine-dependent, and may not be read on a different processor using the function `getw` [see GETC(BA_LIB)].

SEE ALSO

FCLOSE(BA_OS), FERROR(BA_OS), FOPEN(BA_OS), FREAD(BA_OS), PRINTF(BA_LIB), PUTS(BA_LIB), SETBUF(BA_LIB).

LEVEL

Level 1.

NAME

putenv — change or add value to environment

SYNOPSIS

```
int putenv(string)
char *string;
```

DESCRIPTION

The argument `string` points to a string of the the following form:

```
name = value
```

The function `putenv` makes the value of the environment variable `name` equal to `value` by altering an existing variable or creating a new one. In either case, the string pointed to by `string` becomes part of the environment, so altering the string will change the environment. The space used by `string` is no longer used once a new string-defining `name` is passed to the function `putenv`.

RETURN VALUE

The function `putenv` returns non-zero if it was unable to obtain enough space for an expanded environment, otherwise zero.

APPLICATION USAGE

The function `putenv` was added to System V in System V Release 2.0.

The function `putenv` manipulates the environment pointed to by `environ`, and can be used in conjunction with `getenv`. However, `envp`, the third argument to `main`, is not changed [see EXEC(BA_OS)].

A potential error is to call the function `putenv` with a pointer to an automatic variable as the argument and to then exit the calling function while `string` is still part of the environment.

SEE ALSO

EXEC(BA_OS), MALLOC(BA_OS), GETENV(BA_LIB).

LEVEL

Level 1.

NAME

puts, fputs — put a string on a stream

SYNOPSIS

```
#include <stdio.h>

int puts(s)
char *s;

int fputs(s, stream)
char *s;
FILE *stream;
```

DESCRIPTION

The function `puts` writes the null-terminated string pointed to by `s`, followed by a new-line character, to the standard output stream `stdout`.

The function `fputs` writes the null-terminated string pointed to by `s` to the named output `stream`.

Neither function writes the terminating null character.

RETURN VALUE

On success, both routines return the number of characters written.

Both functions return `EOF` on error. This will happen if the routines try to write on a file that has not been opened for writing.

APPLICATION USAGE

The function `puts` appends a new-line character while `fputs` does not.

SEE ALSO

FERROR(BA_OS), FOPEN(BA_OS), FREAD(BA_OS), PRINTF(BA_LIB), PUTC(BA_LIB).

LEVEL

Level 1.

NAME

qsort — quicker sort

SYNOPSIS

```
void qsort(base, nel, width, compar)
char *base;
unsigned nel, width;
int (*compar)();
```

DESCRIPTION

The function `qsort` is a general-sorting algorithm. It sorts a table of data in place.

The argument `base` points to the element at the base of the table.

The argument `nel` is the number of elements in the table.

The argument `width` is the size of an element in bytes.

The argument `compar` is the name of the user-supplied comparison function, which is called with two arguments that point to the elements being compared. The comparison function must return an integer less than, equal to or greater than zero, according as the first argument is to be considered is less than, equal to or greater than the second.

APPLICATION USAGE

The pointer to the base the table should be of type pointer-to-element, and cast to type pointer-to-character.

The comparison function need not compare every byte, so arbitrary data may be contained in the elements in addition to the values being compared.

The relative order in the output of two items which compare as equal is unpredictable.

SEE ALSO

BSEARCH(BA_LIB), LSEARCH(BA_LIB), STRING(BA_LIB).

LEVEL

Level 1.

NAME

rand, srand — simple random-number generator

SYNOPSIS

```
int rand( )

void srand(seed)
unsigned int seed;
```

DESCRIPTION

The function `rand` uses a multiplicative congruential random-number generator with period 2^{32} that returns successive pseudo-random numbers in the range from `0` to `32767`.

The function `srand` uses the argument `seed` as a seed for a new sequence of pseudo-random numbers to be returned by subsequent calls to the function `rand`. If the function `srand` is then called with the same seed value, the sequence of pseudo-random numbers will be repeated. If the function `rand` is called before any calls to the function `srand` have been made, the same sequence will be generated as when the function `srand` is first called with a seed value of `1`.

APPLICATION USAGE

The DRAND48(BA_LIB) routine provides a much more elaborate random-number generator.

The following functions define the semantics of the functions `rand` and `srand`.

```
static unsigned long int next = 1;
int rand( )
{
    next = next * 1103515245 + 12345;
    return ((unsigned int)(next/65536) % 32768);
}
void srand(seed)
unsigned int seed;
{
    next = seed;
}
```

Specifying the semantics makes it possible to reproduce the behavior of programs that use pseudo-random sequences. This facilitates the testing of portable applications in different implementations.

SEE ALSO

DRAND48(BA_LIB).

LEVEL

Level 1.

NAME

regexp — regular-expression compile and match routines

SYNOPSIS

```
#define INIT declarations
#define GETC( ) getc code
#define PEEK( ) peekc code
#define UNGETC( ) ungetc code
#define RETURN(ptr) return code
#define ERROR(val) error code

#include <regexp.h>

char *compile(instring, expbuf, endbuf, eof)
char *instring, *expbuf, *endbuf;
int eof;

int step(string, expbuf)
char *string, *endbuf;

advance(string, expbuf)
char *string, *expbuf;

extern char *loc1, *loc2, *locs;
```

DESCRIPTION

These functions are general-purpose regular-expression matching routines to be used in programs that perform regular-expression matching. These functions are defined by the `<regexp.h>` header file.

The functions `step` and `advance` do pattern matching given a character string and a compiled regular-expression as input.

The function `compile` takes as input a regular-expression as defined below and produces a compiled expression that can be used with `step` or `advance`.

A regular-expression, *re*, specifies a set of character strings. A member of this set of strings is said to be *matched* by the *re*. Some characters have special meaning when used in an *re*; other characters stand for themselves.

The regular-expressions available for use with the function `regexp` are constructed as follows:

Expression	*Meaning*
c	the character *c* where *c* is not a special character.
\c	the character *c* where *c* is any character, except a digit in the range 1–9.
^	the beginning of the line being compared.
$	the end of the line being compared.

.	any character in the input.
[*s*]	any character in the set *s*, where *s* is a sequence of characters and/or a range of characters, e.g., [*c*−*c*].
[^*s*]	any character not in the set *s*, where *s* is defined as above.
*r**	zero or more successive occurrences of the regular-expression *r*. The longest match is chosen.
rx	the occurrence of regular-expression *r* followed by the occurrence of regular-expression *x*. (Concatenation)
r\\{*m*,*n*\\}	any number of *m* through *n* successive occurrences of the regular-expression *r*. The regular-expression *r*\\{*m*\\} matches exactly *m* occurrences *r*\\{*m*,\\} matches at least *m* occurrences.
\\(*r*\\)	the regular-expression *r*. When \n (where *n* is a number greater than zero) appears in a constructed regular-expression, it stands for the regular-expression *x* where *x* is the *n*th regular-expression enclosed in \\(and \\) strings that appeared earlier in the constructed regular-expression. For example, \\(*r*\\)*x*\\(*y*\\)*z*\\2 is the concatenation of regular-expressions *rxyzy*.

Characters that have special meaning except when they appear within square brackets, [ ], or are preceded by \ are: ., *, [, \. Other special characters, such as $ have special meaning in more restricted contexts.

The character ^ at the beginning of an expression permits a successful match only immediately after a new-line, and the character $ at the end of an expression requires a trailing new-line.

Two characters have special meaning only when used within square brackets. The character − denotes a range, [*c*−*c*], unless it is just after the open bracket or before the closing bracket, [−*c*] or [*c*−] in which case it has no special meaning. When used within brackets, the character ^ has the meaning *complement of* if it immediately follows the open bracket, [^*c*], elsewhere between brackets, [*c*^], it stands for the ordinary character ^.

The special meaning of the \ operator can be escaped *only* by preceding it with another \, e.g. \\.

Programs must have the following five macros declared before the `#include <regexp.h>` statement. These macros are used by the `compile` routine. The macros `GETC`, `PEEKC`, and `UNGETC` operate on the regular-expression given as input to `compile`.

`GETC( )` This macro returns the value of the next character in the regular-expression pattern. Successive calls to `GETC( )` should return successive characters of the regular-expression.

`PEEKC( )` This macro returns the next character in the regular-expression. Immediately successive calls to `PEEKC( )` should return the same character, which should also be the next character returned by `GETC( )`.

`UNGETC( )` This macro causes the argument `c` to be returned by the next call to `GETC( )` and `PEEKC( )`. No more than one character of pushback is ever needed and this character is guaranteed to be the last character read by `GETC( )`. The value of the macro `UNGETC(c)` is always ignored.

`RETURN(ptr)` This macro is used on normal exit of the `compile` routine. The value of the argument `ptr` is a pointer to the character after the last character of the compiled regular-expression. This is useful to programs which have memory allocation to manage.

`ERROR(val)` This macro is the abnormal return from the `compile` routine. The argument `val` is an error number [see **ERRORS** below for meanings]. This call should never return.

The syntax of the `compile` routine is as follows:

```
compile(instring, expbuf, endbuf, eof)
```

The first parameter `instring` is never used explicitly by the `compile` routine but is useful for programs that pass down different pointers to input characters. It is sometimes used in the `INIT` declaration (see below). Programs which call functions to input characters or have characters in an external array can pass down a value of `((char*)0)` for this parameter.

The next parameter `expbuf` is a character pointer. It points to the place where the compiled regular-expression will be placed.

The parameter `endbuf` is one more than the highest address where the compiled regular-expression may be placed. If the compiled expression cannot fit in `(endbuf−expbuf)` bytes, a call to `ERROR(50)` is made.

The parameter `eof` is the character which marks the end of the regular-expression. For example, *re/*.

Each program that includes the `<regexp.h>` header file must have a `#define` statement for `INIT`. It is used for dependent declarations and initializations. Most often it is used to set a register variable to point to the beginning of the regular-expression so that this register variable can be used in the declarations for `GETC( )`, `PEEKC( )`, and `UNGETC( )`. Otherwise it can be used to declare external variables that might be used by `GETC( )`, `PEEKC( )` and `UNGETC( )`. See **EXAMPLES** below.

The first parameter to the `step` function is a pointer to a string of characters to be checked for a match. This string should be null terminated.

The second parameter, `expbuf`, is the compiled regular-expression which was obtained by a call to the function `compile`.

The function `step` returns non-zero if some sub-string of `string` matches the regular-expression in `expbuf` and zero if there is no match. If there is a match, two external character pointers are set as a side effect to the call to `step`. The variable `loc1` points to the first character that matched the regular-expression; the variable `loc2` points to the character after the last character that matches the regular-expression. Thus if the regular-expression matches the entire input string, `loc1` will point to the first character of `string` and `loc2` will point to the null at the end of `string`.

The function `advance` returns non-zero if the initial substring of `string` matches the regular-expression in `expbuf`. If there is a match an external character pointer, `loc2`, is set as a side effect. The variable `loc2` points to the next character in `string` after the last character that matched.

When `advance` encounters a `*` or `\{ \}` sequence in the regular-expression, it will advance its pointer to the string to be matched as far as possible and will recursively call itself trying to match the rest of the string to the rest of the regular-expression. As long as there is no match, `advance` will back up along the string until it finds a match or reaches the point in the string that initially matched the `*` or `\{ \}`. It is sometimes desirable to stop this backing up before the inital point in the string is reached. If the external character pointer `locs` is equal to the point in the string at sometime during the backing up process, `advance` will break out of the loop that backs up and will return zero.

The external variables `circf`, `sed`, and `nbra` are reserved.

RETURN VALUE

The function `compile` uses the macro `RETURN` on success and the macro `ERROR` on failure, see above. The functions `step` and `advance` return non-zero on a successful match and zero if there is no match.

ERRORS

11	range endpoint too large.
16	bad number.
25	`\`*digit* out of range.
36	illegal or missing delimiter.
41	no remembered search string.
42	`\(  \)` imbalance.
43	too many `\(`.
44	more than 2 numbers given in `\{  \}`.
45	`}` expected after `\`.
46	first number exceeds second in `\{  \}`.
49	`[  ]` imbalance.
50	regular-expression overflow.

EXAMPLES

The following is an example of how the regular-expression macros and calls might be defined by an application program:

```
#define INIT        register char *sp = instring;
#define GETC( )    (*sp++)
#define PEEKC( )   (*sp)
#define UNGETC(c)   (--sp)
#define RETURN(c)   return;
#define ERROR(c)    regerr( )

#include <regexp.h>

 . . .
      (void) compile(*argv, expbuf, &expbuf[ESIZE],'\0');
 . . .
      if (step(linebuf, expbuf))
                        succeed( );
```

LEVEL

Level 1.

NAME

scanf, fscanf, sscanf — convert formatted input

SYNOPSIS

```
#include <stdio.h>

int scanf(format [ , pointer ]...)
char *format;

int fscanf(stream, format [ , pointer ]...))
FILE *stream;
char *format;

int sscanf(s, format [ , pointer ]...)
char *s, *format;
```

DESCRIPTION

The function `scanf` reads from the standard input stream `stdin`.

The function `fscanf` reads from the named input `stream`.

The function `sscanf` reads from the character string `s`.

Each function reads characters, interprets them according to a format and stores the results in its arguments. Each expects, as arguments, a control string `format` described below and a set of `pointer` arguments indicating where the converted input should be stored.

The control string usually contains conversion specifications, which are used to direct interpretation of input sequences. The control string may contain:

1. White-space characters (blanks, tabs, new-lines, or form-feeds) which, except in two cases described below, cause input to be read up to the next non-white-space character.
2. An ordinary character (not `%`), which must match the next character of the input stream.
3. Conversion specifications, consisting of the character `%`, an optional assignment suppressing the character `*`, a decimal digit string that specifies an optional numerical maximum field width, an optional letter `l` (ell) or `h` indicating the size of the receiving variable, and a conversion code.

A conversion specification directs the conversion of the next input field; the result is placed in the variable pointed to by the corresponding argument unless assignment suppression was indicated by the character `*`. The suppression of assignment provides a way of describing an input field which is to be skipped. An input field is defined as a string of non-space characters; it extends to the next inappropriate character or until the maximum field width, if one is specified, is exhausted. For all descriptors except the character `[` and the character `c`, white space leading an input field is ignored.

