System V Interface Definition
System V
Interface Definition
Issue 2

Volume III
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The System V Interface Definition (SVID) 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
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 all 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 volume of the *System V Interface Definition* corresponds to functionality in AT&T System V Release 1.0, System V Release 2.0, and System V Release 3.0. An implementation of System V may conform to the System V Release 1.0 functionality, the System V Release 2.0 functionality, or the System V Release 3.0 functionality. All System V Release 2.0 enhancements to System V Release 1.0 are identified as such in the SVID; all System V Release 3.0 enhancements to System V Release 2.0 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

- **Volume 3. Base System Addendum**
  - Terminal Interface Extension
  - Network Services 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**
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 three references define the C language for System V Release 1.0, System V Release 2.0, and System V Release 3.0 respectively:


Chapter 2
Future Directions

2.1 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.

2.2 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.

2.3 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.

2.4 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).
2.5 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:

<table>
<thead>
<tr>
<th>Code-Set</th>
<th>Internal Representation</th>
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<tbody>
<tr>
<td>Set 0 (Primary code-set)</td>
<td>0xxxxxxxxxxx</td>
</tr>
<tr>
<td>Set 1 (Supplementary code-set #1)</td>
<td>1xxxxxxxxx</td>
</tr>
<tr>
<td></td>
<td>— or —</td>
</tr>
<tr>
<td></td>
<td>1xxxxxxxxx 1xxxxxxxxx</td>
</tr>
<tr>
<td>Set 2 (Supplementary code-set #2)</td>
<td>SS2 1xxxxxxxxx</td>
</tr>
<tr>
<td></td>
<td>— or —</td>
</tr>
<tr>
<td></td>
<td>SS2 1xxxxxxxxx 1xxxxxxxxx</td>
</tr>
<tr>
<td>Set 3 (Supplementary code-set #3)</td>
<td>SS3 1xxxxxxxxx</td>
</tr>
<tr>
<td></td>
<td>— or —</td>
</tr>
<tr>
<td></td>
<td>SS3 1xxxxxxxxx 1xxxxxxxxx</td>
</tr>
</tbody>
</table>
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, JIS 6226, 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,

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 an 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.
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.

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 Addendum
Chapter 3
Introduction

The Base System Addendum updates the Base System Definition of Issue 2, Volume 1 and serves to document new functionality introduced to System V in System V Release 3.0. New functions not available in earlier releases are identified by the symbols ‡‡ next to the function name at the top of the component page. Functions that existed previously but that have some additional functionality or other change as of Release 3.0 are documented with the changes marked by a vertical bar (I) in the margin. These pages should be compared to their corresponding pages in the System V Interface Definition (SVID) Issue 2, Volume 1. Most of these changes are due to Future Directions now being included in the component definition. An appendix documents changes to Issue 2, Volume 1 that are due to error correction of the earlier SVID volume.

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 of SVID Issue 2, Volume 1. 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 basic set of routines that provide operating system services, e.g., process control, to applications.
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abort</td>
<td>ABORT(BA_OS)</td>
</tr>
<tr>
<td>access</td>
<td>ACCESS(BA_OS)</td>
</tr>
<tr>
<td>alarm</td>
<td>ALARM(BA_OS)</td>
</tr>
<tr>
<td>alloc</td>
<td>MALLOC(BA_OS)</td>
</tr>
<tr>
<td>chdir</td>
<td>CHDIR(BA_OS)</td>
</tr>
<tr>
<td>chmod</td>
<td>CHMOD(BA_OS)</td>
</tr>
<tr>
<td>chown</td>
<td>CHOWN(BA_OS)</td>
</tr>
<tr>
<td>clearerr</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>closedir</td>
<td>DIRECTORY(BA_OS)</td>
</tr>
<tr>
<td>dup</td>
<td>DUP(BA_OS)</td>
</tr>
<tr>
<td>dup2†‡</td>
<td>DUP2(BA_OS)</td>
</tr>
<tr>
<td>exit</td>
<td>EXIT(BA_OS)</td>
</tr>
<tr>
<td>fclose</td>
<td>FCLOSE(BA_OS)</td>
</tr>
<tr>
<td>fcntl</td>
<td>Fcntl(BA_OS)</td>
</tr>
<tr>
<td>fcntl1</td>
<td>FCNTL(BA_OS)</td>
</tr>
<tr>
<td>fdopen</td>
<td>FOPEN(BA_OS)</td>
</tr>
<tr>
<td>feof</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>ferror</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>fflush</td>
<td>FCLOSE(BA_OS)</td>
</tr>
<tr>
<td>fileno</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>fopen</td>
<td>FOPEN(BA_OS)</td>
</tr>
<tr>
<td>fread</td>
<td>FREAD(BA_OS)</td>
</tr>
<tr>
<td>free</td>
<td>MALLOC(BA_OS)</td>
</tr>
<tr>
<td>freopen</td>
<td>FOPEN(BA_OS)</td>
</tr>
<tr>
<td>fseek</td>
<td>FSEEK(BA_OS)</td>
</tr>
<tr>
<td>fstat</td>
<td>STAT(BA_OS)</td>
</tr>
<tr>
<td>ftell</td>
<td>FSEEK(BA_OS)</td>
</tr>
<tr>
<td>fwrite</td>
<td>FREAD(BA_OS)</td>
</tr>
<tr>
<td>getcwd</td>
<td>GETCWD(BA_OS)</td>
</tr>
<tr>
<td>getegid</td>
<td>GETUID(BA_OS)</td>
</tr>
<tr>
<td>geteuid</td>
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</tr>
<tr>
<td>getgidp</td>
<td>GETPID(BA_OS)</td>
</tr>
<tr>
<td>getgwp</td>
<td>GETPID(BA_OS)</td>
</tr>
<tr>
<td>getlopid</td>
<td>GETPID(BA_OS)</td>
</tr>
<tr>
<td>getuid</td>
<td>GETUID(BA_OS)</td>
</tr>
<tr>
<td>iocctl</td>
<td>IOCTL(BA_OS)</td>
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<tr>
<td>kill</td>
<td>KILL(BA_OS)</td>
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<tr>
<td>link</td>
<td>LINK(BA_OS)</td>
</tr>
<tr>
<td>lockf§</td>
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<tr>
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<td>MALLOC(BA_OS)</td>
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<td>MKNOD(BA_OS)</td>
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<tr>
<td>close</td>
<td>CLOSE(BA_OS)</td>
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<tr>
<td>creat</td>
<td>CREAT(BA_OS)</td>
</tr>
<tr>
<td>exec</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execle</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execlep</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execv</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execve</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execvp</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>_exit</td>
<td>EXIT(BA_OS)</td>
</tr>
</tbody>
</table>

Table 3-1: Base System: OS Service Routines

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abort</td>
<td>ABORT(BA_OS)</td>
</tr>
<tr>
<td>access</td>
<td>ACCESS(BA_OS)</td>
</tr>
<tr>
<td>alarm</td>
<td>ALARM(BA_OS)</td>
</tr>
<tr>
<td>alloc</td>
<td>MALLOC(BA_OS)</td>
</tr>
<tr>
<td>chdir</td>
<td>CHDIR(BA_OS)</td>
</tr>
<tr>
<td>chmod</td>
<td>CHMOD(BA_OS)</td>
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<tr>
<td>chown</td>
<td>CHOWN(BA_OS)</td>
</tr>
<tr>
<td>clearerr</td>
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<tr>
<td>closedir</td>
<td>DIRECTORY(BA_OS)</td>
</tr>
<tr>
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<td>DUP(BA_OS)</td>
</tr>
<tr>
<td>dup2†‡</td>
<td>DUP2(BA_OS)</td>
</tr>
<tr>
<td>exit</td>
<td>EXIT(BA_OS)</td>
</tr>
<tr>
<td>fclose</td>
<td>FCLOSE(BA_OS)</td>
</tr>
<tr>
<td>feof</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>ferror</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>fflush</td>
<td>FCLOSE(BA_OS)</td>
</tr>
<tr>
<td>fileno</td>
<td>FERROR(BA_OS)</td>
</tr>
<tr>
<td>fopen</td>
<td>FOPEN(BA_OS)</td>
</tr>
<tr>
<td>fread</td>
<td>FREAD(BA_OS)</td>
</tr>
<tr>
<td>free</td>
<td>MALLOC(BA(OS)</td>
</tr>
<tr>
<td>freopen</td>
<td>FOPEN(BA_OS)</td>
</tr>
<tr>
<td>fseek</td>
<td>FSEEK(BA_OS)</td>
</tr>
<tr>
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<td>STAT(BA(OS)</td>
</tr>
<tr>
<td>ftell</td>
<td>FSEEK(BA_OS)</td>
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<tr>
<td>fwrite</td>
<td>FREAD(BA_OS)</td>
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<tr>
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<tr>
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<td>GETPID(BA_OS)</td>
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<td>GETUID(BA_OS)</td>
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<tr>
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<tr>
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<tr>
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<td>MALLOC(BA_OS)</td>
</tr>
<tr>
<td>malloc</td>
<td>MALLOC(BA_OS)</td>
</tr>
<tr>
<td>mallinfo†</td>
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</tr>
<tr>
<td>mkdir†‡</td>
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</tr>
<tr>
<td>mknod</td>
<td>MKNOD(BA_OS)</td>
</tr>
<tr>
<td>close</td>
<td>CLOSE(BA_OS)</td>
</tr>
<tr>
<td>creat</td>
<td>CREAT(BA_OS)</td>
</tr>
<tr>
<td>exec</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execle</td>
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</tr>
<tr>
<td>execlep</td>
<td>EXEC(BA_OS)</td>
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<tr>
<td>execv</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execve</td>
<td>EXEC(BA_OS)</td>
</tr>
<tr>
<td>execvp</td>
<td>EXEC(BA(OS)</td>
</tr>
<tr>
<td>_exit</td>
<td>EXIT(BA_OS)</td>
</tr>
</tbody>
</table>