The conversion code indicates the interpretation of the input field; the corresponding pointer argument must usually be of a restricted type. For a suppressed field, no pointer argument is given. The following conversion codes are legal:

`%`	a single `%` is expected in the input at this point; no assignment is done.
`d`	a decimal integer is expected; the corresponding argument should be an integer pointer.
`u`	an unsigned decimal integer is expected; the corresponding argument should be an unsigned integer pointer.
`o`	an octal integer is expected; the corresponding argument should be an integer pointer.
`x`	a hexadecimal integer is expected; the corresponding argument should be an integer pointer.
`e`,`f`,`g`	a floating point number is expected; the next field is converted accordingly and stored through the corresponding argument, which should be a pointer to a `float`. The input format for floating point numbers is an optionally signed string of digits, possibly containing a decimal point; followed by an optional exponent field consisting of an `E` or an `e`, followed by an optionally signed integer.
`s`	a character string is expected; the corresponding argument should be a character pointer pointing to an array of characters large enough to accept the string and a terminating `\0`, which will be added automatically. The input field is terminated by a white-space character.
`c`	a character is expected; the corresponding argument should be a character pointer. The normal skip over white space is suppressed in this case; to read the next non-space character, use `%1s`. If a field width is given, the corresponding argument should refer to a character array; the indicated number of characters is read.
`[`	indicates string data and the normal skip over leading white space is suppressed. The left bracket is followed by a set of characters called the *scanset* and a right bracket; the input field is the maximal sequence of input characters consisting entirely of characters in the scanset. The circumflex (`^`), when it appears as the first character in the scanset, serves as a complement operator and redefines the scanset as the set of all characters *not* contained in the remainder of the scanset string.

There are some conventions used in the construction of the scanset. A range of characters may be represented by the construct *first*−*last*, thus `[0123456789]` may be expressed `[0-9]`. Using this convention, *first* must be lexically less than or equal to *last*, or else the dash will stand for itself. The character − will also stand for itself whenever it is the first or the last character in the scanset. To include the right square bracket as an element of the scanset, it must appear as the first character (possibly preceded by a circumflex) of the scanset and in this case it will not be syntactically interpreted as the closing bracket. The corresponding argument must point to a character array large enough to hold the data field and the terminating `\0` which will be added automatically. At least one character must match for this conversion to be considered successful.

If an invalid conversion character follows the `%`, the results of the operation may not be predictable.

The conversion characters `d`, `u`, `o`, and `x` may be preceded by `l` or `h` to indicate that a pointer to `long` or to `short` rather than to `int` is in the argument list. Similarly, the conversion characters `e`, `f`, and `g` may be preceded by `l` to indicate that a pointer to `double` rather than to `float` is in the argument list. The `l` or `h` modifier is ignored for other conversion characters.

The `scanf` conversion terminates at end of file, at the end of the control string or when an input character conflicts with the control string. In the latter case, the offending character is left unread in the input stream.

RETURN VALUE

These routines return the number of successfully matched and assigned input items; this number can be zero in the event of an early conflict between an input character and the control string. If the input ends before the first conflict or conversion, **EOF** is returned.

APPLICATION USAGE

Trailing white space (including a new-line) is left unread unless matched in the control string.

The success of literal matches and suppressed assignments is not directly determinable.

EXAMPLE

The call to the function `scanf`:

```
int i, n; float x; char name[50];
n = scanf("%d%f%s", &i, &x, name);
```

with the input line:

```
25 54.32E−1 thompson
```

will assign to `n` the value `3`, to `i` the value `25`, to `x` the value `5.432`, and `name` will contain `thompson\0`.

The call to the function `scanf`:

```
int i; float x; char name[50];
(void) scanf("%2d%f%*d %[0−9]", &i, &x, name);
```

with the input line:

```
56789 0123 56a72
```

will assign `56` to `i`, `789.0` to `x`, skip `0123`, and place the string `56\0` in `name`. The next call to `getchar` [see GETC(BA_LIB)] will return `a`.

SEE ALSO

GETC(BA_LIB), PRINTF(BA_LIB), STRTOD(BA_LIB), STRTOL(BA_LIB).

FUTURE DIRECTIONS

The function `scanf` will make available character string representations for ∞ and "not a number" (NaN: a symbolic entity encoded in floating point format) to support the **IEEE P754** standard.

LEVEL

Level 1.

NAME

setbuf, setvbuf — assign buffering to a stream

SYNOPSIS

```
#include <stdio.h>

void setbuf(stream, buf)
FILE *stream;
char *buf;

int setvbuf(stream, buf, type, size)
FILE *stream;
char *buf;
int type, size;
```

DESCRIPTION

The function `setbuf` may be used after a stream has been opened but before it is read or written. It causes the array pointed to by `buf` to be used instead of an automatically allocated buffer. If `buf` is the `NULL` pointer input/output will be completely unbuffered.

A constant `BUFSIZ`, defined by the `<stdio.h>` header file, tells how big an array is needed:

```
char buf[BUFSIZ];
```

The function `setvbuf` may be used after `stream` has been opened but before it is read or written. The value of `type` determines how `stream` will be buffered. Legal values for `type`, defined by the `<stdio.h>` header file, are:

`_IOFBF`	causes input/output to be fully buffered.
`_IOLBF`	causes output to be line buffered; the buffer will be flushed when a new-line is written, the buffer is full, or input is requested.
`_IONBF`	causes input/output to be completely unbuffered.

If `buf` is not the `NULL` pointer, the array it points to will be used for buffering instead of an automatically allocated buffer. The value of `size` specifies the size of the buffer to be used. The constant `BUFSIZ` in the `<stdio.h>` header file is suggested as a good buffer size. If input/output is unbuffered, `buf` and `size` are ignored.

By default, output to a terminal is line buffered and all other input/output is fully buffered, except the standard error stream `stderr`, which is normally not buffered.

RETURN VALUE

If an illegal value for `type` or `size` is provided, `setvbuf` returns a non-zero value. Otherwise, the value returned will be zero.

APPLICATION USAGE

The function `setvbuf` was added to System V in System V Release 2.0.

A common source of error is allocating buffer space as an *automatic* variable in a code block, and then failing to close the stream in the same block.

SEE ALSO

FOPEN(BA_OS), MALLOC(BA_OS), GETC(BA_LIB), PUTC(BA_LIB).

LEVEL

Level 1.

NAME

setjmp, longjmp — non-local goto

SYNOPSIS

```
#include <setjmp.h>

int setjmp(env)
jmp_buf env;

void longjmp(env, val)
jmp_buf env;
int val;
```

DESCRIPTION

These functions are useful for dealing with errors and interrupts encountered in a low-level subroutine of a program.

The function `setjmp` saves its stack environment in `env` (whose type, `jmp_buf`, is defined by the `<setjmp.h>` header file) for later use by the function `longjmp`. The function `setjmp` returns the value `0`.

The function `longjmp` restores the environment saved by the last call to the function `setjmp` with the corresponding argument `env`.

After the function `longjmp` is completed, program execution continues as if the corresponding call to the function `setjmp` (the caller of which must not itself have returned in the interim) had just returned the value `val`. All accessible data have values as of the time the function `longjmp` was called.

RETURN VALUE

When the function `setjmp` has been called by the calling-process, it returns `0`.

The function `longjmp` does not return from where it was called, but rather, program execution continues as if the previous call to the function `setjmp` returned with a return value of `val`. That is, when the function `setjmp` *returns* as a result of the function `longjmp` being called, the function `setjmp` returns `val`. However, the function `longjmp` cannot cause the function `setjmp` to return the value `0`. If the function `longjmp` is invoked with a `val` of `0`, the function `setjmp` will return `1`.

APPLICATION USAGE

If the function `longjmp` is called even though the argument `env` was never primed by a call to the function `setjmp`, or when the last such call was in a function which has since returned, the behavior is undefined.

If the call to the function `longjmp` is in a different function from the corresponding call to the function `setjmp`, register variables may have unpredictable values.

SEE ALSO

SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

sinh, cosh, tanh — hyperbolic functions

SYNOPSIS

```
#include <math.h>

double sinh(x)
double x;

double cosh(x)
double x;

double tanh(x)
double x;
```

DESCRIPTION

The functions `sinh`, `cosh`, and `tanh` return, respectively, the hyperbolic sine, cosine and tangent of their argument.

RETURN VALUE

The functions `sinh` and `cosh` return `HUGE`, and `sinh` may return `−HUGE` for negative `x`, when the correct value would overflow and set `errno` to `ERANGE`.

APPLICATION USAGE

These error-handling procedures may be changed with the MATHERR(BA_LIB) routine.

SEE ALSO

MATHERR(BA_LIB).

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file. This macro will call a function which will either return +∞ on a system supporting the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

The functions `sinh` and `cosh` will return `HUGE_VAL` (`sinh` will return `−HUGE_VAL` for negative `n`) when the correct value overflows.

LEVEL

Level 1.

NAME

ssignal, gsignal — software signals

SYNOPSIS

```
#include <signal.h>

int (*ssignal(sig, action))()
int sig,(*action)();

int gsignal(sig)
int sig;
```

DESCRIPTION

The functions `ssignal` and `gsignal` implement a software facility similar to the SIGNAL(BA_OS) routine. This facility is made available to programs for their own purposes.

Software signals available to programs are listed in SIGNAL(BA_OS).

A call to the function `ssignal` associates a procedure, `action`, with the software signal `sig`; the software signal, `sig`, is raised by a call to the function `gsignal`. Raising a software signal causes the action established for that signal to be taken.

The first argument, `sig`, to the function `ssignal`, is a signal number in the range `1-15` for which an action is to be established. The second argument, `action`, defines the action; it is either the name of a (user-defined) function `action` or one of the manifest constants `SIG_DFL` (default) or `SIG_IGN` (ignore). The function `ssignal` returns the action previously established for that signal type; if no action has been established or the signal is illegal, the function `ssignal` returns `SIG_DFL`.

The function `gsignal` raises the signal identified by its argument, `sig`:

> If the function `action` has been established for the argument `sig`, then that `action` is reset to `SIG_DFL` and the function `action` is entered with argument `sig`. The function `gsignal` returns the value returned to it by the function `action`.
>
> If the action for the argument `sig` is `SIG_IGN`, the function `gsignal` returns the value `1` and takes no other action.
>
> If the action for the argument `sig` is `SIG_DFL`, the function `gsignal` returns the value `0` and takes no other action.
>
> If the argument `sig` has an illegal value or no action was ever specified for the argument `sig`, the function `gsignal` returns the value `0` and takes no other action.

SEE ALSO

SIGNAL(BA_OS).

LEVEL

Level 2, December 1, 1985

NAME

strcat, strncat, strcmp, strncmp, strcpy, strncpy, strlen, strchr, strrchr, strpbrk, strspn, strcspn, strtok — string operations

SYNOPSIS

```
#include <string.h>

char *strcat(s1, s2)
char *s1, *s2;

char *strncat(s1, s2, n)
char *s1, *s2;
int n;

int strcmp(s1, s2)
char *s1, *s2;

int strncmp(s1, s2, n)
char *s1, *s2;
int n;

char *strcpy(s1, s2)
char *s1, *s2;

char *strncpy(s1, s2, n)
char *s1, *s2;
int n;

int strlen(s)
char *s;

char *strchr(s, c)
char *s;
int c;

char *strrchr(s, c)
char *s;
int c;

char *strpbrk(s1, s2)
char *s1, *s2;

int strspn(s1, s2)
char *s1, *s2;

int strcspn(s1, s2)
char *s1, *s2;

char *strtok(s1, s2)
char *s1, *s2;
```

DESCRIPTION

The arguments `s1`, `s2` and `s` point to strings (arrays of characters terminated by a null character). The functions `strcat`, `strncat`, `strcpy`, `strncpy` and `strtok` all alter `s1`. These functions do not check for overflow of the array pointed to by `s1`.

The function `strcat` appends a copy of string `s2` to the end of string `s1`.

The function `strncat` appends at most `n` characters. Each returns a pointer to the null-terminated result.

The function `strcmp` compares its arguments and returns an integer less than, equal to or greater than `0`, according as `s1` is lexicographically less than, equal to or greater than `s2`.

The function `strncmp` makes the same comparison but looks at at most `n` characters.

The function `strcpy` copies string `s2` to `s1`, stopping after the null character has been copied.

The functions `strncpy` copies exactly `n` characters, truncating `s2` or adding null characters to `s1` if necessary. The result will not be null-terminated if the length of `s2` is `n` or more. Each function returns `s1`.

The function `strlen` returns the number of characters in `s`, not including the terminating null character.

The function `strchr` or the function `strrchr` returns a pointer to the first (last) occurrence of character `c` in string `s`, or a `NULL` pointer if `c` does not occur in the string. The null character terminating a string is considered to be part of the string.

The function `strpbrk` returns a pointer to the first occurrence in string `s1` of any character from string `s2`, or a `NULL` pointer if no character from `s2` exists in `s1`.

The function `strspn` or the function `strcspn` returns the length of the initial segment of string `s1` which consists entirely of characters from (not from) string `s2`.

The function `strtok` considers the string `s1` to consist of a sequence of zero or more text tokens separated by spans of one or more characters from the separator string `s2`. The first call (with pointer `s1` specified) returns a pointer to the first character of the first token, and will have written a null character into `s1` immediately following the returned token. The function keeps track of its position in the string between separate calls, so that subsequent calls (which must be made with the first argument a `NULL` pointer) will work through the string `s1` immediately following that token. In this way subsequent calls will work through the string `s1`, returning a pointer to the first character of each subsequent token. A null character will have been written into `s1` by `strtok` immediately following the token. The separator string `s2` may be different from call to call. When no token remains in `s1`, a `NULL` pointer is returned.

APPLICATION USAGE

All these functions are declared by the `<string.h>` header file.

Both `strcmp` and `strncmp` use native character comparison. The sign of the value returned when one of the characters has its high-order bit set is implementation-dependent.

Character movement is performed differently in different implementations. Thus overlapping moves may yield surprises.

SEE ALSO

MEMORY(BA_LIB).

FUTURE DIRECTIONS

The type of argument `n` to `strncat`, `strncmp` and `strncpy` and the type of value returned by `strlen` will be declared through the `typedef` facility in a header file as `size_t`.

LEVEL

Level 1.

NAME

strtod, atof — convert string to double-precision number

SYNOPSIS

```
double strtod(str, ptr)
char *str, **ptr;

double atof(str)
char *str;
```

DESCRIPTION

The function `strtod` returns as a double-precision floating-point number the value represented by the character string pointed to by `str`. The string is scanned up to the first unrecognized character.