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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, Volume I: Part III — Kernel Extension Definition.

All the routines in Table 3-1, except those marked with †, ††, or §, are common to System V Release 1.0, System V Release 2.0, and System V Release 3.0. 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. Those marked with †† first appeared in System V Release 3.0.

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

<table>
<thead>
<tr>
<th>Routine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abs</td>
<td>ABS(BA_LIB)</td>
</tr>
<tr>
<td>acos</td>
<td>TRIG(BA_LIB)</td>
</tr>
<tr>
<td>asin</td>
<td>TRIG(BA_LIB)</td>
</tr>
<tr>
<td>atan2</td>
<td>TRIG(BA_LIB)</td>
</tr>
<tr>
<td>atan</td>
<td>TRIG(BA_LIB)</td>
</tr>
<tr>
<td>ceil</td>
<td>FLOOR(BA_LIB)</td>
</tr>
<tr>
<td>cos</td>
<td>TRIG(BA_LIB)</td>
</tr>
<tr>
<td>cosh</td>
<td>SINH(BA_LIB)</td>
</tr>
<tr>
<td>erf</td>
<td>ERF(BA_LIB)</td>
</tr>
<tr>
<td>erfc</td>
<td>ERF(BA_LIB)</td>
</tr>
<tr>
<td>exp</td>
<td>EXP(BA_LIB)</td>
</tr>
<tr>
<td>fabs</td>
<td>FLOOR(BA_LIB)</td>
</tr>
<tr>
<td>floor</td>
<td>FLOOR(BA_LIB)</td>
</tr>
<tr>
<td>fmod</td>
<td>FLOOR(BA_LIB)</td>
</tr>
<tr>
<td>frexp</td>
<td>FLOOR(BA_LIB)</td>
</tr>
<tr>
<td>gamma</td>
<td>GAMMA(BA_LIB)</td>
</tr>
<tr>
<td>hypot</td>
<td>HYPOT(BA_LIB)</td>
</tr>
<tr>
<td>_tolower</td>
<td>CONV(BA_LIB)</td>
</tr>
<tr>
<td>_toupper</td>
<td>CONV(BA_LIB)</td>
</tr>
<tr>
<td>advance</td>
<td>REGEXP(BA_LIB)</td>
</tr>
<tr>
<td>asctime</td>
<td>CTIME(BA_LIB)</td>
</tr>
<tr>
<td>atof</td>
<td>STRTOD(BA_LIB)</td>
</tr>
<tr>
<td>atoi</td>
<td>STRTOL(BA_LIB)</td>
</tr>
<tr>
<td>atol</td>
<td>STRTOL(BA_LIB)</td>
</tr>
<tr>
<td>compile</td>
<td>RESEXPERT(BA_LIB)</td>
</tr>
<tr>
<td>crypt#</td>
<td>CRYPT(BA_LIB)</td>
</tr>
<tr>
<td>ct ime</td>
<td>CTIME(BA_LIB)</td>
</tr>
<tr>
<td>encrypt#</td>
<td>CRYPT(BA_LIB)</td>
</tr>
<tr>
<td>gmtime</td>
<td>CTIME(BA_LIB)</td>
</tr>
<tr>
<td>isalpha</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isascii</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>iscntl</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isdigit</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isgraph</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>islower</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isprint</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>ispunct</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isspace</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isupper</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>isxdigit</td>
<td>CTYPE(BA_LIB)</td>
</tr>
<tr>
<td>localtime</td>
<td>CTIME(BA_LIB)</td>
</tr>
<tr>
<td>bsearch</td>
<td>BSEARCH(BA_LIB)</td>
</tr>
<tr>
<td>clock</td>
<td>CLOCK(BA_LIB)</td>
</tr>
<tr>
<td>ctermid</td>
<td>CTERMID(BA_LIB)</td>
</tr>
<tr>
<td>drand48</td>
<td>DRAND48(BA_LIB)</td>
</tr>
<tr>
<td>erand48</td>
<td>DRAND48(BA_LIB)</td>
</tr>
<tr>
<td>fgetc</td>
<td>GETC(BA_LIB)</td>
</tr>
<tr>
<td>fgets</td>
<td>GETS(BA_LIB)</td>
</tr>
<tr>
<td>fprintf</td>
<td>PRINTF(BA_LIB)</td>
</tr>
<tr>
<td>fscanf</td>
<td>SCANF(BA_LIB)</td>
</tr>
<tr>
<td>fprintf</td>
<td>PUTC(BA_LIB)</td>
</tr>
<tr>
<td>fputs</td>
<td>PUTS(BA_LIB)</td>
</tr>
<tr>
<td>ftw</td>
<td>FTW(BA_LIB)</td>
</tr>
</tbody>
</table>
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 † first appeared in System V Release 2.0. Routines marked with †† first appeared in System V Release 3.0. All others are in System V Release 1.0, System V Release 2.0, and System V Release 3.0. 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.
ASCII character set
Tables 4-1 and 4-2 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).

Table 4-1: Octal map of ASCII character set.

<table>
<thead>
<tr>
<th>Octal</th>
<th>Character</th>
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</thead>
<tbody>
<tr>
<td>000</td>
<td>nul</td>
</tr>
<tr>
<td>001</td>
<td>soh</td>
</tr>
<tr>
<td>002</td>
<td>stx</td>
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<tr>
<td>003</td>
<td>etx</td>
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<td>si</td>
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<tr>
<td>020</td>
<td>die</td>
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<tr>
<td>021</td>
<td>del</td>
</tr>
<tr>
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<td>dc2</td>
</tr>
<tr>
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<td>dc3</td>
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<tr>
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Table 4-2: Hexadecimal map of ASCII character set.

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Page 26 Base System Definition Addendum
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:

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<th>Name</th>
<th>Description</th>
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<td>number of bits in a char</td>
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<td>max. integer value of a char</td>
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<td>max. number of processes per user-ID</td>
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<td>max. decimal value of an int</td>
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<td>max. number of entries in system lock table</td>
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<td>max. number of files a process can have open</td>
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<tr>
<td>{PIPE_BUF}</td>
<td>max. number bytes atomic in write to a pipe</td>
</tr>
<tr>
<td>{PIPE_MAX}</td>
<td>max. number of bytes written to a pipe in a write</td>
</tr>
<tr>
<td>{PROC_MAX}</td>
<td>max. number of simultaneous processes, system wide</td>
</tr>
<tr>
<td>{SHRT_MAX}</td>
<td>max. decimal value of a short</td>
</tr>
<tr>
<td>{STD_BLK}</td>
<td>number of bytes in a physical I/O block</td>
</tr>
<tr>
<td>{SYS_NMLN}</td>
<td>number of characters in string returned by uname</td>
</tr>
<tr>
<td>{SYS_OPEN}</td>
<td>max. number of files open on system</td>
</tr>
<tr>
<td>{TMP_MAX}</td>
<td>max. number of unique names generated by tmpnam</td>
</tr>
<tr>
<td>{UID_MAX}</td>
<td>max. value for a user-ID or group-ID</td>
</tr>
<tr>
<td>{USL_MAX}</td>
<td>max. decimal value of an unsigned</td>
</tr>
<tr>
<td>{WORD_BIT}</td>
<td>number of bits in a word or int</td>
</tr>
<tr>
<td>{CHAR_MIN}</td>
<td>min. integer value of a char</td>
</tr>
<tr>
<td>{INT_MIN}</td>
<td>min. decimal value of an int</td>
</tr>
<tr>
<td>{LONG_MIN}</td>
<td>min. decimal value of a long</td>
</tr>
<tr>
<td>{SHRT_MIN}</td>
<td>min. decimal value of a short</td>
</tr>
</tbody>
</table>
**parent-process-ID**
The parent-process-ID of a process is the process-ID of its creator, for the lifetime of its creator [see \texttt{EXIT(BA\_OS)}]. A new process is created by a currently active-process [see \texttt{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:

\[
\text{<path\_name>} ::= \text{<file\_name>} | \text{<path\_prefix>}\text{<file\_name>} | / | . | .. \\
\text{<path\_prefix>} ::= \text{<rtprefix>} | / | \text{<rtprefix>} | \text{empty} \\
\text{<rtprefix>} ::= \text{<dirname>} | / | \text{<rtprefix>}\text{<dirname>}
\]

where \text{<file\_name>} is a string of 1 to \{NAME\_MAX\} significant characters other than slash and null, and \text{<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. An attempt to create or delete the path-name slash by itself is undefined and may be considered an error.

The meanings of . and .. are defined under \texttt{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 \texttt{KILL(BA\_OS)}]. A process inherits the process-group-ID of the process that created it [see \texttt{FORK(BA\_OS)} and \texttt{EXEC(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 that is not a process-group-leader may detach itself from its current process-group and become a new process-group-leader by calling the \texttt{SETPGRP(BA\_OS)} routine.
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 [see CHROOT(BA_OS)].

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 6, the system service (BA_OS) routines or Chapter 7, the general library (BA_LIB) routines.

(BA_OS) clearerr, fclose, fdopen, feof, ferror, fileno, fflush, fopen, fread, freopen, fseek, ftell, fwrite, popen, pclose, 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, 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,
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 buffer required by the `SETBUF(BA_LINUX)` routine.

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_LINUX)` 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_LINUX)` 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
ERRNO(BA_ENV)

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.
ERRNO(BA_ENV)

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.

ELIBACC Reserved.

ELIBBAD Reserved.

ELIBEXEC Reserved.

ELIBMAX Reserved.

ELIBSCN Reserved.

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, or a path-name is longer than {PATH_MAX} characters.

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.
ERRNO(BA_ENV)

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(KS_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.
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 the signal SIGABRT 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, SIGABRT, should not be caught or ignored by applications.

SEE ALSO
EXIT(BA_OS), SIGNAL(BA_OS), SIGSET(BA_OS).

LEVEL
Level 1.
NAME
access — determine accessibility of a file

SYNOPSIS
#include <unistd.h>

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

DESCRIPTION
The function access checks the named file for either accessibility according
to the bit-pattern contained in amode, or checks the named file for
existence. In either case, the function access uses 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 symbolic constants for the argument amode are defined by the
<unistd.h> header file and are as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_OK</td>
<td>test for read permission.</td>
</tr>
<tr>
<td>W_OK</td>
<td>test for write permission.</td>
</tr>
<tr>
<td>X_OK</td>
<td>test for execute (search) permission.</td>
</tr>
<tr>
<td>F_OK</td>
<td>test for existence of file.</td>
</tr>
</tbody>
</table>

The argument amode is either the logical OR of one or more of the values
of the symbolic constants for R_OK, W_OK, and X_OK or is the value of
the symbolic constant F_OK.

When checking for accessibility, 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; oth-
ervise, it will return -1 and errno will indicate the error.
ACCESS(BA_OS)

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.
ENOENT   if the path-name is longer than \{PATH_MAX\} characters.
EACCESS  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
EINV AL will be returned in errno if the argument amode is invalid.

LEVEL
  Level 1.
NAME
chmod — change mode of file

SYNOPSIS

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

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.

Symbolic constants defining the access permission bits are in the `<sys/stat.h>` header file and should be used to construct the argument `mode`. The value of the argument `mode` should be the logical OR of the values of the desired permissions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_ISUID</td>
<td>Set user-ID on execution.</td>
</tr>
<tr>
<td>S_ISGID</td>
<td>Set group-ID on execution.</td>
</tr>
<tr>
<td>S_ISVTX</td>
<td>Reserved.</td>
</tr>
<tr>
<td>S_IRUSR</td>
<td>Read by owner.</td>
</tr>
<tr>
<td>S_IWUSR</td>
<td>Write by owner.</td>
</tr>
<tr>
<td>S_IXUSR</td>
<td>Execute (search) by owner.</td>
</tr>
<tr>
<td>S_IRGRP</td>
<td>Read by group.</td>
</tr>
<tr>
<td>S_IWGRP</td>
<td>Write by group.</td>
</tr>
<tr>
<td>S_IXGRP</td>
<td>Execute (search) by group.</td>
</tr>
<tr>
<td>S_IROTH</td>
<td>Read by others (i.e., anyone else).</td>
</tr>
<tr>
<td>S_IWOTH</td>
<td>Write by others.</td>
</tr>
<tr>
<td>S_IXOTH</td>
<td>Execute (search) by others.</td>
</tr>
</tbody>
</table>
CHMOD(BA_OS)

S_ENFMT  Record locking enforced.

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, the access permission S_ISGID (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.

For ordinary files, if the mode bit S_ENFMT (record locking enforced) is set and the mode bit S_IXGRP (execute or search by group) is not set, enforced record locking is enabled. This will affect future calls to OPEN(BA_OS), CREAT(BA_OS), READ(BA_OS) and WRITE(BA_OS) routines on this file.

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.
ENOENT   if the path-name is longer than {PATH_MAX} characters.
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).

LEVEL
Level 1.
NAME
cre:J.t — create a new file or rewrite an existing one

SYNOPSIS

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

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.

Symbolic constants defining the access permission bits are specified in the `<sys/stat.h>` header file and should be used to construct `mode` [see `CHMOD(BA_OS)`].

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

```c
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.
CREAT(BA_OS)

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.
ENOENT    if the path-name is longer than {PATH_MAX} characters.
EACCES    if a component of the path-prefix denies search permission.
EACCES    if the file does not exist and the directory in which the file is
to be created does not permit writing.
EACCES    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.
EAGAIN    if the file exists with enforced record locking enabled and
there are record-locks on the file [see CHMOD(BA_OS)].

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).
LEVEL

Level 1.
NAME

closedir, opendir, readdir, rewinddir — directory operations

SYNOPSIS

#include <sys/types.h>
#include <dirent.h>

int closedir(dirp)
DIR *dirp;

DIR *opendir(filename)
char *filename;

struct dirent *readdir (dirp)
DIR *dirp;

void rewinddir(dirp)
DIR *dirp;

DESCRIPTION

The function closedir closes the directory-descriptor indicated by the argument dirp and frees the DIR structure associated with the directory-descriptor.

The function opendir opens the directory named by the argument filename and returns a pointer to the DIR structure associated with the directory.

The function readdir returns a pointer to a directory structure dirent that contains the next non-empty directory entry in the directory specified by the argument dirp. The structure dirent defined by the <dirent.h> header file describes a directory entry. It includes the inode number (d_ino) and the filename (d_name), which is a null-terminated string of at most \{NAME_MAX\} characters:

```c
long d_ino;         /* inode number of entry */
char d_name[1];     /* name of file */
```

The function rewinddir(dirp) resets the position of the directory pointer specified by the argument dirp to the beginning of the directory.

RETURN VALUE

The function opendir returns a NULL pointer if filename cannot be accessed, or if filename is not a directory, or if enough memory to hold a DIR structure or a buffer for the directory entries cannot be allocated and errno indicates the error.
If successful, the function `readdir` returns a valid pointer. Upon reaching the end of the directory, the function `readdir` returns a NULL pointer. Otherwise, the function `readdir` returns a NULL pointer and `errno` indicates the error.

The function `closedir` returns 0 if successful; otherwise, it returns -1 and `errno` indicates the error.

**ERROR**

Under the following conditions, the functions `closedir`, `opendir`, and `readdir` will fail and will set `errno` to:

- **opendir:**
  - ENOTDIR if a component of the path-prefix is not a directory.
  - EACCES if a component of the path-prefix denies search permission.
  - EACCES if read permission is denied for the specified directory.
  - EMFILE if `{OPEN_MAX}` file- or directory-descriptors are currently open in this process.
  - ENOENT if the path-name is longer than `{PATH_MAX}` characters.

- **readdir:**
  - ENOENT if the current directory-descriptor is not located at a valid entry.
  - EBADF if `dirp` is not a valid open directory-descriptor.

- **closedir:**
  - EBADF if `dirp` is not a valid open directory-descriptor.

**APPLICATION USAGE**

The functions `closedir`, `opendir`, `readdir`, and `rewinddir` were added in System V Release 3.0.
DIRECTORY(BA_OS)††

EXAMPLE
The following sample code will search a directory for the entry name:

```c
    dirp = opendir(".");
    while ((dp = readdir(dirp)) != NULL)
        if (strcmp(dp -> d_name, name) == 0) {
            closedir(dirp);
            return(FOUND);
        }
    
    closedir(dirp);
    return(NOT_FOUND);
```

LEVEL
Level 1.
NAME
dup2 — duplicate an open file-descriptor

SYNOPSIS

int dup2(fildes, fildes2)
int fildes, fildes2;

DESCRIPTION
The function dup2 causes duplication of an open file-descriptor.
The argument fildes is an open file-descriptor [see file-descriptor in Chapter 4 — Definitions].
The argument fildes2 is a non-negative integer less than {OPEN_MAX}.
The argument fildes2 is set to refer to the same file as the argument fildes. If fildes2 already refers to an open file, this file-descriptor is first closed.

RETURN VALUE
If successful, the function dup2 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 dup2 will fail and will set errno to:

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

EBADF if fildes2 is negative or greater than or equal to {OPEN_MAX}.

APPLICATION USAGE
The function dup2 was added in System V Release 3.0.

SEE ALSO
CREAT(BA_OS), CLOSE(BA_OS), DUP(BA_OS), EXEC(BA_OS), FCNTL(BA_OS), LOCKF(BA_OS), OPEN(BA_OS), PIPE(BA_OS).

LEVEL
Level 1.
NAME  
execl, execv, execl, 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 execl(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 argv 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 `exec1` 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 held (SIG_HOLD) by the calling-process will be held 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) and SIGSET(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), SIGNAL(BA_OS) and SIGSET(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)]
- record-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.
ENOENT if the path-name is longer than \{PATH_MAX\} characters.
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.

ELIBACC Reserved.

ELIBEXEC Reserved.

APPLICATION USAGE
Two interfaces for these functions are available. The list (l) versions: `execl`, `execle`, and `exclp` 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)`, `SIGSET(BA_OS)`, `TIMES(BA_OS)`, `ULIMIT(BA_OS)`, `UMASK(BA_OS)`.

LEVEL
Level 1.
FCNTL(BA_OS)

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 speci­
fied 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).
FCNTL(9OS)

F_GETFL  Get file status flags:
         O_RDONLY, O_WRONLY, O_RDWR, O_NDELAY, O_APPEND, O_SYNC
         [see OPEN(9OS)].

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

The following commands are used for 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.

If an ordinary file has enforced record locking enabled, then record-locks on the file will affect calls to `Creat(BA_OS), Open(BA_OS), Read(BA_OS), and Write(BA_OS).`
RETURN VALUE
If successful, the function `fcntl` will return a value greater than or equal to zero 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.
- `EBADF` if `cmd` is `F_SETLK` or `F_SETLKW`, the type of lock `L_type` is a read-lock (F_RDLCK), and `fildes` is not a valid file-descriptor open for reading.
- `EBADF` if `cmd` is `F_SETLK` or `F_SETLKW`, the type of lock `L_type` is a write-lock (F_WRLCK), and `fildes` is not a valid file-descriptor open for writing.
- `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 the data `arg` points to is not valid.
FCNTL(BA_OS)

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 `{LOCK_MAX}` regions are already locked in the system.

EDEADLK if `cmd` is `F_SETLKW` and a deadlock condition was detected.

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:

```c
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 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), 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].

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:

- real-user-id, real-group-id, effective-user-id, effective-group-id
- environment
- close-on-exec flag [see EXEC(BA_OS)]
- signal-handling settings (i.e., SIG_DFL, SIG_IGN, SIG_HOLD, address)
- set-user-ID mode bit
- set-group-ID mode bit
- process-group-ID
- tty-group-ID [see EXIT(BA_OS), SIGNAL(BA_OS) and SIGSET(BA_OS)]
- current-working-directory
- root-directory
- file mode creation mask [seeUMASK(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’ file-descriptors shares a common file-pointer with the corresponding file-descriptor of the parent-process.

The child-process’ utime, stime, cutime, and cstime [see TIMES(BA_OS)] are set to 0. The time left until an alarm clock signal is reset to 0.
FORK(BA_OS)

Record-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), SIGSET(BA_OS), TIMES(BA_OS), ULIMIT(BA_OS), UMASK(BA_OS), WAIT(BA_OS).

LEVEL
Level 1.
NAME
fread, fwrite — buffered input/output

SYNOPSIS

```c
#include <sys/types.h>
#include <stdio.h>

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

int fwrite(ptr, size, nitems, stream)
char *ptr;
size_t size;
int 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 `FERROR(BA_OS)` or `FEOF(BA_OS)` routines must be used to distinguish between an error condition and an end-of-file condition.
FREAD(BA_OS)

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),
SCANTF(BA_LIB). WRITE(BA_OS),

LEVEL
Level 1.
NAME
fseek, rewind, ftell — reposition a file-pointer in a stream

SYNOPSIS
#include <stdio.h>
#include <unistd.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 to the value of whence, which is defined in the <unistd.h> header file as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEEK_SET</td>
<td>set position equal to offset bytes.</td>
</tr>
<tr>
<td>SEEK_CUR</td>
<td>set position to current location plus offset.</td>
</tr>
<tr>
<td>SEEK_END</td>
<td>set position to EOF plus offset.</td>
</tr>
</tbody>
</table>

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

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

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.
FSEEK(BA_OS)

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

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 with advisory-mode or enforcement-mode locks depending on the mode of the file [see CHMOD(BA_OS)]. 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 {FCHP_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_UNLOCK 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' 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.
The function `lockf` will fail and will set `errno` to:

- **EBADF** if `fildes` is not a valid open file-descriptor.
- **EBADF** if `function` is `F_LOCK` or `F_TLOCK` and `fildes` is not a valid file-descriptor open for writing.
- **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 `{LOCK_MAX}` regions are already locked in the system.

**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:

```c
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 */
```

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].
LOCKF(BA__OS)

LEVEL
   Level 1.
NAME
lseek — move read/write file-pointer

SYNOPSIS
#include <unistd.h>

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

DESCRIPTION
The function lseek sets the file-pointer associated with fildes as specified
by the value of the argument whence. Symbolic constants for whence are
declared in the <unistd.h> header file:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEEK_SET</td>
<td>set file-pointer equal to offset bytes.</td>
</tr>
<tr>
<td>SEEK_CUR</td>
<td>set file-pointer to current location plus offset.</td>
</tr>
<tr>
<td>SEEK_END</td>
<td>set file-pointer to EOF plus offset.</td>
</tr>
</tbody>
</table>

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 SEEK_SET, SEEK_CUR, or SEEK_END.

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

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).

LEVEL
Level 1.
**NAME**

mkdir — make a directory

**SYNOPSIS**

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

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

**DESCRIPTION**

The function `mkdir` creates a new directory.

The argument `path` specifies the name of the new directory.

The argument `mode` specifies the initial mode of the new directory. The protection bits of the argument `mode` are modified by the process' file mode creation mask [see UMASK(BA_OS)]. The value of the argument `mode` should be the logical OR of the values of the desired permissions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_IREAD</td>
<td>Read by owner.</td>
</tr>
<tr>
<td>S_IWRITE</td>
<td>Write by owner.</td>
</tr>
<tr>
<td>S_IEXEC</td>
<td>Execute (search) by owner.</td>
</tr>
<tr>
<td>S_IRGRP</td>
<td>Read by group.</td>
</tr>
<tr>
<td>S_IWGRP</td>
<td>Write by group.</td>
</tr>
<tr>
<td>S_IXGRP</td>
<td>Execute (search) by group.</td>
</tr>
<tr>
<td>S_IROTH</td>
<td>Read by others (i.e., anyone else).</td>
</tr>
<tr>
<td>S_IWOTH</td>
<td>Write by others.</td>
</tr>
<tr>
<td>S_IXOTH</td>
<td>Execute (search) by others.</td>
</tr>
</tbody>
</table>

The directory's owner ID is set to the process' effective-user-ID. The directory's group ID is set to the process' effective-group-ID. The newly created directory is empty, except for possible directory entries for "." (the directory itself) and ".." (the parent-directory) [see directory in Chapter 4 — Definitions].

**RETURN VALUE**

If successful, `mkdir` will return a value of 0; otherwise, a value of -1 is returned, no directory is created, and `errno` will indicate the error.
MKDIR(BA_OS)††

ERRORS
Under the following conditions, the function mkdir 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-prefix does not exist.
- **ENOENT** if the path-name is longer than \{PATH_MAX\} characters.
- **EACCES** if a component of the path-prefix denies search permission, or if write permission is denied on the parent directory of the directory to be created.
- **EEXIST** if the named path-name exists.
- **EROFS** if the directory to be created is located on a read-only file system.
- **EMLINK** if the maximum number of links to the parent directory, \{LINK_MAX\}, would be exceeded.
- **EIO** if a physical I/O error has occurred.
- **ENOSPC** if there is no free space available on the device containing the directory.

APPLICATION USAGE
The function mkdir was added in System V Release 3.0.

SEE ALSO
CHMOD(BA_OS), UMASK(BA_OS).

LEVEL
Level 1.
NAME
mknod — make a directory, a special or ordinary file, or a FIFO

SYNOPSIS

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

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. Symbolic
constants defining the value of the argument mode are in the
<sys/stat.h> header file and should be used to construct mode. The value
of the argument mode should be the logical OR of the values of the desired
permissions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_IFMT</td>
<td>file type; one of the following:</td>
</tr>
<tr>
<td>S_IFIFO</td>
<td>FIFO-special</td>
</tr>
<tr>
<td>S_IFCHR</td>
<td>character-special</td>
</tr>
<tr>
<td>S_IFDIR</td>
<td>directory node</td>
</tr>
<tr>
<td>S_IFBLK</td>
<td>block-special</td>
</tr>
<tr>
<td>S_IFREG</td>
<td>ordinary-file</td>
</tr>
<tr>
<td>S_ISUID</td>
<td>set user-ID on execution</td>
</tr>
<tr>
<td>S_ISGID</td>
<td>set group-ID on execution</td>
</tr>
<tr>
<td>S_ISVTX</td>
<td>(reserved)</td>
</tr>
<tr>
<td>S_ENFMT</td>
<td>record locking enforced</td>
</tr>
<tr>
<td>S_IRUSR</td>
<td>read by owner</td>
</tr>
<tr>
<td>S_IWUSR</td>
<td>write by owner</td>
</tr>
</tbody>
</table>
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’ file mode creation mask: the function mknod clears each bit whose corresponding bit in the process’ 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_rdev 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.
ENOENT if the path-name is longer than \{PATH_MAX\} characters.
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.

**APPLICATION USAGE**

Normally, applications should use the MKDIR(BA_OS) routine to make a directory, since the function mknod may not establish directory entries for "." (the directory itself) and ".." (the parent-directory) [see directory in Chapter 4 — Definitions] and super-user privilege is not required.

**SEE ALSO**

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

**LEVEL**

Level 1.
OPEN(BA_OS)

NAME
open — open file 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 will affect subsequent reads and writes [see README(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_SYNC` If opening an ordinary file, this flag will affect subsequent writes. Each write [see `WRITE(BA_OS)`] should wait for both the file data and file status to be physically updated.

`O_CREAT` If the file does not exist, it 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' 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.

Otherwise, if the file exists and `O_EXCL` is not set, this flag has no effect.

`O_TRUNC` If the file exists, its length is truncated to 0 and the mode, owner, and group are unchanged.

`O_EXCL` If `O_CREAT` is set and the file exists, the function `open` will fail.

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)`].
OPEN(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.
- **ENOENT** if a component of the path-name should exist but does not.
- **ENOENT** if the path-name is longer than \{PATH_MAX\} characters.
- **EACCES** if a component of the path-prefix denies search permission.
- **EACCES** if O_CREAT is set, 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.
OPEN(BA_OS)

ENOSPC  if the directory to contain the file cannot be extended, the file does not exist, and O_CREAT is specified.

EAGAIN  if the file exists with enforced record locking enabled, there are record-locks on the file [see CHMOD(BA_OS)], and O_TRUNC 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).

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 asso­
ciated 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 ordinary file with enforced record locking
enabled [see CHMOD(BA_OS)], and all or part of the file to be read has a
write-lock owned by another process (i.e., a blocking write-lock):

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 all block­
ing write-locks are removed, or the function read is terminated by
a signal.
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. Otherwise,

if O_NDELAY is clear, the read will block until data is written to the pipe or the pipe is no longer open for writing.

if O_NDELAY is set, 0 will be returned.

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.

If O_NDELAY is set, 0 will be returned.

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.
EAGAIN if enforced record locking was enabled, O_NDELAY was set, and there was a write-lock owned by another process.
READ(BA_OS)

ENOLCK if \{LOCK_MAX\} regions are already locked in the system.

EDEADLK if O_NDELAY is clear and a deadlock condition was detected.

APPLICATION USAGE

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

When O_NDELAY is set, portable application-programs should test for two conditions to determine that no data is currently available, for example:

\begin{verbatim}
  fildes = open(path, O_RDONLY | O_NDELAY);
  ret = read(fildes, buf, nbyte);
  if (ret == 0 || (ret == -1 && errno == EAGAIN)) {
    /* Data not available now. */
  }
\end{verbatim}

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 \texttt{read} on a pipe, FIFO, or \texttt{tty-line} with the O_NDELAY flag set will return \texttt{-1}, rather than \texttt{0}, and \texttt{errno} will be set to EAGAIN.

LEVEL

Level 1.
NAME
   rmdir — remove a directory

SYNOPSIS
   int rmdir(path)
   char *path;

DESCRIPTION
   The function rmdir removes a directory.

   The argument path specifies the path-name of the directory to be removed.

   The directory must be empty, that is, not have any directory entries other
   than, possibly, "." (the directory itself) and ".." (the parent-directory) [see
   directory in Chapter 4 — Definitions].

RETURN VALUE
   If successful, rmdir will return a value of 0; otherwise, a value of -1 is
   returned, and errno will indicate the error.

ERRORS
   Under the following conditions, the function rmdir will fail and will set
   errno to:

   EEXIST  if the directory to be removed contains directory entries
           other than "." and "..".

   ENOTDIR  if a component of the path-prefix is not a directory.

   ENOENT  if the named directory does not exist.

   ENOENT  if the path-name is longer than {PATH_MAX} characters.

   EACCES  if a component of the path-prefix denies search permission,
           or if write permission is denied on the parent directory of the
           directory to be removed.

   EBUSY  if the directory to be removed is currently in use by the sys-
           tem.

   EROFS  if the directory to be removed is located on a read-only file
           system.

   EIO  if a physical I/O error has occurred.

APPLICATION USAGE
   The function rmdir was added in System V Release 3.0.

SEE ALSO
   MKDIR(BA_OS).
RMDIR(BA_OS)††

LEVEL
   Level 1.
NAME
setuid, setgid — set user-ID and group-IDs

SYNOPSIS

```c
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, effective-user-ID, and the saved set-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`.

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

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

```c
#include <signal.h>

void (*signal(sig, fun)(
int sig;
void (*fun)();
```

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 `fun` 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)*
- **SIGABRT** abort*
- **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

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

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SIGNAL(BA_OS)

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 argument func is assigned one of three values: SIG_DFL, SIG_IGN, or an address of a signal-catching function. The argument func is declared as type pointer to a function returning void. 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 the 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 SIG_ERR and errno will indicate the error.

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

EINVVAL  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

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

LEVEL

Level 1.
NAME
    sigset, sighold, sigrelse, sigignore — signal management

SYNOPSIS

    #include <signal.h>

    void (*sigset(sig, func))();
    int sig;
    void (*func)();

    int sighold(sig)
    int sig;

    int sigrelse(sig)
    int sig;

    int sigignore(sig)
    int sig;

DESCRIPTION

The functions **sigset**, **sighold**, **sigrelse**, and **sigignore** enhance the signal facility and provide signal management for application processes.

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)*
- **SIGABRT** abort*
- **SIGFPE**  floating point exception*

* The default action for these signals is an abnormal process termination. See **SIG_DFL**.
SIGSET(BA_OS)††

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 argument func is assigned one of four values: SIG_DFL, SIG_IGN, SIG_HOLD, or an address of a signal-catching function. The argument func is declared as type pointer to a function returning void. 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.