The function `strtod` recognizes an optional string of *white-space* characters [as defined by `isspace` in CTYPE(BA_LIB)], then an optional sign, then a string of digits optionally containing a decimal point, then an optional `e` or `E` followed by an optional sign, followed by an integer.

If the value of `ptr` is not `((char **)0)`, a pointer to the character terminating the scan is returned in the location pointed to by `ptr`. If no number can be formed, `*ptr` is set to `str`, and `0` is returned.

The function call `atof(str)` is equivalent to:

```
strtod(str, (char **)0)
```

RETURN VALUE

If the correct value would cause overflow, ±`HUGE` is returned (according to the sign of the value) and `errno` is set to `ERANGE`.

If the correct value would cause underflow, zero is returned and `errno` is set to `ERANGE`.

APPLICATION USAGE

The function `strtod` was added to System V in System V Release 2.0.

SEE ALSO

CTYPE(BA_LIB), SCANF(BA_LIB), STRTOL(BA_LIB).

FUTURE DIRECTIONS

A macro `HUGE_VAL` will be defined by the `<math.h>` header file. This macro will call a function which will either return $+\infty$ on a system that supports the **IEEE P754** standard or +{MAXDOUBLE} on a system that does not support the **IEEE P754** standard.

If the correct value overflows, ±`HUGE_VAL` will be returned (according to the sign of the value).

LEVEL

Level 1.

NAME

strtol, atol, atoi — convert string to integer

SYNOPSIS

```
long strtol(str, ptr, base)
char *str, **ptr;
int base;

long atol(str)
char *str;

int atoi(str)
char *str;
```

DESCRIPTION

The function `strtol` returns as a long integer the value represented by the character string pointed to by `str`. The string is scanned up to the first character inconsistent with the base. Leading *white-space* characters [as defined by `isspace` in CTYPE(BA_LIB)] are ignored.

If the value of `ptr` is not `((char **)0)`, a pointer to the character terminating the scan is returned in the location pointed to by `ptr`. If no integer can be formed, that location is set to `str` and zero is returned.

If `base` is positive (and not greater than `36`), it is used as the base for conversion. After an optional leading sign, leading zeros are ignored and `0x` or `0X` is ignored if `base` is `16`.

If `base` is zero, the string itself determines the base in the following way: After an optional leading sign a leading zero indicates octal conversion and a leading `0x` or `0X` hexadecimal conversion. Otherwise, decimal conversion is used.

Truncation from `long` to `int` can, of course, take place upon assignment or by an explicit cast.

The function call `atol(str)` is equivalent to:

```
strtol(str, (char **)0, 10)
```

The function call `atoi(str)` is equivalent to:

```
(int)strtol(str, (char **)0, 10)
```

RETURN VALUE

If the argument `ptr` is a null-pointer, the function `strtol` will return the value of the string `str` as a long integer.

If the argument `ptr` is not `NULL`, the function `strtol` will return the value of the string `str` as a long integer, and a pointer to the character terminating the scan will be returned in the location pointed to by `ptr`.

If no integer can be formed, that location is set to the argument `str` and the function `strtol` returns `0`.

APPLICATION USAGE

Overflow conditions are ignored.

SEE ALSO

CTYPE(BA_LIB), SCANF(BA_LIB), STRTOD(BA_LIB).

FUTURE DIRECTIONS

Error handling will be added to the function `strtol`.

LEVEL

Level 1.

NAME

swab — swap bytes

SYNOPSIS

```
void swab(from, to, nbytes)
char *from, *to;
int nbytes;
```

DESCRIPTION

The function `swab` copies `nbytes` bytes pointed to by `from` to the array pointed to by `to`, exchanging adjacent even and odd bytes. It is useful for carrying binary data between machines with different low-order/high-order byte arrangements.

The argument `nbytes` should be even and non-negative. If the argument `nbytes` is odd and positive, the function `swab` uses `nbytes-1` instead. If the argument `nbytes` is negative, the function `swab` does nothing.

LEVEL

Level 1.

NAME

tmpfile — create a temporary file

SYNOPSIS

```
#include <stdio.h>

FILE *tmpfile( )
```

DESCRIPTION

The function `tmpfile` creates a temporary file using a name generated by the TMPNAM(BA_LIB) library routine, and returns a corresponding pointer to the `FILE` structure associated with the stream [see **stdio-stream** in **Chapter 4 — Definitions**]. The temporary file will automatically be deleted when the process that opened it terminates or the temporary file is closed. The temporary file is opened for update (`w+`) [see FOPEN(BA_OS)].

RETURN VALUE

If the temporary file cannot be opened, an error message is written and a `NULL` pointer is returned.

SEE ALSO

CREAT(BA_OS), UNLINK(BA_OS), FOPEN(BA_OS), MKTEMP(BA_LIB), TMPNAM(BA_LIB).

LEVEL

Level 1.

NAME

tmpnam, tempnam — create a name for a temporary file

SYNOPSIS

```
#include <stdio.h>

char *tmpnam(s)
char *s;

char *tempnam(dir, pfx)
char *dir, *pfx;
```

DESCRIPTION

These functions generate file-names that can safely be used for a temporary file.

The function `tmpnam` always generates a file-name using the path-prefix defined by the `<stdio.h>` header file as `P_tmpdir`. If the argument `s` is `NULL`, the function `tmpnam` leaves its result in an internal static area and returns a pointer to that area. The next call to the function `tmpnam` will destroy the contents of the area. If the argument `s` is not `NULL`, it is assumed to be the address of an array of at least `L_tmpnam` bytes, where `L_tmpnam` is a constant defined by the `<stdio.h>` header file; the function `tmpnam` places its result in that array and returns `s`.

The function `tempnam` allows the user to control the choice of a directory. If defined in the user's environment, the value of the environmental variable `TMPDIR` is used as the name of the desired temporary file directory. The argument `dir` points to the name of the directory in which the file is to be created. If the argument `dir` is `NULL` or points to a string that is not a name for an appropriate directory, the path-prefix defined by the `<stdio.h>` header file as `P_tmpdir` is used. If that directory is not accessible, the directory `/tmp` will be used as a last resort.

The function `tempnam` uses the MALLOC(BA_OS) routine to get space for the constructed file-name, and returns a pointer to this area. Thus, any pointer value returned from the function `tempnam` may serve as an argument to the function `free` defined in MALLOC(BA_OS). If the function `tempnam` cannot return the expected result for any reason, for example, the MALLOC(BA_OS routine failed or none of the above-mentioned attempts to find an appropriate directory was successful, a `NULL` pointer will be returned.

APPLICATION USAGE

Many applications prefer their temporary-files to have certain favorite initial letter sequences in their names. Use the `pfx` argument for this. This argument may be `NULL` or point to a string of up to five characters to be used as the first few characters of the temporary-file name.

The functions `tmpnam` and `tempnam` generate a different file-name each time they are called.

Files created using these functions and either the FOPEN(BA_OS) routine or the CREAT(BA_OS) routine are temporary only in the sense that they reside in a directory intended for temporary use, and their names are unique. It is the user's responsibility to use the UNLINK(BA_OS) routine to remove the file when its use is ended.

If called more than {TMP_MAX} times in a single process, these functions will start recycling previously used names.

Between the time a file-name is created and the file is opened, it is possible for some other process to create a file with the same name. This can never happen if that other process is using these functions or `mktemp`, and the file-names are chosen so as to render duplication by other means unlikely.

SEE ALSO

CREAT(BA_OS), UNLINK(BA_OS), FOPEN(BA_OS), MALLOC(BA_OS), MKTEMP(BA_LIB), TMPFILE(BA_LIB).

LEVEL

Level 1.

NAME

sin, cos, tan, asin, acos, atan, atan2 — trigonometric functions

SYNOPSIS

```
#include <math.h>

double  sin(x)
double  x;

double  cos(x)
double  x;

double  tan(x)
double  x;

double  asin(x)
double  x;

double  acos(x)
double  x;

double  atan(x)
double  x;

double  atan2(y, x)
double  y, x;
```

DESCRIPTION

The functions `sin`, `cos` and `tan` return respectively the sine, cosine and tangent of their argument, **x**, measured in radians.

The function `asin` returns the arcsine of the argument **x** in the range $-\pi/2$ to $\pi/2$.

The function `acos` returns the arccosine of the argument **x** in the range 0 to π.

The function `atan` returns the arctangent of the argument **x** in the range $-\pi/2$ to $\pi/2$.

The function `atan2` returns the arctangent of `y/x` in the range $-\pi$ to π, using the signs of both arguments to determine the quadrant of the return value.

RETURN VALUE

Both `sin` and `cos` lose accuracy when their argument is far from zero. For arguments sufficiently large, these functions return zero when there would otherwise be a complete loss of significance. In this case a message indicating `TLOSS` error is printed on the standard error output [see MATHERR(BA_LIB)]. For less extreme arguments causing partial loss of significance, a `PLOSS` error is generated but no message is printed. In both cases, `errno` is set to `ERANGE`.

If the magnitude of the argument of `asin` or `acos` is greater than one, or if both arguments of `atan2` are zero, zero is returned and `errno` is set to `EDOM`. In addition, a message indicating `DOMAIN` error is printed on the standard error output.

APPLICATION USAGE

These error-handling procedures may be changed with the MATHERR(BA_LIB) routine.

SEE ALSO

MATHERR(BA_LIB).

LEVEL

Level 1.

NAME

tsearch, tfind, tdelete, twalk — manage binary search trees

SYNOPSIS

```
#include <search.h>

char *tsearch(key, rootp, compar)
char *key;
char **rootp;
int (*compar)( );

char *tfind(key, rootp, compar)
char *key;
char **rootp;
int (*compar)( );

char *tdelete(key, rootp, compar)
char *key;
char **rootp;
int (*compar)( );

void twalk(root, action)
char *root;
void(*action)( );
```

DESCRIPTION

The functions `tsearch`, `tfind`, `tdelete`, and `twalk` manipulate binary search trees. All comparisons are done with a user-supplied function, `compar`. The comparison function is called with two arguments, the pointers to the elements being compared. It returns an integer less than, equal to or greater than 0, according to whether the first argument is to be considered less than, equal to or greater than the second argument. The comparison function need not compare every byte, so arbitrary data may be contained in the elements in addition to the values being compared.

The function `tsearch` is used to build and access the tree. The value of `key` is a pointer to a datum to be accessed or stored. If there is a datum in the tree equal to `*key` (the value pointed to by `key`), a pointer to this found datum is returned. Otherwise, `*key` is inserted, and a pointer to it returned. Only pointers are copied, so the calling routine must store the data. The value of `rootp` points to a variable that points to the root of the tree. A `NULL` value for the variable pointed to by `rootp` denotes an empty tree; in this case, the variable will be set to point to the datum which will be at the root of the new tree.

Like `tsearch`, `tfind` will search for a datum in the tree, returning a pointer to it if found. However, if it is not found, `tfind` will return a `NULL` pointer. The arguments for `tfind` are the same as for `tsearch`.

The function `tdelete` deletes a node from a binary search tree. The arguments are the same as for `tsearch`. The variable pointed to by `rootp` will be changed if the deleted node was the root of the tree.

The function `twalk` traverses a binary search tree. The value of `root` is the root of the tree to be traversed. (Any node in a tree may be used as the root for a walk below that node.) The value of `action` is the name of a user-defined routine to be invoked at each node. This routine is, in turn, called with three arguments.

The first argument is the address of the node being visited.

The second argument is a value from an enumeration data type, `VISIT` defined by the `<search.h>` header file. The values `preorder`, `postorder`, `endorder`, indicate whether this is the first, second or third time that the node has been visited (during a depth-first, left-to-right traversal of the tree), or the value `leaf` indicates that the node is a leaf.

The third argument is an integer that identifies the level of the node in the tree, with the root being level zero.

RETURN VALUE

A `NULL` pointer is returned by `tsearch` if there is not enough space available to create a new node.

A `NULL` pointer is returned by `tsearch`, `tfind` and `tdelete` if `rootp` is `NULL` on entry.

If the datum is found, both `tsearch` and `tfind` return a pointer to it. If not, `tfind` returns `NULL`, and `tsearch` returns a pointer to the inserted item. The function `tdelete` returns a pointer to the parent of the deleted node, or a `NULL` pointer if the node is not found.

APPLICATION USAGE

The function `tfind` was added to System V in System V Release 2.0.

The pointers to the key and the root of the tree should be of type pointer-to-element, and cast to type pointer-to-character. Similarly, although declared as type pointer-to-character, the value returned should be cast into type pointer-to-element.

The `root` argument to `twalk` is one level of indirection less than the `rootp` arguments to `tsearch` and `tdelete`.

There are two nomenclatures used to refer to the order in which tree nodes are visited. The function `tsearch` uses preorder, postorder and endorder to respectively refer to visiting a node before any of its children, after its left child and before its right, and after both its children. The alternate nomenclature uses preorder, inorder and postorder to refer to the same visits, which could result in some confusion over the meaning of postorder.

If the calling function alters the pointer to the root, results are unpredictable.

EXAMPLE

The following code reads in strings and stores structures containing a pointer to each string and a count of its length. It then walks the tree, printing out the stored strings and their lengths in alphabetical order.

```
#include <search.h>
#include <stdio.h>

struct node {  /* pointers to these are stored in the tree */
    char *string;
    int length;
};
char string_space[10000]; /* space to store strings */
struct node nodes[500];   /* nodes to store */
struct node *root = NULL; /* this points to the root */

main( )
{
    char *strptr = string_space;
    struct node *nodeptr = nodes;
    void print_node( ), twalk( );
    int i = 0, node_compare( );

    while (gets(strptr) != NULL && i++ < sizeof(nodes [0]) {
        /* set node */
        nodeptr->string = strptr;
        nodeptr->length = strlen(strptr);
        /* put node into the tree */
        (void) tsearch((char *)nodeptr, &root, node_compare);
        /* adjust pointers, to not overwrite tree */
        strptr += nodeptr->length + 1;
        nodeptr++;
    }
    twalk(root, print_node);
}
/* This routine compares two nodes, based on an */
/* alphabetical ordering of the string field. */
int node_compare(node1, node2)
struct node *node1, *node2;
{
    return strcmp(node1->string, node2->string);
}
/* This routine prints out a node, the */
/* first time twalk encounters it. */
void print_node(node, order, level)
struct node **node;
VISIT order;
int level;
{
    if (order == preorder || order == leaf) {
        (void) printf("string = %20s,  length = %d\n",
            (*node)->string, (*node)->length);
    }
}
```

SEE ALSO

BSEARCH(BA_LIB), HSEARCH(BA_LIB), LSEARCH(BA_LIB).

LEVEL

Level 1.

NAME

ttyname, isatty — find name of a terminal

SYNOPSIS

```
char *ttyname(fildes)
int fildes;

int isatty(fildes)
int fildes;
```

DESCRIPTION

The function `ttyname` returns a pointer to a string containing the null-terminated path name of the terminal device associated with file descriptor `fildes`.

The function `isatty` returns 1 if the argument `fildes` is associated with a terminal device, 0 otherwise.

RETURN VALUE

The function `ttyname` returns a null-pointer if the argument `fildes` does not describe a terminal device.

APPLICATION USAGE

The return value points to static data whose content is overwritten by each call.

LEVEL

Level 1.

NAME

ungetc — push character back into input stream

SYNOPSIS

```
#include <stdio.h>

int ungetc(c, stream)
int c;
FILE *stream;
```

DESCRIPTION

The function `ungetc` inserts the character `c` into the buffer associated with an input `stream`. That character, `c`, will be returned by the next call to the GETC(BA_LIB) routine on that `stream`. The function `ungetc` returns `c`, and leaves the file corresponding to `stream` unchanged.

One character of pushback is guaranteed, provided something has already been read from the stream and the stream is actually buffered.

If the argument `c` equals `EOF`, the function `ungetc` does nothing to the buffer and returns `EOF`.

The FSEEK(BA_OS) routine erases all memory of inserted characters.

RETURN VALUE

If successful, the function `ungetc` returns `c`; the function `ungetc` returns `EOF` if it cannot insert the character.

SEE ALSO

FSEEK(BA_OS), GETC(BA_LIB), SETBUF(BA_LIB).

LEVEL

Level 1.

NAME

vprintf, vfprintf, vsprintf — print formatted output of a varargs argument list

SYNOPSIS

```
#include <stdio.h>
#include <varargs.h>

int vprintf(format, ap)
char *format;
va_list ap;

int vfprintf(stream, format, ap)
FILE *stream;
char *format;
va_list ap;

int vsprintf(s, format, ap)
char *s, *format;
va_list ap;
```

DESCRIPTION

The functions `vprintf`, `vfprintf`, and `vsprintf` are the same as `printf`, `fprintf`, and `sprintf` respectively, except that instead of being called with a variable number of arguments, they are called with an argument list as defined by the `<varargs.h>` header file.

The `<varargs.h>` header file defines the type `va_list` and a set of macros for advancing through a list of arguments whose number and types may vary. The argument `ap` to the `vprint` family of library routines is of type `va_list`. This argument is used with the `<varargs.h>` header file macros `va_start`, `va_arg` and `va_end`. The **EXAMPLE** section below shows their use with `vprintf`.

The macro `va_alist` is used as the parameter list in a function definition as in the function called `error` in the example below. The macro `va_dcl` is the declaration for `va_alist` and should not be followed by a semicolon. The macro `va_start(ap)`, where `ap` is of type `va_list`, must be called before any attempt to traverse and access the list of arguments. Calls to `va_arg(ap, atype)` traverse the argument list. Each execution of `va_arg` expands to an expression with the value of the next argument in the list `ap`. The argument `atype` is the type that the returned argument is expected to be. The `va_end(ap)` macro must be executed when all desired arguments have been accessed. (The argument list in `ap` can be traversed again if `va_start` is called again after `va_end`.) In the example below, `va_arg` is executed first to return the function_name passed to `error` and it is called again to retrieve the format passed to `error`. The remaining `error` arguments, `arg1`, `arg2`, ..., are given to `vfprintf` in the argument `ap`.

APPLICATION USAGE

The functions `vprintf`, `vfprintf` and `vsprintf` were added to System V in System V Release 2.0.

EXAMPLE

The following demonstrates how `vfprintf` could be used to write an error routine:

```
#include <stdio.h>
#include <varargs.h>
...
/*
 *   error should be called like
 *          error(function_name, format, arg1, arg2...);
 */
void error(va_alist)
va_dcl
{
     va_list ap;
     char *fmt;

     va_start(ap);
     /* print out name of function causing error */
     (void) fprintf(stderr, "ERR in %s:
     fmt = va_arg(ap, char *);
     /* print out remainder of message */
     (void) vfprintf(stderr, fmt, ap);
     va_end(ap);
     (void) abort( );
}
```

SEE ALSO

PRINTF(BA_LIB).

LEVEL

Level 1.

Part III

Kernel Extension Definition

Chapter 8 Introduction

While the Base System is intended to support a run-time environment for executable applications, the Kernel Extension provides additional operating system services that will not be required by many application-programs but which are needed for some environments.

The Kernel Extension provides operating system services to support process accounting tools, software development tools, and applications or tools that require more sophisticated inter-process communication than is provided by the Base System.

Definitions for the Kernel Extension are given in the next chapter, **Chapter 8 — Definitions**. **Chapter 9 — Environment** describes the Kernel Extension Environment including additional behavior of Base System components when the Kernel Extension is present on a system [see EFFECTS(KE_ENV)]. **Chapter 10 — OS Service Routines** has the component definitions of the operating system services in the Kernel Extension.

The following operating system services constitute the System V *Kernel Extension.* An application-program that uses any of these components would require the target run-time environment to support the Kernel Extension in addition to the Base System.

TABLE 8-1. Kernel Extension: OS Service Routines

`acct`	ACCT(KE_OS)	`ptrace`	PTRACE(KE_OS)
`chroot`	CHROOT(KE_OS)	`semctl`	SEMCTL(KE_OS)
`msgctl`	MSGCTL(KE_OS)	`semget`	SEMGET(KE_OS)
`msgget`	MSGGET(KE_OS)	`semop`	SEMOP(KE_OS)
`msgrcv`	MSGOP(KE_OS)	`shmctl#`	SHMCTL(KE_OS)
`msgsnd`	MSGOP(KE_OS)	`shmget#`	SHMGET(KE_OS)
`nice`	NICE(KE_OS)	`shmat#`	SHMOP(KE_OS)
`plock`	PLOCK(KE_OS)	`shmdt#`	SHMOP(KE_OS)
`profil`	PROFIL(KE_OS)		

The run-time behavior of these routines, which is supported by the Kernel Extension, and the source-code interface to the routines are defined in **Chapter 10 — OS Service Routines.**

# Optional. These routines are hardware-dependent and will only appear on machines with the appropriate hardware.

Chapter 9
Definitions

ipc-permissions

The Kernel Extension includes three mechanisms for inter-process communication (ipc): messages, semaphores, and shared-memory. All of these use a common structure type, ipc-perm, to pass information used in determining permission to perform an ipc operation.

The ipc_perm structure is defined by the <ipc.h> header file and includes the following members:

```
ushort  cuid;     /* creator user id */
ushort  cgid;     /* creator group id */
ushort  uid;      /* user id */
ushort  gid;      /* group id */
ushort  mode;     /* r/w permission */
```

The following symbolic constants are also defined by the <ipc.h> header file:

Name	*Description*
IPC_CREAT	create entry if key does not exist
IPC_EXCL	fail if key exists
IPC_NOWAIT	error if request must wait
IPC_PRIVATE	private key
IPC_RMID	remove identifier
IPC_SET	set options
IPC_STAT	get options

message-queue-identifier

A message queue identifier msqid is a unique positive integer created by a call to the MSGGET(KE_OS) routine. Each msqid has a message queue and a data structure associated with it. The data structure is referred to as msqid_ds and contains the following members:

```
struct ipc_perm msg_perm;   /* operation perms */
ushort          msg_qnum;   /* no. of messages on q */
ushort          msg_qbytes; /* max no. of bytes on q */
ushort          msg_lspid;  /* pid, last msgsnd call */
ushort          msg_lrpid;  /* pid, last msgrcv call */
time_t          msg_stime;  /* last msgsnd time */
time_t          msg_rtime;  /* last msgrcv time */
time_t          msg_ctime;  /* last change time */
                            /* time in secs since */
                            /* 00:00:00 GMT 1 Jan 70 */
```

`msg_perm`	is an `ipc_perm` structure [see **ipc-permissions**] that specifies the message-operation permission.
`msg_qnum`	is the number of messages currently on the queue.
`msg_qbytes`	is the maximum number of bytes allowed on the queue.
`msg_lspid`	is the process-ID of the last process that performed a `msgsnd` operation.
`msg_lrpid`	is the process-ID of the last process that performed a `msgrcv` operation.
`msg_stime`	is the time of the last `msgsnd` operation.
`msg_rtime`	is the time of the last `msgrcv` operation.
`msg_ctime`	is the time of the last `msgctl` operation that changed a member of the above structure.

message-operation-permissions

In the MSGOP(KE_OS) and MSGCTL(KE_OS) routines, the permission required for an operation is determined by the bit-pattern in `msg_perm.mode`, where the type of permission needed is interpreted as follows:

`00400`	Read by user
`00200`	Write by user
`00040`	Read by group
`00020`	Write by group
`00004`	Read by others
`00002`	Write by others

The Read and Write permissions on a `msqid` are granted to a process if one or more of the following are true:

- The effective-user-ID of the process is super-user.
- The effective-user-ID of the process matches `msg_perm.cuid` or `msg_perm.uid` in the data structure associated with `msqid` and the appropriate bit of the *user* portion (`0600`) of `msg_perm.mode` is set.
- The effective-user-ID of the process does not match `msg_prm.cuid` or `msg_perm.uid`, and the effective-group-ID of the process matches `msg_perm.cgid` or `msg_perm.gid`, and the appropriate bit of the *group* portion (`0060`) of `msg_perm.mode` is set.
- The effective-user-ID of the process does not match `msg_perm.cuid` or `msg_perm.uid`, and the effective-group-ID of the process does not match `msg_perm.cgid` or `msg_perm.gid`, and the appropriate bit of the *other* portion (`0006`) of `msg_perm.mode` is set.

Otherwise, the corresponding permissions are denied.

semaphore-identifier

A semaphore-identifier `semid` is a unique positive integer created by a SEMGET(KE_OS) routine. Each `semid` has a set of semaphores and a data structure associated with it.

The data structure is `semid_ds` and contains the following members:

```
struct ipc_perm sem_perm;  /* operation perms */
ushort          sem_nsems; /* count of sems in set */
time_t          sem_otime; /* last operation time */
time_t          sem_ctime; /* last change time */
                           /* time in secs since */
                           /* 00:00:00 GMT 1 Jan 70 */
```

`sem_perm`	is an `ipc_perm` structure that specifies the semaphore-operation-permission [see **ipc-permissions**].
`sem_nsems`	is a value that is equal to the number of semaphores in the set. Each semaphore in the set is referenced by a positive integer referred to as a `sem_num`. The value of `sem_num` runs sequentially from 0 to the value of `sem_nsems-1`. `sem_otime` is the time of the last `semop` operation, and `sem_ctime` is the time of the last `semctl` operation that changed a member of the above structure.

A semaphore is a data structure containing the following members:

```
ushort semval;  /* semaphore value */
short  sempid;  /* pid of last operation */
ushort semncnt; /* no. awaiting semval > cval */
ushort semzcnt; /* no. awaiting semval = 0 */
```

`semval`	is a non-negative integer.
`sempid`	is equal to the process-ID of the last process that performed a semaphore operation on this semaphore.
`semncnt`	is a count of the number of processes that are currently suspended awaiting this semaphore's `semval` to become greater than its current value.
`semzcnt`	is a count of the number of processes that are currently suspended awaiting this semaphore's `semval` to become zero.

semaphore-operation-permissions

In the SEMOP(KE_OS) and SEMCTL(KE_OS) routines, the permission required for an operation is determined by the bit-pattern in `sem_perm.mode`, where the type of permission needed is interpreted as follows:

00400	Read by user
00200	Alter by user
00040	Read by group
00020	Alter by group
00004	Read by others
00002	Alter by others

The Read and Alter permissions on a `semid` are granted to a process if one or more of the following are true:

- The effective-user-ID of the process is super-user.
- The effective-user-ID of the process matches `sem_perm.cuid` or `sem_perm.uid` in the data structure associated with `semid` and the appropriate bit of the *user* portion (0600) of `sem_perm.mode` is set.
- The effective-user-ID of the process does not match `sem_perm.cuid` or `sem_perm.uid`, and the effective-group-ID of the process matches `sem_perm.cgid` or `sem_perm.gid`, and the appropriate bit of the *group* portion (0060) of `sem_perm.mode` is set.
- The effective-user-ID of the process does not match `sem_perm.cuid` or `sem_perm.uid`, and the effective-group-ID of the process does not match `sem_perm.cgid` or `sem_perm.gid`, and the appropriate bit of the *other* portion (0006) of `sem_perm.mode` is set.

Otherwise, the corresponding permissions are denied.

shared-memory-identifier

A shared-memory-identifier `shmid` is a unique positive integer created by a SHMGET(KE_OS) routine. Each `shmid` has associated with it a segment of memory (referred to as a shared memory segment) and a data structure.

The data structure is referred to as `shmid_ds` and contains the following members:

```
struct ipc_perm shm_perm;   /* operation perms */
int             shm_segsz;  /* size of segment */
ushort          shm_cpid;   /* pid, creator */
ushort          shm_lpid;   /* pid, last operation */
short           shm_nattch; /* no. of current attaches */
time_t          shm_atime;  /* last attach time */
time_t          shm_dtime;  /* last detach time */
time_t          shm_ctime;  /* last change time */
                            /* times in secs since */
                            /* 00:00:00 GMT 1 Jan 70 */
```

shm_perm	is an ipc_perm structure that specifies the shared-memory-operation permission [see **ipc-permissions**].
shm_segsz	specifies the size of the shared-memory-segment.
shm_cpid	is the process-ID of the process that created the shared-memory-identifier.
shm_lpid	is the process-ID of the last process that performed a SHMOP(KE_OS) routine.
shm_nattch	is the number of processes that currently have this segment attached.
shm_atime	is the time of the last shmat operation.
shm_dtime	is the time of the last shmdt operation.
shm_ctime	is the time of the last shmctl operation that changed one of the members of the above structure.

shared-memory-operation-permissions
In the SHMOP(KE_OS) and SHMCTL(KE_OS) routines, the permission required for an operation is determined by the bit-pattern in shm_perm.mode, where the type of permission needed is interpreted as follows:

00400	Read by user
00200	Write by user
00040	Read by group
00020	Write by group
00004	Read by others
00002	Write by others

The Read and Write permissions on a shmid are granted to a process if one or more of the following are true:

- The effective-user-ID of the process is super-user.
- The effective-user-ID of the process matches shm_perm.cuid or sem_perm.uid in the data structure associated with shmid and the appropriate bit of the *user* portion (0600) of shm_perm.mode is set.
- The effective-user-ID of the process does not match shm_perm.cuid or sem_perm.uid, and the effective-group-ID of the process matches shm_perm.cgid or sem_perm.gid, and the appropriate bit of the *group* portion (0060) of shm_perm.mode is set.
- The effective-user-ID of the process does not match shm_perm.cuid or sem_perm.uid, and the effective-group-ID of the process does not match shm_perm.cgid or sem_perm.gid, and the appropriate bit of the *other* portion (0006) of shm_perm.mode is set.