Any pending signal sig is discarded. A pending signal is a signal that has occurred but for which no action has been taken. The system signal action is set to ignore future occurrences of this signal type.

SIG_HOLD Hold signal.

The signal sig is to be held. Any pending signal of this type remains held. Only one signal of each type is held.
address  Catch signal.

Upon receipt of the signal sig, the receiving process is to execute the signal-catching function pointed to by func. Any pending signal of this type is released. This address is retained across calls to the other signal management functions, sighold and sigrelse. The signal number sig will be passed as the only argument to the signal-catching function. Before entering the signal-catching function, the value of func for the caught signal will be set to SIG_HOLD. During normal return from the signal-catching handler, the system signal action is restored to func and any held signal of this type is released. If a non-local goto [see SETJMP(BA_LIB)] is taken, the function sigrelse must be invoked to restore the system signal action and to release any held signal of this type.

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 the 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.

The function sigset specifies the system signal action to be taken upon receipt of the argument sig.

The function sighold and the function sigrelse establish critical regions of code. A call to the function sighold is analogous to raising the priority level and deferring or holding a signal until the priority is lowered by the function sigrelse. The function sigrelse restores the system signal action to the action that was previously specified by the function sigset.

The function sigignore sets the action for the argument sig to SIG_IGN.

RETURN VALUE
If successful, the function sigset will return the previous value of the system signal action for the specified signal sig; otherwise, it will return SIG_ERR and errno will indicate the error.
For the functions `sighold`, `sigrelse`, and `sigignore` a value of 0 will be returned upon success. Otherwise, a value of -1 will be returned and `errno` will indicate the error.

**ERRORS**

Under the following conditions, the functions `sigset`, `sighold`, `sigrelse`, and `sigignore` will fail and will set `errno` to:

- **EINVAL** if `sig` is an illegal signal number or `SIGKILL` or if the default handling of `sig` cannot be changed.

**APPLICATION USAGE**

The functions `sigset`, `sighold`, `sigrelse`, and `sigignore` were added in System V Release 3.0.

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.

The other signal management routine, `SIGNAL(BA_OS)`, should not be used in conjunction with these routines for a particular signal type.

**SEE ALSO**

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

**LEVEL**

Level 1.
NAME

time — get time

SYNOPSIS

#include <sys/types.h>

time_t time(tloc)
time_t *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

ustat — get file system statistics

SYNOPSIS

#include <sys/types.h>
#include <ustat.h>

int ustat(dev, buf)
  dev_t 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 informa­
 tion 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
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 argu­
ment 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.

For ordinary files, if the O_SYNC flag of the file status flags is set, the
write should not return until both the file data and file status have been
physically updated. For block special files, if O_SYNC is set, the write
should not return until the data has been physically updated. The way the
data reaches the physical media is implementation- and hardware­
dependent.

When attempting to write to an ordinary file with enforced record locking
enabled [see CHMOD(BA_OS)], and all or part of the file to be written has a
read or write lock owned by another process (i.e., a blocking lock):

If O_NDELAY is set, the function write will return -1 and
errno will be set to EAGAIN.

If O_NDELAY is clear, the function write will sleep until all
blocking locks are removed, or the function write is terminated by
a signal.
If a write requests that more bytes be written than there is room for (e.g., beyond the user process' 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.

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' 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.
- **EAGAIN** if enforced record locking was enabled, **O_NDELAY** was set and there were record locks on the file.
- **ENOLCK** if enforced record locking was enabled and **LOCK_MAX** regions are already locked in the system.
- **EDEADLK** if enforced record locking was enabled, **O_NDELAY** was clear and a deadlock condition was detected.
WRITE(BA_OS)

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.

When O_NDELAY is set, portable application-programs should test for two conditions to determine that no data is currently available, for example:

```c
fildes = open(path, O_WRONLY | O_NDELAY);
ret = write(fildes, buf, nbyte);
if (ret == 0 || (ret == -1 && errno == EAGAIN)) {
    /* Data not available now. */
}
```

Use of the O_SYNC flag should be used by applications that require extra reliability at the cost of performance.

SEE ALSO
CREAT(BA_OS), DUP(BA_OS), LSEEK(BA_OS), OPEN(BA_OS), PIPE(BA_OS), ULIMIT(BA_OS).

LEVEL
Level 1.
Chapter 7
General Library Routines
CLOCK(BA_LIB)

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), PCLOSE(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), POPEN(BA_OS), SYSTEM(BA_OS).

LEVEL
Level 1.
NAME
cctime, localtime, gmtime, asctime, tzset — convert date and time to string

SYNOPSIS

#include <sys/types.h>
#include <time.h>

char *ctime(clock)
time_t *clock;

struct tm *localtime(clock)
time_t *clock;

struct tm *gmtime(clock)
time_t *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 value of type time_t, 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 Saving 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:

```c
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 Saving 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 Saving 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

```c
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 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
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, x 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).

LEVEL
Level 1.
NAME

gopt — get option letter from argument vector

SYNOPSIS

```c
int getopt(argc, argv, optstring)
int argc;
char *argv[], *optstring;

extern char *optarg;
extern int optind, opterr;
```

DESCRIPTION

The function `gopt` is a command-line parser. It returns the next option letter in `argv` that matches a letter in `optstring`.

The function `gopt` 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 `gopt`.

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 must be separated from it by white space.

The variable `optarg` is set to point to the start of the option argument on return from `gopt`.

When all options have been processed (i.e., up to the first non-option argument), the function `gopt` returns EOF. The special option `--` may be used to delimit the end of the options; EOF will be returned and `--` will be skipped.

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.
GETOPT(BA_LIB)

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.

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 opt-string. 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:

```c
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': case 'f': case 'o':
                aflg++;
            break;
        case '?': errflg++;
        }
    if (errflg) {
        fprintf(stderr, "usage: ...
    exit(2);
    }
    for ( ; optind < argc; optind++) {
        if (access(argv[optind], 4)) {
            ...
        }
    }
```

LEVEL

Level 1.
PRINTF(BA_LIB)

NAME
printf, fprintf, sprintf — print formatted output

SYNOPSIS

#include <stdio.h>

int printf(format [ , arg ] ...)
cchar *format;

int fprintf(stream, format [ , arg ] ...)
FILE *stream;
cchar *format;

int sprintf(s, format [ , arg ] ...)
cchar *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, i, 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, E and f conversions, the maximum number of significant digits for the g and 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. Padding specified by the precision overrides the padding specified by the field width.

An optional 1 (ell) to specify that a following d, i, o, u, x or X conversion character applies to a long integer arg. An 1 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. If the precision argument is
negative, it will be changed to zero.

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, i, 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, i, o, u, x, X** The integer arg is converted to signed decimal (d or i), 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.
The float or double **arg** is converted to the style \([-\text{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 \(1\text{E}+100\), additional exponent digits will be printed as necessary.

**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.

**The character arg is printed.**

**The arg is taken to be a string (character pointer) and characters from the string are printed until a null character (\(\text{\textbackslash 0}\)) 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.
PRINTF(BA_LIB)

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 %i, %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 \( \infty \) and "not a number" (NaN: a symbolic entity encoded in floating point format) to support the IEEE P754 standard.

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 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 charac-
   ter 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.
- i: an integer is expected; the corresponding argument should be an integer pointer. The value of the next input item, interpreted according to C conventions, will be stored; a leading 0 implies octal; a leading Ox implies hexadecimal; otherwise, decimal is assumed.
- n: causes the total number of characters (including white space) that have been scanned so far since the function call to be stored; the corresponding argument should be an integer pointer. No input is consumed.
- 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 \texttt{E} or an \texttt{e}, followed by an optionally signed integer.

\texttt{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 \ \texttt{\0}, \ which will \ be \ added \ automatically. \ The \ input \ field \ is \ terminated \ by \ a white-space \ character.

\texttt{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.

\texttt{[} \ 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 \ \texttt{scanset} \ and \ a \ right \ bracket; \ the \ input \ field is \ the \ maximal \ sequence \ of \ input \ characters \ consisting \ entirely of \ characters \ in \ the \ scanset. \ The \ circumflex \ (\texttt{"\^"}), \ 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 \texttt{first-last}, \ thus [0123456789] may be expressed [0-9]. Using this convention, \texttt{first} must be lexically less than or equal to \texttt{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 \texttt{\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.
SCANF(BA_LIB)

The conversion characters d, u, o, x, and i 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:

```c
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:

```c
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\n$\infty$ and "not a number" (NaN: a symbolic entity encoded in floating point\nformat) to support the IEEE P754 standard.