Otherwise, the corresponding permissions are denied.

Chapter 10
Environment

NAME

effects — effects of the Kernel Extension on the Base System.

DESCRIPTION

Some of the Base System V operating system services are affected by the additional services in this extension. The effects are listed below for each routine:

EXEC(BA_OS)

The `AFORK` flag in the `ac_flag` field of the accounting record is turned off, and the `ac_comm` field is reset by executing an `exec` routine [see ACCT(KE_OS)].

Any process, data, or text locks are removed and not inherited by the new process [see PLOCK(KE_OS)].

Profiling is disabled for the new process [see PROFIL(KE_OS)].

The shared-memory-segments attached to the calling-process will not be attached to the new process [see SHMOP(KE_OS)].

The new process also inherits the following additional attributes from the calling-process:

nice value [see NICE(KE_OS)];

`semadj` values [see SEMOP(KE_OS)];

trace flag [see request 0 in PTRACE(KE_OS)].

EXIT(BA_OS)

An accounting record is written on the accounting file if the system's accounting routine is enabled [see ACCT(KE_OS)].

If the process has a process-lock, text-lock, or data-lock, the lock is removed [see PLOCK(KE_OS)].

Each attached shared-memory-segment is detached and the value of `shm_nattch` in the data structure associated with its shared-memory-identifier is decremented by 1.

For each semaphore for which the calling-process has set a `semadj` value [see SEMOP(KE_OS)], that `semadj` value is added to the `semval` of the specified semaphore.

FORK(BA_OS)

The `AFORK` flag is turned on when the function `fork` is executed.

The child-process inherits the following additional attributes from the parent-process:

> The `ac_comm` contents of the accounting record [see ACCT(KE_OS)];
>
> nice value [see NICE(KE_OS)];
>
> profiling on/off status [see PROFIL(KE_OS)];
>
> all attached shared-memory-segments [see SHMOP(KE_OS)].

The child-process differs from the parent-process in the following additional ways:

> All `semadj` values are cleared [see SEMOP(KE_OS)].
>
> Process-locks, text-locks, and data-locks are not inherited by the child-process [see PLOCK(KE_OS)].

LEVEL

Level 1.

NAME

error — error codes and condition definitions

SYNOPSIS

```
#include <errno.h>

extern int errno;
```

DESCRIPTION

In addition to the values defined in the Base System for the external variable `errno` [see ERRNO(BA_ENV)], two additional error conditions are defined in the Kernel Extension:

`ENOMSG`	No message of desired type. An attempt was made to receive a message of a type that does not exist on the specified message queue.
`EIDRM`	Identifier removed. This error is returned to processes that resume execution because of the removal of an identifier [see MSGCTL(KE_OS), SEMCTL(KE_OS), and SHMCTL(KE_OS)].

LEVEL

Level 1.

Chapter 11
OS Service Routines

NAME

acct — enable or disable process accounting

SYNOPSIS

```
int acct(path)
char *path;
```

DESCRIPTION

The function `acct` is used to enable or disable the system process accounting routine. If the routine is enabled, for each process that terminates, an accounting record will be written on an accounting file. Termination can be caused by one of two things: an `exit` call or a signal [see EXIT(BA_OS) and SIGNAL(BA_OS)]. The effective-user-ID of the calling-process must be super-user to use this function.

The variable `path` points to a path-name naming the accounting file. The format of an accounting file produced as a result of calling the `acct` function has records in the format defined by the structure `acct` in `<sys/acct.h>` which defines the following data-type:

```
comp_t /* floating point - 13-bit fraction, */
       /*                  3-bit exponent */
```

and defines the following members in the structure `acct`:

```
char    ac_flag;    /* accounting flag */
char    ac_stat;    /* exit status */
ushort  ac_uid;     /* accounting user-ID */
ushort  ac_gid;     /* accounting group-ID */
dev_t   ac_tty;     /* control typewriter */
time_t  ac_btime;   /* beginning time */
comp_t  ac_utime;   /* user-time in CLKTCKs */
comp_t  ac_stime;   /* system-time in CLKTCKs */
comp_t  ac_etime;   /* elapsed-time in CLKTCKs */
comp_t  ac_mem;     /* memory usage */
comp_t  ac_io;      /* chars transferred */
comp_t  ac_rw;      /* blocks read or written */
char    ac_comm[8]; /* command name */
```

and defines the following symbolic names:

```
AFORK  /* has executed fork, but no exec */
ASU    /* used super-user privileges */
ACCTF  /* record type: 00 = acct */
```

The `AFORK` flag is set in `ac_flag` when the FORK(BA_OS) routine is executed and reset when an EXEC(BA_OS) routine is executed. The `ac_comm` field is inherited from the parent process when a child process is created with the FORK(BA_OS) routine and is reset when the EXEC(BA_OS) routine is executed. The variable `ac_mem` is a cumulative record of memory usage and is incremented each time the system charges the process with a clock tick.

The accounting routine is enabled if `path` is non-zero and no errors occur during the call. It is disabled if `path` is 0 and no errors occur during the call.

RETURN VALUE

If successful, the function `acct` returns 0; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `acct` will fail if one or more of the following are true:

`EPERM`	The effective user of the calling-process is not super-user.
`EBUSY`	An attempt is being made to enable accounting when it is already enabled.
`ENOTDIR`	A component of the path-prefix is not a directory.
`ENOENT`	One or more components of the accounting file path-name do not exist.
`EACCES`	The file named by `path` is not an ordinary file.
`EROFS`	The named file resides on a read-only file system.

SEE ALSO

EXIT(BA_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

chroot — change root directory

SYNOPSIS

```
int chroot(path)
char *path;
```

DESCRIPTION

The function `chroot` causes the named directory to become the root directory, the starting point for `path` searches for path-names beginning with the character /. The user's working directory is unaffected by the function `chroot`.

The argument `path` points to a path-name naming a directory.

The effective-user-ID of the process must be super-user to change the root directory.

The .. entry in the root directory is interpreted to mean the root directory itself. Thus, .. cannot be used to access files outside the sub-tree rooted at the root-directory.

RETURN VALUE

If successful, the function `chroot` returns 0; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `chroot` will fail and the root directory will remain unchanged if one or more of the following are true:

`ENOTDIR`	Any component of the path-name is not a directory.
`ENOENT`	The named directory does not exist.
`EPERM`	The effective-user-ID is not super-user.

SEE ALSO

CHDIR(BA_OS).

LEVEL

Level 1.

NAME

msgctl — message-control-operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>

int msgctl(msqid, cmd, buf)
int msqid, cmd;
struct msqid_ds *buf;
```

DESCRIPTION

The function `msgctl` provides a variety of message-control-operations as specified by `cmd`. The following values for `cmd` and the message-control-operations they specify are available:

`IPC_STAT` Place the current value of each member of the data structure associated with `msqid` into the structure pointed to by `buf`. The contents of this structure are defined in **Chapter 9 — Definitions.**

`IPC_SET` Set the value of the following members of the data structure associated with `msqid` to the corresponding value found in the structure pointed to by `buf`:

```
msg_perm.uid
msg_perm.gid
msg_perm.mode /* only low 9-bits */
msg_qbytes
```

This `cmd` can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of `msg_perm.cuid` or `msg_perm.uid` in the data structure associated with `msqid`. Only super-user can raise the value of `msg_qbytes`.

`IPC_RMID` Remove the message-queue-identifier specified by `msqid` from the system and destroy the message-queue and data structure associated with it. This `cmd` can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of `msg_perm.cuid` or `msg_perm.uid` in the data structure associated with `msqid`.

RETURN VALUE

If successful, the function `msgctl` returns 0; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function msgctl will fail if one or more of the following are true:

EINVAL	The value of msqid is not a valid message-queue-identifier; or the value of cmd is not a valid command.
EACCES	The argument cmd is equal to IPC_STAT and the calling-process does not have read permission [see **mesage-operation-permissions** in **Chapter 9 — Definitions**].
EPERM	The argument cmd is equal to IPC_RMID or IPC_SET and the effective-user-ID of the calling-process is not equal to that of super-user and it is not equal to the value of msg_perm.cuid or msg_perm.uid in the data structure associated with msqid.
EPERM	The argument cmd is equal to IPC_SET, an attempt is being made to increase to the value of msg_qbytes, and the effective-user-ID of the calling-process is not equal to that of super-user.

SEE ALSO

MSGGET(KE_OS), MSGOP(KE_OS).

LEVEL

Level 1.

NAME

msgget — get message-queue

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>

int msgget(key, msgflg)
key_t key;
int msgflg;
```

DESCRIPTION

The function `msgget` returns the message-queue-identifier associated with the argument `key`.

A message-queue-identifier and associated message-queue and data structure [see **Chapter 9 — Definitions**] are created for the argument `key` if one of the following are true:

if the argument `key` is equal to `IPC_PRIVATE`.

if the argument `key` does not already have a message-queue-identifier associated with it, and `(msgflg&IPC_CREAT)` is true.

Upon creation, the data structure associated with the new message-queue-identifier is initialized as follows:

`msg_perm.cuid` and `msg_perm.uid` are set equal to the effective-user-ID of the calling-process;

`msg_perm.cgid`, and `msg_perm.gid` are set equal to the effective-group-ID of the calling-process;

The low-order 9-bits of `msg_perm.mode` are set equal to the low-order 9-bits of `msgflg`;

`msg_qnum`, `msg_lspid`, `msg_lrpid`, `msg_stime`, and `msg_rtime` are set equal to 0;

`msg_ctime` is set equal to the current-time;

`msg_qbytes` is set equal to the system-limit.

RETURN VALUE

If successful, the function `msgget` returns a non-negative integer, namely a message-queue-identifier; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `msgget` will fail if one or more of the following are true:

`EACCES`	A message-queue-identifier exists for the argument `key`, but operation permission [see **Chapter 9 — Definitions**] as specified by the low-order 9-bits of `msgflg` would not be granted.
`ENOENT`	A message-queue-identifier does not exist for the argument `key` and `(msgflg&IPC_CREAT)` is "false".
`ENOSPC`	A message-queue-identifier is to be created but the system-imposed limit on the maximum number of allowed message-queue-identifiers system-wide would be exceeded.
`EEXIST`	A message-queue-identifier exists for the argument `key` but `((msgflg&IPC_CREAT)&&(msgflg&IPC_EXCL))` is "true".

SEE ALSO

MSGCTL(KE_OS), MSGOP(KE_OS).

LEVEL

Level 1.

NAME

msgop — message operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>

int msgsnd(msqid, msgp, msgsz, msgflg)
int msqid;
struct mymsg *msgp;
int msgsz, msgflg;

int msgrcv(msqid, msgp, msgsz, msgtyp, msgflg)
int msqid;
struct mymsg *msgp;
int msgsz;
long msgtyp;
int msgflg;
```

DESCRIPTION

The function `msgsnd` is used to send a message to the queue associated with the message queue identifier specified by `msqid`.

The argument `msgp` points to a user-defined buffer that must contain first a field of type long integer that will specify the type of the message, and then a data portion that will hold the text of the message. The structure below is an example of what this user-defined buffer might look like.

```
struct mymsg {
    long mtype;  /* message type */
    char mtext[];  /* message text */
}
```

The structure member `mtype` is a positive integer that can be used by the receiving process for message selection (see `msgrcv` below).

The structure member `mtext` is any text of length `msgsz` bytes. The argument `msgsz` can range from 0 to a system-imposed maximum.

The argument `msgflg` specifies the action to be taken if one or more of the following are true:

The number of bytes already on the queue is equal to `msg_qbytes` [see **Chapter 9 — Definitions**].

The total number of messages on all queues system-wide is equal to the system-imposed limit.

These actions are as follows:

If `(msgflg&IPC_NOWAIT)` is "true", the message will not be sent and the calling-process will return immediately.

If `(msgflg&IPC_NOWAIT)` is "false", the calling-process will suspend execution until one of the following occurs:

The condition responsible for the suspension no longer exists, in which case the message is sent.

The message-queue-identifier `msqid` is removed from the system [see MSGCTL(KE_OS)]. When this occurs, `errno` is set equal to `EIDRM` and a value of −1 is returned.

The calling-process receives a signal that is to be caught. In this case the message is not sent and the calling-process resumes execution in the manner prescribed in the SIGNAL(BA_OS) routine.

Upon successful completion, the following actions are taken with respect to the data structure associated with `msqid` [see **Chapter 9 – Definitions**].

`msg_qnum` is incremented by 1.

`msg_lspid` is set equal to the process-ID of the calling-process.

`msg_stime` is set equal to the current time.

The function `msgrcv` reads a message from the queue associated with the message queue identifier specified by `msqid` and places it in the user-defined buffer pointed to by `msgp`. The buffer must contain a message type field followed by the area for the message text (see the structure `mymsg` above).

The structure member `mtype` is the received message's type as specified by the sending process.

The structure member `mtext` is the text of the message.

The argument `msgsz` specifies the size in bytes of `mtext`. The received message is truncated to `msgsz` "bytes" if it is larger than `msgsz` and `(msgflg&MSG_NOERROR)` is "true". The truncated part of the message is lost and no indication of the truncation is given to the calling-process.

The symbolic name `MSG_NOERROR` is defined by the `<sys/msg.h>` header file.

The argument `msgtyp` specifies the type of message requested as follows:

If `msgtyp` is equal to `0`, the first message on the queue is received.

If `msgtyp` is greater than `0`, the first message of type `msgtyp` is received.

If `msgtyp` is less than `0`, the first message of the lowest type that is less than or equal to the absolute value of `msgtyp` is received.

The argument `msgflg` specifies the action to be taken if a message of the desired type is not on the queue. These are as follows:

If `(msgflg&IPC_NOWAIT)` is "true", the calling-process will return immediately with a return value of `-1` and `errno` set to `ENOMSG`.

If `(msgflg&IPC_NOWAIT)` is "false", the calling-process will suspend execution until one of the following occurs:

A message of the desired type is placed on the queue.

The message queue identifier `msqid` is removed from the system. When this occurs, `errno` is set equal to `EIDRM` and a value of `-1` is returned.

The calling-process receives a signal that is to be caught. In this case a message is not received and the calling-process resumes execution in the manner prescribed in SIGNAL(BA_OS).

Upon successful completion, the following actions are taken with respect to the data structure associated with `msqid`.

`msg_qnum` is decremented by `1`.

`msg_lrpid` is set equal to the process-ID of the calling-process.

`msg_rtime` is set equal to the current time.

RETURN VALUE

If successful, the function `msgsnd` returns a value of `0`.

If successful, the function `msgrcv` returns a value equal to the number of bytes actually placed into the buffer `mtext`.

Otherwise, the function `msgsnd` and the function `msgrcv` return `-1` and `errno` will indicate the error.

ERRORS

The function `msgsnd` will fail and no message will be sent if one or more of the following are true:

`EINVAL`	The value of `msqid` is not a valid message-queue-identifier; or the value of `mtype` is less than 1; or the value of `msgsz` is less than 0 or greater than the system-imposed limit.
`EACCES`	Operation permission is denied to the calling-process.
`EAGAIN`	The message cannot be sent for one of the reasons cited above and `(msgflg&IPC_NOWAIT)` is "true".
`EINTR`	The function `msgsnd` was interrupted by a signal.
`EIDRM`	The message-queue-identifier `msgid` has been removed from the system.

The function `msgrcv` will fail and no message will be received if one or more of the following are true:

`EINVAL`	The value of `msqid` is not a valid message-queue-identifier; or the value of `msgsz` is less than `0`.
`EACCES`	Operation permission is denied to the calling-process.
`EINTR`	The function `msgrcv` was interrupted by a signal.
`EIDRM`	The message-queue-identifier `msqid` has been removed from the system.
`E2BIG`	The value of `mtext` is greater than `msgsz` and `(msgflg&MSG_NOERROR)` is "false".
`ENOMSG`	The queue does not contain a message of the desired type and `(msgtyp&IPC_NOWAIT)` is "true".

SEE ALSO

MSGCTL(KE_OS), MSGGET(KE_OS), SIGNAL(BA_OS).

LEVEL

Level 1.

NAME

nice — change priority of a process

SYNOPSIS

```
int nice(incr)
int incr;
```

DESCRIPTION

The function `nice` adds the value of `incr` to the nice-value of the calling-process. A process's *nice-value* is a positive number for which a more positive value results in lower CPU priority.

The system imposes an implementation-specific, maximum process-nice-value of `2*{NZERO}-1` and a minimum process-nice-value of `0`. If adding `incr` to the process's current nice-value would cause the result to be above or below these limits, the process's nice-value will be set to the corresponding limit.

RETURN VALUE

If successful, the function `nice` returns the process's new nice-value minus `{NZERO}`.

ERRORS

`EPERM`	The function `nice` will fail and not change the process's nice-value if `incr` is negative or greater than `2*{NZERO}` and the effective-user-ID of the calling-process is not super-user.

SEE ALSO

EXEC(BA_OS).

LEVEL

Level 1.

NAME

plock — lock process, text, or data in memory

SYNOPSIS

```
#include <sys/lock.h>

int plock(op)
int op;
```

DESCRIPTION

The function `plock` allows the calling-process to lock its text segment (text lock), its data segment (data lock), or both its text and data segments (process lock) into memory. Locked segments are immune to all routine swapping. The function `plock` also allows these segments to be unlocked. The effective-user-ID of the calling-process must be super-user to use this call. The argument `op` specifies the following, which are defined by the `<sys/lock.h>` header file:

`PROCLOCK`	lock text and data segments into memory (process lock)
`TXTLOCK`	lock text segment into memory (text lock)
`DATLOCK`	lock data segment into memory (data lock)
`UNLOCK`	remove locks

RETURN VALUE

If successful, the function `plock` returns `0` to the calling-process; otherwise, it returns `−1` and `errno` will indicate the error.

ERRORS

The function `plock` will fail and not perform the requested operation if one or more of the following are true:

`EPERM`	The effective-user-ID of the calling-process is not super-user.
`EINVAL`	The argument `op` is equal to `PROCLOCK` and a process-lock, a text-lock, or a data-lock already exists on the calling-process.
`EINVAL`	The argument `op` is equal to `TXTLOCK` and a text-lock, or a process-lock already exists on the calling-process.
`EINVAL`	The argument `op` is equal to `DATLOCK` and a data-lock, or a process-lock already exists on the calling-process.
`EINVAL`	The argument `op` is equal to `UNLOCK` and no type of lock exists on the calling-process.

APPLICATION USAGE

The function `plock` should not be used by most applications. Only programs that must have the type of real-time control it provides should use it.

SEE ALSO

EXEC(BA_OS), EXIT(BA_OS), FORK(BA_OS).

LEVEL

Level 1.

NAME

profil — execution time profile

SYNOPSIS

```
void profil(buff, bufsiz, offset, scale)
char *buff;
int bufsiz, offset, scale;
```

DESCRIPTION

The argument `buff` points to an area of memory whose length (in bytes) is given by `bufsiz`. After the call to `profil`, the user's program counter (pc) is examined each clock tick ({CLK_TCK} times per second); `offset` is subtracted from it, and the result multiplied by `scale`. If the resulting number corresponds to an entry inside `buff`, that entry is incremented. An "entry" is defined as a series of bytes with length `sizeof(short)`.

The scale is interpreted as an unsigned, fixed-point fraction with binary point at the left: `0177777` (octal) gives a 1-1 mapping of pc's to words in `buff`; `077777` (octal) maps each pair of instruction words together. `02`(octal) maps all instructions onto the beginning of `buff` (producing a non-interrupting core clock).

Profiling is turned off by giving a `scale` of `0` or `1`. It is rendered ineffective by giving a `bufsiz` of `0`. Profiling is turned off when an EXEC(BA_OS) routine is executed, but remains on in both child and parent after a call to the FORK(BA_OS) routine. Profiling will be turned off if an update in `buff` would cause a memory fault.

RETURN VALUE

Not defined.

APPLICATION USAGE

The function `profil` would normally be used by an application program only during development of a program to analyze the program's performance.

LEVEL

Level 1.

NAME

ptrace — process trace

SYNOPSIS

```
int ptrace(request, pid, addr, data)
int request, pid, data;
```

DESCRIPTION

The function `ptrace` provides a means by which a parent-process may control the execution of a child-process. Its primary use is for the implementation of breakpoint debugging. The child-process behaves normally until it encounters a signal [see SIGNAL(BA_OS)] at which time it enters a stopped state and its parent is notified via the WAIT(BA_OS) routine. When the child is in the stopped state, its parent can examine and modify its *core-image* using `ptrace`. Also, the parent can cause the child either to terminate or continue, with the possibility of ignoring the signal that caused it to stop.

The data type of the argument `addr` depends upon the particular `request` given to `ptrace`.

The argument `request` determines the precise action to be taken by `ptrace` and is one of the following:

0 This request must be issued by the child-process if it is to be traced by its parent. It turns on the child's trace flag that stipulates that the child should be left in a stopped state upon receipt of a signal rather than the state specified by `func` [see SIGNAL(BA_OS)]. The `pid`, `addr`, and `data` arguments are ignored, and a return value is not defined for this request. Peculiar results will ensue if the parent does not expect to trace the child.

The remainder of the requests can only be used by the parent-process. For each, `pid` is the process-ID of the child. The child must be in a stopped state before these requests are made.

1, 2 With these requests, the word at location `addr` in the address space of the child-process is returned to the parent-process. If instruction (I) and data (D) space are separated, request 1 returns a word from I-space, and request 2 returns a word from D-space. If I-space and D-space are not separated either request 1 or request 2 may be used with equal results. The `data` argument is ignored. These two requests will fail if `addr` is not the start address of a word, in which case a value of −1 is returned to the parent-process and the parent's `errno` is set to `EIO`.

3 With this request, the word at location `addr` in the child's *user-area* in the system's address space is returned to the parent-process.

The argument `data` is ignored. This request will fail if `addr` is not the start address of a word or is outside the *user-area*, in which case a value of −1 is returned to the parent-process and the parent's `errno` is set to `EIO`.

4, 5 With these requests, the value given by the `data` argument is written into the address space of the child at location `addr`. If I-space and D-space are separated, request 4 writes a word into I-space, and request 5 writes a word into D-space. If I-space and D-space are not separated, either request 4 or request 5 may be used with equal results. Upon successful completion, the value written into the address space of the child is returned to the parent.

These two requests will fail if `addr` is a location in a pure procedure space and another process is executing in that space, or `addr` is not the start address of a word. Upon failure a value of −1 is returned to the parent-process and the parent's `errno` is set to `EIO`.

6 With this request, a few entries in the child's *user-area* can be written.

The argument `data` gives the value that is to be written and `addr` is the location of the entry. Entries that can be written are implementation-specific but might include general registers portions of the *processor-status-word.*

7 This request causes the child to resume execution. If the `data` argument is 0, all pending signals including the one that caused the child to stop are canceled before it resumes execution.

If the argument `data` is a valid signal number, the child resumes execution as if it had incurred that signal, and any other pending signals are canceled. The `addr` argument must be equal to 1 for this request. Upon successful completion, the value of `data` is returned to the parent. This request will fail if `data` is not 0 or a valid signal number, in which case a value of −1 is returned to the parent-process and the parent's `errno` is set to `EIO`.

8 This request causes the child to terminate with the same consequences as the EXIT(BA_OS) routine.

9 This request is implementation-dependent but if operative, it is used to request single-stepping through the instructions of the child.

To forestall possible fraud, the function `ptrace` inhibits the set-user-ID facility on subsequent EXEC(BA_OS) routines. If a traced process calls and EXEC(BA_OS) routine, it will stop before executing the first instruction of the new image showing signal `SIGTRAP`.

RETURN VALUE

Upon failure, the function `ptrace` returns -1. Return values on successful completion are specific to the request type (see above).

ERRORS

In general, the function `ptrace` will fail if one or more of the following are true:

`EIO`	The value of `request` is an illegal number. See the summary for each request type above.
`ESRCH`	The argument `pid` identifies a child that does not exist or has not executed a `ptrace` with request 0.

APPLICATION USAGE

The function `ptrace` should not be used by application-programs. It is only used by software debugging programs and it is hardware-dependent.

When the function `ptrace` is used to read a word from the address space of the child-process, `request` 1, 2 or 3, the data read and returned by `ptrace` could have the value −1. In this case, a return value of −1 would not indicate an error.

SEE ALSO

EXEC(BA_OS), SIGNAL(BA_OS), WAIT(BA_OS).

LEVEL

Level 1.

NAME

semctl — semaphore-control-operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/sem.h>

int semctl(semid, semnum, cmd, arg)
int semid, cmd;
int semnum;
union semun {
     int val;
     struct semid_ds *buf;
     ushort *array;  } arg;
```

DESCRIPTION

The function `semctl` provides a variety of semaphore-control-operations as specified by `cmd`.

The following semaphore-control-operations as specified by `cmd` are executed with respect to the semaphore specified by `semid` and `semnum`. The level of permission required for each operation is shown with each command [see **semaphore-operation-permissions** in **Chapter 9 — Definitions]**. The symbolic names for the values of `cmd` are defined by the `<sys/sem.h>` header file.

`GETVAL`	Return the value of `semval` [see **Chapter 9 — Definitions]**. Requires read permission.
`SETVAL`	Set the value of `semval` to `arg.val`. When this `cmd` is successfully executed, the `semadj` value corresponding to the specified semaphore in all processes is cleared. Requires alter permission.
`GETPID`	Return the value of `sempid`. Requires read permission.
`GETNCNT`	Return the value of `semncnt`. Requires read permission.
`GETZCNT`	Return the value of `semzcnt`. Requires read permission.

The following cmds operate on each semval in the set of semaphores.

GETALL	Return semvals and place into the array pointed to by arg.array. Requires read permission.
SETALL	Set semvals according to the array pointed to by arg.array. When this cmd is successfully executed, the semadj values corresponding to each specified semaphore in all processes are cleared. Requires alter permission.

The following cmds are also available:

IPC_STAT
: Place the current value of each member of the data structure associated with semid into the structure pointed to by arg.buf. The contents of this structure are defined in **Chapter 9 — Definitions.**
Requires read permission.

IPC_SET
: Set the value of the following members of the data structure associated with semid to the corresponding value found in the structure pointed to by arg.buf:

```
sem_perm.uid
sem_perm.gid
sem_perm.mode /* only low 9-bits */
```

This cmd can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of sem_perm.cuid or sem_perm.uid in the data structure associated with semid.

IPC_RMID
: Remove the semaphore-identifier specified by semid from the system and destroy the set of semaphores and data structure associated with it. This cmd can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of sem_perm.cuid or sem_perm.uid in the data structure associated with semid.

RETURN VALUE

If successful, the value semctl returns depends on cmd as follows:

GETVAL	the value of semval.
GETPID	the value of sempid.
GETNCNT	the value of semncnt.
GETZCNT	the value of semzcnt.
All others	a value of 0.

Otherwise, shmctl returns −1 and errno indicates the error.

ERRORS

The function `semctl` will fail if one or more of the following are true:

`EINVAL`	The value of `semid` is not a valid semaphore-identifier; or the value of `semnum` is less than 0 or greater than `sem_nsems`; or the value of `cmd` is not a valid command.
`EACCES`	Operation permission is denied to the calling-process [see **Chapter 9 — Definitions**].
`ERANGE`	The argument `cmd` is equal to `SETVAL` or `SETALL` and the value to which `semval` is to be set is greater than the system imposed maximum.
`EPERM`	The argument `cmd` is equal to `IPC_RMID` or `IPC_SET` and the effective-user-ID of the calling-process is not equal to that of super-user and it is not equal to the value of `sem_perm.cuid` or `sem_perm.uid` in the data structure associated with `semid`.

SEE ALSO

SEMGET(KE_OS), SEMOP(KE_OS).

LEVEL

Level 1.