LEVEL
Level 1.
STRING(BA_LIB)

NAME
strcat, strlen, strcmp, strcpy, strncpy, strdup, strlen, strchr, strchr, strpbrk, strspn, strcspn, strtok — string operations

SYNOPSIS
#include <string.h>
#include <sys/types.h>

char *strcat(s1, s2)
char *s1, *s2;

char *strncat(s1, s2, n)
char *s1, *s2;
size_t n;

int strcmp(s1, s2)
char *s1, *s2;

int strncmp(s1, s2, n)
char *s1, *s2;
size_t n;

char *strcpy(s1, s2)
char *s1, *s2;

char *strncpy(s1, s2, n)
char *s1, *s2;
size_t n;

char *strdup(s1)
char *s1;

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 type `size_t` is defined in the `<sys/types.h>` header file.

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 function `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 `strdup` returns a pointer to a new string, which is a duplicate of the string pointed to by s1. Space for the new string is obtained using `MALLOC(BA_OS)`. A NULL pointer is returned if the new string cannot be created.

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 value returned by `strlen` will be declared as `size_t`.

**LEVEL**
Level 1.
Appendix

Changes From Issue 2 Volume 1
Appendix
Changes From Issue 2 Volume 1

This Appendix documents changes from Issue 2, Volume 1 of the Base System Definition of the System V Interface Definition. Only changes that serve to clarify information, provide additional information, or identify incorrect information that appears in Issue 2, Volume 1 are documented. Changes that do not alter meaning are not listed below.

The paragraphs below identify specific changes to detailed component definitions:

1. BASE SYSTEM DIFFERENCES

   Environment.

   ERRORS(BA_ENV)

   The errno ENOENT has the added meaning that a path-name argument to a BA_OS function is longer than \{PATH_MAX\} characters. This affects the functions ACCESS(BA_OS), CHDIR(BA_OS), CHMOD(BA_OS), CHOWN(BA_OS), CREAT(BA_OS), EXEC(BA_OS), FOPEN(BA_OS), LINK(BA_OS), MKNOO(BA_OS), OPEN(BA_OS), STAT(BA_OS), UNLlNK(BA_OS), and UTIME(BA_OS).

   FUTURE DIRECTION: To conform with the IEEE POSIX standard, when it is adopted as a full-use standard, the value of errno indicating that a path-name argument exceeds \{PATH_MAX\} characters may be changed. Currently, the POSIX trial-use draft specifies ENAMETOOLONG for this condition.

   TERMIO(BA_ENV)

   Issue 2 incorrectly listed 38400 as a valid baud rate. This baud rate should be deleted.

   OS Service Routines.

   CHMOD(BA_OS)

   Issue 2 identified the access permission bit 01000 as (execute or search by group) in the FUTURE DIRECTIONS section; this should correctly refer to access permission bit 00010.
In Issue 2, the first paragraph under DESCRIPTION should be changed to the following:

The function **ferror** determines if an I/O error (e.g., EINTR, ENOSPC) has occurred when reading from or writing to the file associated with the named stream.

The last statement in the RETURN VALUE section should state:

The function **fopen** or the function **fdopen** may also fail if there are no free **stdio** streams and may not set **errno**.

Issue 2 defined the default value for **maxfast** to be 0. This value should be defined as implementation dependent.

Issue 2 specified that the **mode** argument to the OPEN(BA_OS) routine was required. This argument should be defined to be optional, i.e., **int open (path, oflag [,mode])**.

**General Library Routines**

Issue 2 incorrectly specified the function names on the NAME line. This line should state:

**compile, step, advance — regular-expression compile and match routines**

In Issue 2, the last paragraph under APPLICATION USAGE should be deleted.

The last sentence of the last paragraph in the DESCRIPTION section should be changed to the following:

All accessible variables of storage class static or external have values as of the time the function **longjmp** was called. The values of variables of storage class automatic or register are indeterminate.
Issue 2 incorrectly described the RETURN VALUE, which should correctly read:

If the temporary file cannot be opened, a NULL pointer is returned.

VPRINTF(BA_LIB)  
Issue 2 presented an incomplete statement in the EXAMPLE. The line

    (void) fprintf(stderr, " ERR in %s:

should correctly read

    (void) fprintf(stderr, " ERR in %s: 
    va_arg (args, char *));

The following section should appear under the APPLICATION USAGE section.

Specification of a second argument to the va_arg macro of type char, short, or float is non-portable, since arguments seen by the called function are not char, short, or float. The C compiler converts char and short arguments to int and converts float arguments to double before passing them to a function.

2. KERNEL EXTENSION DIFFERENCES

MSGOP(KE_OS)  
Issue 2 incorrectly specified the function names on the NAME line. This line should state:

    msgsnd, msgrcv — message operations

PROFIL(KE_OS)  
Issue 2 incorrectly specified types for two of the arguments to profil. The argument buff should be defined as short *buff and the argument offset should be defined as void (*offset()).

PTRACE(KE_OS)  
The description of the action to be taken when the value of the argument request is 7 should read as follows:

7  
This request causes the child to resume execution. The data argument is taken as a signal number and the child’s execution continues at location addr as if it had incurred that signal. Normally the signal number will be either 0 to indicate that the signal that caused the stop should be
ignored, or the value of the signal that caused the stop. If \texttt{addr} is 1, then execution continues from where it stopped.

Upon successful completion, the value of \texttt{data} is returned to the parent. This request will fail if \texttt{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 \texttt{errno} is set to \texttt{EIO}.

**SEMGET(KE_OS)**

Issue 2 incorrectly included a paragraph in the \texttt{DESCRIPTION} section. The last paragraph, which states "The data structure associated with each semaphor in the set is not initialized. The function \texttt{semctl} with the command \texttt{SETVAL} or \texttt{SETALL} can be used to initialize each semaphore.", should be removed.

**SEMOP(KE_OS)**

Issue 2 incorrectly specified use of \texttt{IPC_CREAT} instead of \texttt{IPC_NOWAIT}. All instances of \texttt{IPC_CREAT} should be replaced by \texttt{IPC_NOWAIT}.

**SHMOP(KE_OS)**

Issue 2 incorrectly specified the function names on the \texttt{NAME} line. This line should state:

```
shmat, shmdt — shared-memory-operations
```
Part III

Terminal Interface Extension Definition
Chapter 8
Introduction

8.1 OVERVIEW
The Terminal Interface Extension (TI) 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 the terminal actually in use. Currently, the `curses/terminfo` package supports asynchronous character terminals.

The System V Base, the Basic Utilities Extension, the Advanced Utilities Extension, and the Software Development Extension are prerequisites for the Terminal Interface Extension.

The components of the Terminal Interface Extension are new in System V Release 2.

8.2 DESCRIPTION

DATA FILES

`/usr/lib/terminfo/?/*`

UTILITIES

tic  tput
### LIBRARY ROUTINES

#### General Routines

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** Level 2: December 1, 1985.

### 8.3 DEFINITIONS

The following environment variables are used by the components of the TI extension. See `SH(BU_CMD)` for information on the shell environment.

**TERM**
The environmental variable `TERM` usually contains a user’s current terminal type and can be set by the user.

**TERMINFO**
The environmental variable `TERMINFO`, if set, contains the place where local terminal descriptions can be found. `TERMINFO` can be set by the user. If it is set, any program using `CURSES(TI_LIB)` will check the `TERMINFO` location for a terminal’s description before checking `/usr/lib/terminfo`, the standard location for terminal descriptions. See `CURSES(TI_LIB)` and `TERMINFO(TILENV)` for further information.

**LINES and COLUMNS**
The environmental variables `LINES` and `COLUMNS`, if set, contain the number of lines and number of columns, respectively, on a terminal screen and can be set by the user. If defined, the values of these variables, `LINES` and `COLUMNS`, will override the screen size values given in a terminal’s `terminfo` [see `TERMINFO(TILENV)`] description. See `CURSES(TI_LIB)` for further information.
8.4 TRADEMARKS

Tektronix is a registered trademark of Tektronix, Inc.
TeleVideo is a registered trademark of TeleVideo Systems, Inc.
VT100 is a trademark of Digital Equipment Corporation.
LSI is a trademark of Lear Siegler, Inc.
HP is a trademark of Hewlett-Packard Co.
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Teleray is a trademark of Research, Inc.
Micro-Term, ACT and MIME are trademarks of Micro-Term, Inc.
Concept is a trademark of Human Designed Systems, Inc.
NAME

terminfo - terminal capability database

SYNOPSIS

/usr/lib/terminfo/*

DESCRIPTION

The terminfo database describes terminals, by giving a set of capabilities which they have, by describing how operations are performed, by describing padding requirements, and by specifying initialization sequences. The terminfo database is built by using the TIC(TI_CMD) compiler.