NAME

semget — get set of semaphores

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/sem.h>
int semget(key, nsems, semflg)
key_t key;
int nsems, semflg;
```

DESCRIPTION

The function `semget` returns the semaphore-identifier associated with `key`.

A semaphore-identifier with its associated `semid_ds` data structure and its associated set of `nsems` semaphores [see **Chapter 9 — Definitions**] are created for `key` if one of the following are true:

> The argument `key` is equal to `IPC_PRIVATE`.
>
> The argument `key` does not already have a semaphore-identifier associated with it, and `(semflg&IPC_CREAT)` is "true".

Upon creation, the `semid_ds` data structure associated with the new semaphore-identifier is initialized as follows:

> In the operation-permissions structure, `sem_perm.cuid` and `sem_perm.uid` are set equal to the effective-user-ID of the calling-process; while `sem_perm.cgid` and `sem_perm.gid` are set equal to the effective-group-ID of the calling-process.
>
> The low-order 9-bits of `sem_perm.mode` are set equal to the low-order 9-bits of `semflg`.
>
> The variable `sem_nsems` is set equal to the value of `nsems`.
>
> The variable `sem_otime` is set equal to 0 and `sem_ctime` is set equal to the current time.
>
> The data structure associated with each semaphore in the set is not initialized. The function `semctl` with the command `SETVAL` or `SETALL` can be used to initialize each semaphore.

RETURN VALUE

If successful, the function `semget` returns a non-negative integer, namely a semaphore-identifier; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `semget` will fail if one or more of the following are true:

`EACCES`	A semaphore-identifier exists for `key`, but operation permission as specified by the low-order 9-bits of `semflg` would not be granted.
`EINVAL`	The value of `nsems` is either less than or equal to `0` or greater than the system-imposed limit, or a semaphore-identifier exists for the argument `key`, but the number of semaphores in the set associated with it is less than `nsems` and `nsems` is not equal to `0`.
`ENOENT`	A semaphore-identifier does not exist for the argument `key` and `(semflg&IPC_CREAT)` is "false".
`ENOSPC`	A semaphore identifier is to be created but the system-imposed limit on the maximum number of allowed semaphores system wide would be exceeded.
`EEXIST`	A semaphore-identifier exists for the argument `key` but `((semflg&IPC_CREAT)&&(semflg&IPC_EXCL))` is "true".

SEE ALSO

SEMCTL(KE_OS), SEMOP(KE_OS).

LEVEL

Level 1.

NAME

semop — semaphore operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/sem.h>

int semop(semid, sops, nsops)
int semid;
struct sembuf *sops;
unsigned nsops;
```

DESCRIPTION

The function semop is used to automatically perform an user-defined array of semaphore operations on the set of semaphores associated with the semaphore identifier specified by the argument semid.

The argument sops is a pointer to a user-defined array of semaphore-operation structures.

The argument nsops is the number of such structures in the array.

Each structure, sembuf, includes the following members:

```
short sem_num;    /* semaphore number */
short sem_op;     /* semaphore operation */
short sem_flg;    /* operation flags */
```

Each semaphore operation specified by sem_op is performed on the corresponding semaphore specified by semid and sem_num.

The variable sem_op specifies one of three semaphore operations:

1. If sem_op is a negative integer and the calling-process has alter permission, one of the following will occur:

   - If semval is greater than or equal to the absolute value of sem_op, the absolute value of sem_op is subtracted from semval. Also, if (sem_flg&SEM_UNDO) is "true", the absolute value of sem_op is added to the calling-process's semadj value for the specified semaphore [see EXIT(BA_OS) in EFFECTS(BA_ENV) in **Chapter 10 — Environment**]. The symbolic name SEM_UNDO is defined by the <sys/sem.h> header file.

   - If semval is less than the absolute value of sem_op and (sem_flg&IPC_CREAT) is "true", semop will return immediately.

   - If semval is less than the absolute value of sem_op and (sem_flg&IPC_CREAT) is "false", semop will increment the semncnt associated with the specified semaphore and suspend execution of the calling-process until one of the following conditions occur:

- The value of `semval` becomes greater than or equal to the absolute value of `sem_op`. When this occurs, the value of `semncnt` associated with the specified semaphore is decremented, the absolute value of `sem_op` is subtracted from `semval` and, if `(sem_flg&SEM_UNDO)` is "true", the absolute value of `sem_op` is added to the calling-process's `semadj` value for the specified semaphore.
- The `semid` for which the calling-process is awaiting action is removed from the system [see SEMCTL(KE_OS)]. When this occurs, `errno` is set equal to `EIDRM`, and a value of −1 is returned.
- The calling-process receives a signal that is to be caught. When this occurs, the value of `semncnt` associated with the specified semaphore is decremented, and the calling-process resumes execution in the manner prescribed in the routines defined in SIGNAL(BA_OS).

2. If `sem_op` is a positive integer and the calling-process has alter permission, the value of `sem_op` is added to `semval` and, if `(sem_flg&SEM_UNDO)` is "true", the value of `sem_op` is subtracted from the calling-process's `semadj` value for the specified semaphore.
3. If `sem_op` is 0 and the calling-process has read permission, one of the following will occur:
   - If `semval` is 0, the function `semop` will return immediately.
   - If `semval` is not equal to 0 and `(sem_flg&IPC_CREAT)` is "true", the function `semop` will return immediately.
   - If `semval` is not equal to 0 and `(sem_flg&IPC_CREAT)` is "false", the function `semop` will increment the `semzcnt` associated with the specified semaphore and suspend execution of the calling-process until one of the following occurs:
     - The value of `semval` becomes 0, at which time the value of `semzcnt` associated with the specified semaphore is decremented.
     - The `semid` for which the calling-process is awaiting action is removed from the system. When this occurs, `errno` is set equal to `EIDRM`, and a value of −1 is returned.
     - The calling-process receives a signal that is to be caught. When this occurs, the value of `semzcnt` associated with the specified semaphore is decremented, and the calling-process resumes execution in the manner prescribed in the routines defined in SIGNAL(BA_OS).

RETURN VALUE

If successful, the function `semop` returns 0; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `semop` will fail if one or more of the following are true for any of the semaphore operations specified by `sops`:

`EINVAL`	The value of `semid` is not a valid semaphore-identifier; or the number of individual semaphores for which the calling-process requests a `SEM_UNDO` would exceed the limit.
`EFBIG`	The value of `sem_num` is less than 0 or greater than or equal to the number of semaphores in the set associated with `semid`.
`E2BIG`	The value of `nsops` is greater than the system-imposed maximum.
`EACCES`	Operation permission is denied to the calling-process [see **Chapter 9 — Definitions**].
`EAGAIN`	The operation would result in suspension of the calling-process but `(sem_flg&IPC_CREAT)` is "true".
`ENOSPC`	The limit on the number of individual processes requesting a `SEM_UNDO` would be exceeded.
`ERANGE`	An operation would cause a `semval` to overflow the system-imposed limit, or an operation would cause a `semadj` value to overflow the system-imposed limit.
`EINTR`	The function `semop` was interrupted by a signal.
`EIDRM`	The semaphore identifier `semid` has been removed from the system.

Upon successful completion, the value of `sempid` for each semaphore specified in the array pointed to by `sops` is set equal to the process-ID of the calling-process.

SEE ALSO

EXEC(BA_OS), EXIT(BA_OS), FORK(BA_OS), SEMCTL(KE_OS), SEMGET(KE_OS).

LEVEL

Level 1.

NAME

shmctl — shared-memory-control-operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

int shmctl(shmid, cmd, buf)
int shmid, cmd;
struct shmid_ds *buf;
```

DESCRIPTION

The function `shmctl` provides a variety of shared-memory-control-operations as specified by `cmd`. The following values for `cmd` are available:

`IPC_STAT` Place the current value of each member of the data structure associated with `shmid` into the structure pointed to by `buf`. The contents of this structure are defined in **Chapter 9 — Definitions.**

`IPC_SET` Set the value of the following members of the data structure associated with `shmid` to the corresponding value found in the structure pointed to by `buf`:

```
shm_perm.uid
shm_perm.gid
shm_perm.mode /* only low 9-bits */
```

This `cmd` can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of `shm_perm.cuid` or `shm_perm.uid` in the data structure associated with `shmid`.

`IPC_RMID` Remove the shared memory identifier specified by `shmid` from the system and destroy the shared memory segment and data structure associated with it. This `cmd` can only be executed by a process that has an effective-user-ID equal to either that of super-user or to the value of `shm_perm.cuid` or `shm_perm.uid` in the data structure associated with `shmid`.

RETURN VALUE

If successful, the function `shmctl` returns 0; otherwise, it returns −1 and `errno` will indicate the error.

ERRORS

The function `shmctl` will fail if one or more of the following are true:

`EINVAL`	The value of `shmid` is not a valid shared-memory-identifier; or the value of `cmd` is not a valid command.
`EACCES`	The argument `cmd` is equal to `IPC_STAT` and the calling-process does not have read permission [see **shared-memory-operation-permissions** in **Chapter 9 — Definitions**].
`EPERM`	The argument `cmd` is equal to `IPC_RMID` or `IPC_SET` and the effective-user-ID of the calling-process is not equal to that of super user and it is not equal to the value of `shm_perm.cuid` or `shm_perm.uid` in the data structure associated with `shmid`.

APPLICATION USAGE

The functions `shmctl`, `shmget`, and `shmat` and `shmdt` are hardware-dependent and may not be present on all systems. The shared memory routines should not be used by applications except when extreme performance considerations require them.

SEE ALSO

SHMGET(KE_OS), SHMOP(KE_OS).

LEVEL

Level 1.

Optional: The function `shmctl` may not be present in all implementations of the Kernel Extension.

NAME

shmget — get shared-memory-segment

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

int shmget(key, size, shmflg)
key_t key;
int size, shmflg;
```

DESCRIPTION

The function `shmget` returns the shared memory identifier associated with `key`.

A shared-memory-identifier and associated data structure and shared-memory-segment of at least `size` bytes [see **Chapter 9 — Definitions**] are created for `key` if one of the following are true:

The argument `key` is equal to `IPC_PRIVATE`.

The argument `key` does not already have a shared-memory-identifier associated with it and `(shmflg&IPC_CREAT)` is "true".

Upon creation, the data structure associated with the new shared-memory-identifier is initialized as follows:

The value of `shm_perm.cuid` and `shm_perm.uid` are set equal to the effective-user-ID of the calling-process.

The value of `shm_perm.cgid` and `shm_perm.gid` are set equal to the effective-group-ID of the calling-process.

The low-order 9-bits of `shm_perm.mode` are set equal to the low-order 9-bits of `shmflg`.

The argument `shm_segsz` is set equal to the value of `size`.

The value of `shm_lpid`, `shm_nattch`, `shm_atime`, and `shm_dtime` are set equal to `0`.

The value of `shm_ctime` is set equal to the current time.

RETURN VALUE

If successful, the function `shmget` returns a non-negative integer, namely a shared-memory-identifier; otherwise, it returns `-1` and `errno` will indicate the error.

ERRORS

The function `shmget` will fail if one or more of the following are true:

`EINVAL`	The value of `size` is less than the system-imposed minimum or greater than the system-imposed maximum, or a shared-memory-identifier exists for the argument `key` but the size of the segment associated with it is less than `size` and `size` is not equal to `0`.
`EACCES`	A shared-memory-identifier exists for `key` but operation permission as specified by the low-order 9-bits of `shmflg` would not be granted.
`ENOENT`	A shared-memory-identifier does not exist for the argument `key` and `(shmflg&IPC_CREAT)` is "false".
`ENOSPC`	A shared memory identifier is to be created but the system-imposed limit on the maximum number of allowed shared memory identifiers system wide would be exceeded.
`ENOMEM`	A shared memory identifier and associated shared memory segment are to be created but the amount of available physical memory is not sufficient to fill the request.
`EEXIST`	A shared-memory-identifier exists for the argument `key` but `((shmflg&IPC_CREAT)&&(shmflg&IPC_EXCL))` is "true".

APPLICATION USAGE

The functions `shmctl`, `shmget` and `shmat` and `shmdt` are hardware-dependent and may not be present on all systems. The shared memory routines should not be used by applications except when extreme performance considerations require them.

SEE ALSO

SHMCTL(KE_OS), SHMOP(KE_OS).

LEVEL

Level 1.

Optional: The function `shmget` may not be present in all implementations of the Kernel Extension.

NAME

shmop — shared-memory-operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

char *shmat(shmid, shmaddr, shmflg)
int shmid;
char *shmaddr
int shmflg;

int shmdt(shmaddr)
char *shmaddr
```

DESCRIPTION

The function `shmat` attaches the shared-memory-segment associated with the shared-memory-identifier specified by `shmid` to the data segment of the calling-process. The segment is attached at the address specified by one of the following criteria:

If `shmaddr` is equal to `0`, the segment is attached at the first available address as selected by the system.

If `shmaddr` is not equal to 0 and `(shmflg&SHM_RND)` is "true", the segment is attached at the address given by `(shmaddr-(shmaddr%SHMLBA))`. The character `%` is the C language modulos operator.

If `shmaddr` is not equal to 0 and `(shmflg&SHM_RND)` is "false", the segment is attached at the address given by `shmaddr`.

The segment is attached for reading if `(shmflg&SHM_RDONLY)` is "true" and the calling-process has read permission; otherwise, if it is not true and the calling-process has read and write permission, the segment is attached for reading and writing.

The function `shmdt` detaches from the calling-process's data segment the shared memory segment located at the address specified by `shmaddr`.

The following symbolic names are defined by the `<sys/shm.h>` header file:

Name	*Description*
SHMLBA	segment low boundary address multiple
SHM_RDONLY	attach read-only (else read-write)
SHM_RND	round attach address to SHMLBA

RETURN VALUE

If successful, the function `shmat` will return the data segment start address of the attached shared-memory-segment. If successful, the function `shmdt` will return a value of `0`. Otherwise, the function `shmat` and the function `shmdt` will return −1 and `errno` will indicate the error.

ERRORS

The function `shmat` will fail and not attach the shared-memory-segment if one or more of the following are true:

`EACCES`	Operation permission is denied to the calling-process [see **Chapter 9 — Definitions**].
`ENOMEM`	The available data space is not large enough to accommodate the shared memory segment.
`EINVAL`	The value of `shmid` is not a valid shared-memory-identifier; or the value of `shmaddr` is not equal to `0` and the value of `(shmaddr-(shmaddr % SHMLBA))` is an illegal-address; or the value of `shmaddr` is not equal to `0`, `(shmflg&SHM_RND)` is "false" and the value of `shmaddr` is an illegal-address.
`EMFILE`	The number of shared-memory-segments attached to the calling-process would exceed the system-imposed limit.

The function `shmdt` will fail and not detach the shared-memory-segment if the following is true:

`EINVAL`	`shmaddr` is not the data segment start address of a shared-memory-segment.

APPLICATION USAGE

The functions `shmctl`, `shmget`, `shmat`, and `shmdt` are hardware dependent and may not be present on all systems. The shared memory routines should not be used by applications except when extreme performance considerations require them.

SEE ALSO

EXEC(BA_OS), EXIT(BA_OS), FORK(BA_OS), SHMCTL(KE_OS), SHMGET(KE_OS).

LEVEL

Level 1.

Optional: the functions `shmat` and `shmdt` may not be present in all implementations of the Kernel Extension.

Appendix

Changes from Issue 1

Appendix
Changes from Issue 1

Only substantive changes from Issue 1 to Issue 2 of the *System V Interface Definition* are described here. Changes that did not alter meaning, for example when text was changed or added for clarity, are not listed below.

Changes in the organization or general changes in the content of the SVID are described first. Summaries of changes in the detailed component definitions follow.

12.1 BASE SYSTEM DIFFERENCES

Organization. The information in the definition of the Base System is ordered somewhat differently in Issue 2. For example, error conditions, environmental variables, data files, directory tree structure, and special device files appear together in **Chapter 5 — Environment**, in Issue 2. Signals appear in the definition of the function SIGNAL(BA_OS) in **Chapter 6 — Operating System Service Routines.**

Omissions. Section 2.6 on Header Files in Issue 1 has been omitted. Issue 1 specified that the header files were *not* expected to be present on an implementation of the Base System. However, the presence of the header file Section was misinterpreted by many to mean that these files were part of the Base System. In Issue 2, all necessary information about a header file appears in the detailed definitions of those routines that use the header file.

Appendix 1.6 in Issue 1, Comparison to the 1984 /usr/group Standard, was not carried over to Issue 2 because the work of the /usr/group committee has been subsumed by the **IEEE P1003** working group.

The routines `regcmp` and `regex` were mistakenly included in Issue 1. Issue 2 removed and replaced these routines with the routines defined in REGEXP(BA_LIB).

The names of three external variables, `errno`, `sys_errlist` and `sys_nerr`, mistakenly appeared in the list of library routine names in Section 2.5 of Issue 1. They have been removed from the corresponding table in Issue 2.

Future Directions. Issue 2 made some additions to **Chapter 2 — Future Directions**; these are not detailed in this summary.

The paragraphs below identify specific changes to detailed component definitions:

Definitions.

special-processes Issue 1 specified that process-IDs 0 and 1 were reserved for special-processes. To allow implementations to reserve more ID numbers for special-processes, Issue 2 specifies that *at least* these two IDs are reserved.

Environment.

ERRORS(BA_ENV). Issue 2 additionally specifies that no error condition will have the value zero.

In Issue 2 the `EFAULT` error condition, when an address is outside the address space of a process, is not required from all systems [see ERRNO(BA_ENV)].

Issue 2 additionally specifies that `errno` should not be checked unless an error is indicated by a routine.

FILSYS(BA_ENV). Issue 1 incorrectly specified that all the environmental variables required to be set in the Base System environment were defined by the `/etc/profile` file. Issue 2 specifies that the `/etc/profile` file may define the variables PATH and TZ.

Issue 2 removed the description of an encrypted password from the definition of the /etc/passwd file.

TERMIO(BA_ENV). Issue 1 incorrectly listed the commands TCGETA and TCSETA as TCGETS and TCSETS in the definition of TERMIO(DEV). Issue 2 lists them as TCGETA and TCSETA in TERMIO(BA_ENV).

Issue 2 eliminated the **APPLICATION USAGE** section.

OS Service Routines.

CHMOD(BA_OS). Issue 1 identified the access permission bit 01000 as "save text image after execution"; Issue 2 identifies it as "reserved".

CHOWN(BA_OS). Issue 1 read "if chown is invoked by other than the super-user, the set-user-ID and the set-group-ID bits of the file mode will be cleared." Issue 2 clarifies that chown must be *successfully* invoked by other than super-user for this to occur.

CREAT(BA_OS). Issue 1 mistakenly stated that corresponding access-permission bits of the file mode were ANDed with the process's file-mode creation mask. Issue 2 correctly specifies that corresponding access-permission bits of the file mode are ANDed with the *complement* of the process's file-mode creation mask.

EXIT(BA_OS). Issue 2 specifies that termination of a process by exiting does not terminate its children.

Issue 1 mistakenly stated that the SIGHUP signal is sent to each member of a process-group if the calling-process is a process-group-leader. Issue 2 specifies that the calling-process must also be associated with a control terminal.

FCNTL(BA_OS). Issue 2 notes that the function fcntl commands F_GETLK, F_SETLK and F_SETLKW are post-System V Release 2.0 features.

Issue 2 clarifies when a read-lock or a write-lock can be set on a file with existing locks.

Issue 1 incorrectly specified the l_sysid element in the flock structure. It was removed in Issue 2.

Issue 1 incorrectly specified that the EDEADLK error condition would occur when the fcntl command was F_SETLK and putting the process to sleep would cause a deadlock. Issue 2 correctly specifies that the command in this case is F_SETLKW.

In Issue 1, the error condition EAGAIN should have been EACCES. This was changed in Issue 2 and the migration to EAGAIN is shown in **FUTURE DIRECTIONS**.

Issue 2 recommends that applications test for errno equal to either EAGAIN or EACCES.

FOPEN(BA_OS). Issue 2 additionally specifies that the functions fopen and freopen will fail if the argument type is invalid or the file cannot be opened; the function fdopen will fail if the argument type is invalid or the argument fildes is not an open file-descriptor; fopen and freopen will fail if there are no free *stdio* streams available.

Issue 1 specified that if the argument path could not be accessed by the functions fopen and freopen, errno could contain any of the values listed for the function open. Issue 2 further specifies which of these errno values are possible.

GETCWD(BA_OS). Issue 1 specified a side-effect if the function were called with a null pointer. Issue 2 removed this side-effect from the definition.

IOCTL(BA_OS). Issue 2 additionally specifies that the data type of the argument arg is either an integer or a pointer to a device-specific data structure.

LOCKF(BA_OS). Issue 1 misspelled the F_ULOCK value of the argument function as F_UNLOCK in one place.

Issue 1 incorrectly specified that the error condition EDEADLK would occur if the argument cmd was F_LOCK or F_TLOCK and a deadlock would occur. Issue 2 correctly specifies that the argument cmd was F_LOCK and a deadlock would occur.

In Issue 1, the error condition EAGAIN should have been EACCES. This was changed in Issue 2 and the migration to EAGAIN is shown in **FUTURE DIRECTIONS**.

Issue 2 recommends that applications test for errno equal to either EAGAIN or EACCES.

LSEEK(BA_OS). Issue 2 removed the reference to the SIGSYS signal on the error condition EINVAL.

MALLOC(BA_OS). Issue 1 incorrectly specified that the argument value to the function mallopt must be greater than 0 when the argument command is equal to M_NLBLKS. Issue 2 correctly specifies that value must be greater than 1.

Issue 2 additionally specifies that the function `mallinfo` must not be called until after some storage has been allocated using the function `malloc`. Issue 2 additionally specifies that the functions `malloc`, `calloc` and `realloc` will fail if `nbyte` is `0`.

MKNOD(BA_OS). Issue 1 identified the access permission bit `01000` as "save text image after execution"; Issue 2 identifies it as "reserved". For the error condition `EACCES`, Issue 2 additionally specifies that the effective-user-ID of the process is not super-user.

MOUNT(BA_OS). Issue 2 adds a new **FUTURE DIRECTIONS** section.

OPEN(BA_OS). Issue 1 mistakenly stated that corresponding access-permission bits of the file mode were ANDed with the process's file-mode creation mask. Issue 2 correctly specifies that corresponding access-permission bits of the file mode are ANDed with the *complement* of the process's file-mode creation mask.

Issue 2 additionally specifies that the new file-descriptor returned is the lowest numbered file-descriptor available.

READ(BA_OS). Issue 2 added the error conditions `EIO` and `ENXIO` which were mistakenly omitted in Issue 1.

Issue 2 additionally specifies that reading from a section of a file to which no data were written will read bytes with value zero into the buffer.

SETUID(BA_OS). Issue 2 removed references to the saved set-group-ID because this is not a feature in System V Release 1.0 or Release 2.0.

SYSTEM(BA_OS). Issue 2 removed references to positional parameters. Issue 2 also removed the paragraph on "here" documents, `<<[-]word`, which was incorrectly included in Issue 1.

TIME(BA_OS). Issue 1 read "As long as the argument `tloc` is not zero, the return value is also stored in the location to which the argument `tloc` points." Issue 2 reads "As long as the argument `tloc` is not a null pointer, the return value is also stored in the location to which the argument `tloc` points."

WRITE(BA_OS). Issue 2 specifies in more detail the run-time behavior when writing to a pipe, particularly atomic and partial writes.

Issue 2 added the error conditions `EIO` and `ENXIO`, which were mistakenly omitted in Issue 1.

UTIME(BA_OS). Issue 2 clarifies that the `utimebuf` structure must be defined by the user.

WAIT(BA_OS). Issue 2 removed all references in the Base System to a child-process stopping as a result of being traced because this functionality applies to the Kernel Extension.

General Library Routines.

CRYPT(BA_LIB). Issue 2 made the functions `crypt`, `setkey` and `encrypt` optional because U.S. State Department regulations may restrict the export of these routines. If present on an implementation, each routine's source-code interface and run-time behavior is expected to conform to the definition.

CTIME(BA_LIB). Issue 2 removed the include statement for the `<sys/types.h>` header file, which was mistakenly included in the **SYNOPSIS** section.

EXP(BA_LIB). The **RETURN VALUE** section in Issue 1 read "`log` and `log10` will return `HUGE`". Issue 2 corrected this to read "`log` and `log10` will return `-HUGE`".

The **FUTURE DIRECTIONS** section in Issue 1 read "`log` and `log10` will return `-HUGE_VAL` when `n` is not positive" and "`sqrt` will return `-0` when the value of `n` is `-0`". Issue 2 corrected this to read "`log` and `log10` will return `-HUGE_VAL` when `x` is not positive" and "`sqrt` will return `-0` when the value of `x` is `-0`".

FTW(BA_LIB). Issue 1 specified that if the value of the argument `depth` were zero or negative, the effect was the same as if the value were 1. Issue 2 specifies that the value of `depth` should be in the range of 1 to {OPEN_MAX}.

GAMMA(BA_LIB). The **RETURN VALUE** paragraph in Issue 1 read "For non-negative integer arguments, `HUGE` is returned". Issue 2 corrected this to read "For non-positive integer arguments, `HUGE` is returned".

HSEARCH(BA_LIB). Issue 2 removed the second paragraph of the **APPLICATION USAGE** section because it applies to developing an application-program using HSEARCH(BA_LIB), and it does not apply to an executable program that uses HSEARCH(BA_LIB).

PERROR(BA_LIB). Issue 2 additionally specifies the behavior of the function when the argument is a null string.

PRINTF(BA_LIB). Issue 2 additionally specifies escape sequences that may be used in the `format` argument.

Issue 2 removed the conversion character `i` because it is not available in System V Release 1.0 or Release 2.0.

PUTC(BA_LIB).	Issue 2 specifies the return value of the function `putw`; Issue 1 did not.
PUTENV(BA_LIB).	Issue 1 failed to specify that this routine first became available with System V Release 2.0.
SCANF(BA_LIB).	Issue 2 removed the conversion characters `i` and `n` because they are not available in System V Release 1.0 or System V Release 2.0.
STRING(BA_LIB).	Issue 2 specifies that the function `strtok` will write a null character into the string `s1` immediately following a matched token.
	Issue 2 removed the word "optional" from the first sentence of the **APPLICATION USAGE** section.
UNGETC(BA_LIB)	The special case for `stdin` that appeared in Issue 1 was removed from the definition in Issue 2.

12.2 KERNEL EXTENSION DIFFERENCES

Definitions.

`sem` structure	Issue 1 incorrectly included two elements, `semnwait` and `semzwait`, in the structure `sem`; Issue 2 removed them.
EFFECTS(KE_ENV)	Issue 2 added effects on EXEC(BA_OS) and FORK(BA_OS) routines that were mistakenly omitted in Issue 1.
	Issue 2 specifies additional values of `errno` for the Kernel Extension that were omitted in Issue 1.
ACCT(KE_OS).	Issue 1 incorrectly specified the type of the element `ac_etime` of the structure `acct` as `time_t`; Issue 2 specifies its type as `comp_t`.
	Issue 2 specifies the values of the fields `ac_flag` and `ac_comm` that result from a call to an EXEC(BA_OS) routine or the FORK(BA_OS) routine.

OS Service Routines.

MSGCTL(KE_OS).	Issue 2 specifies that read permission is needed for the `IPC_STAT` command.
NICE(KE_OS).	Issue 2 replaced the constant `39` with the expression `2*`{NZERO}`-1` to indicate that this is an implementation-specific constant.
PTRACE(KE_OS).	Issue 1 specified the type of the argument `addr` as `int`. Issue 2 specifies that the type of the argument `addr` is dependent upon the value of the argument `request`.
SEMCTL(KE_OS).	Issue 2 specifies the permission level needed for `semctl` operations.

SEMOP(KE_OS). Issue 1 incorrectly specified the type of the argument `sops` as `struct sembuf **`; Issue 2 specifies the type as `struct sembuf *`.

Issue 1 incorrectly specifies the type of the argument `nsops` as `int`; Issue 2 specifies the type as `unsigned`.

Issue 2 specifies the permission level needed for `sem_op` operations.

Issue 1 incorrectly specified the successful return value of the function. Issue 2 specifies that the function will return 0 on success. Issue 2 removed the first paragraph of the **RETURN VALUE** section.

SHMCTL(KE_OS). Issue 1 incorrectly included the commands `SHM_LOCK` and `SHM_UNLOCK`. Issue 2 removed these and the two error conditions that referenced them.

Issue 2 specifies that read permission is needed for the `IPC_STAT` command.

Issue 1 omitted from the description of the `EPERM` error condition that the effective-user-ID was not equal to `shm_perm.cuid`; Issue 2 added this.

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