The terminfo source files consist of entries that contain a number of comma-separated fields. White space after each comma is ignored. The first entry for each terminal gives the names which are known for the terminal, separated by vertical bar (|) characters. The first name given is the most common abbreviation for the terminal; the last name given should be a long name fully identifying the terminal; and all others are understood as synonyms for the terminal name. All names but the last should be in lowercase letters and contain no blanks; the last name may well contain uppercase letters and blanks for readability.

Terminal names (except for the last, verbose entry) should be chosen using the following conventions. The particular piece of hardware making up the terminal should have a root name chosen, for example, “att4424”. Modes that the hardware can be in, or user preferences, should be indicated by appending a hyphen and an indicator of the mode. The following suffixes should be used where possible:

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>-w</td>
<td>Wide mode (more than 80 columns)</td>
</tr>
<tr>
<td>-am</td>
<td>With automatic margins (usually default)</td>
</tr>
<tr>
<td>-nam</td>
<td>Without automatic margins</td>
</tr>
<tr>
<td>-n</td>
<td>Number of lines on the screen (e.g., -60)</td>
</tr>
<tr>
<td>-na</td>
<td>No arrow keys (leave them in local)</td>
</tr>
<tr>
<td>-np</td>
<td>Number of pages of memory (e.g., -8p)</td>
</tr>
<tr>
<td>-rv</td>
<td>Reverse video</td>
</tr>
</tbody>
</table>

To avoid conflicts with the naming conventions used in describing the different modes of a terminal (e.g., -w), it is recommended that a terminal’s root name not contain hyphens. Further, it is good practice to make all terminal names used in the terminfo database unique.
Capabilities

In the table below, "Variable" is the name by which the programmer (at the terminfo level) accesses the capability. "Capname" is the short name used in the text of the database, and is used by a person updating the database. The "Termcap Code" is the two letter code that corresponds to the old termcap capability name.

Capability names have no hard length limit, but an informal limit of 5 characters has been adopted to keep them short. Whenever possible, names are chosen to be the same as or similar to the ANSI X3.64-1979 standard. Semantics are also intended to match those of the specification.

All string capabilities listed below may have padding specified, with the exception of those used for input. Input capabilities, listed under the Strings section of the table below, are denoted by the string key_ at the beginning of their variable name. The following indicators may appear at the end of the Description for a variable.

(G) indicates that the string is passed through tparm() with parms as given (#i).

(*) indicates that padding may be based on the number of lines affected.

(#) indicates the i_th parameter.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cap-</th>
<th>Term-</th>
<th>Description Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>auto_left_margin</td>
<td>bw</td>
<td>bw</td>
<td>cub1 wraps from col 0 to last column</td>
</tr>
<tr>
<td>auto_right_margin</td>
<td>am</td>
<td>am</td>
<td>Terminal has automatic margins</td>
</tr>
<tr>
<td>ceol_standout_glitch</td>
<td>xhp</td>
<td>xs</td>
<td>Standout not erased by overwriting</td>
</tr>
<tr>
<td>dest_tabs_magic_smso</td>
<td>xt</td>
<td>xt</td>
<td>Destructive tabs, magic smso char</td>
</tr>
<tr>
<td>eat_newline_glitch</td>
<td>xenl</td>
<td>xn</td>
<td>Newline ignored after 80 cols</td>
</tr>
<tr>
<td>erase_overstrike</td>
<td>eo</td>
<td>eo</td>
<td>Can erase overstrikes with a blank</td>
</tr>
<tr>
<td>generic_type</td>
<td>gn</td>
<td>gn</td>
<td>Generic line type (e.g., dialup, switch)</td>
</tr>
<tr>
<td>hard_copy</td>
<td>hc</td>
<td>hc</td>
<td>Hardcopy terminal</td>
</tr>
<tr>
<td>hard_cursor</td>
<td>chts</td>
<td>HC</td>
<td>Cursor is hard to see</td>
</tr>
<tr>
<td>has_meta_key</td>
<td>km</td>
<td>km</td>
<td>(Reserved)</td>
</tr>
<tr>
<td>has_status_line</td>
<td>hs</td>
<td>hs</td>
<td>Has extra &quot;status line&quot;</td>
</tr>
<tr>
<td>insert_null_glitch</td>
<td>in</td>
<td>in</td>
<td>Insert mode distinguishes nulls</td>
</tr>
<tr>
<td>memory_above</td>
<td>da</td>
<td>da</td>
<td>Display may be retained above screen</td>
</tr>
<tr>
<td>Variable</td>
<td>Cap-name</td>
<td>Term-cap</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>memory_below</td>
<td>db</td>
<td>db</td>
<td>Display may be retained below screen</td>
</tr>
<tr>
<td>move_insert_mode</td>
<td>mir</td>
<td>mi</td>
<td>Safe to move while in insert mode</td>
</tr>
<tr>
<td>move_standout_mode</td>
<td>msgr</td>
<td>ms</td>
<td>Safe to move in standout modes</td>
</tr>
<tr>
<td>needs_xon_xoff</td>
<td>nxon</td>
<td>nx</td>
<td>Padding won't work, xon/xoff required</td>
</tr>
<tr>
<td>(Reserved)</td>
<td>xsb</td>
<td>xb</td>
<td></td>
</tr>
<tr>
<td>no_pad_char</td>
<td>npc</td>
<td>NP</td>
<td>'Pad character doesn't exist.</td>
</tr>
<tr>
<td>non_rev_rmcup</td>
<td>nrrmc</td>
<td>NR</td>
<td>smcup does not reverse rmcup.</td>
</tr>
<tr>
<td>over_strike</td>
<td>os</td>
<td>os</td>
<td>Terminal overstrikes</td>
</tr>
<tr>
<td>prtr_silent</td>
<td>mc5i</td>
<td>5i</td>
<td>Printer won't echo on screen.</td>
</tr>
<tr>
<td>status_line_esc_ok</td>
<td>eslok</td>
<td>es</td>
<td>Escape can be used on the status line</td>
</tr>
<tr>
<td>tilde_glitch</td>
<td>hz</td>
<td>hz</td>
<td>Cannot print tildes</td>
</tr>
<tr>
<td>transparent_underline</td>
<td>ul</td>
<td>ul</td>
<td>Underline character overstrikes</td>
</tr>
<tr>
<td>xon_xoff</td>
<td>xon</td>
<td>xo</td>
<td>Terminal uses xon/xoff handshaking</td>
</tr>
</tbody>
</table>

**Numbers:**
- columns: cols, co
  - Number of columns in a line
- init_tabs: it, it
  -Tabs initially every # spaces
- label_height: lh, lh
  - Number of rows in each label
- label_width: lw, lw
  - Number of cols in each label
- lines: lines, li
  - Number of lines on screen or page
- lines_of_memory: lm, lm
  - Lines of memory if > lines, 0=varies
- magic_cookie_glitch: xmc, sg
  - Number of blank chars left by smso or rmso
- num_labels: nlab, Nl
  - Number of labels on screen (start at 1)
- padding_baud_rate: pb, pb
  - Lowest baud where padding is needed
- virtual_terminal: vt, vt
  - (Reserved)
- width_status_line: wsl, ws
  - Number of columns in status line

**Strings:**
- acs_chars: acsc, ac
  - Graphic charset pairs aAbBcC - default=vt100
- back_tab: cbt, bt
  - Back tab
- bell: bel, bl
  - Audible signal (bell)
- carriage_return: cr, cr
  - Carriage return (*)
- change_scroll_region: csr, cs
  - Change to lines #1 through #2 (G)
- char_padding: rmp, rP
  - Like ip but when in replace mode
- clear_all_tabs: tbc, ct
  - Clear all tab stops
- clearMargins: mge, MC
  - Clear left and right soft margins
- clear_screen: clear, cl
  - Clear screen and home cursor (*)
- clr_bol: el, cb
  - Clear to beginning of line, inclusive
- clr_eol: el, ce
  - Clear to end of line
- clr_eos: ed, cd
  - Clear to end of display (*)
- column_address: hpa, ch
  - Horizontal position absolute (G)
- command_character: cmdch, CC
  - (Reserved)
- cursor_address: cup, cm
  - Cursor motion to row #1 col #2 (G)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Cap-name</th>
<th>Term-cap</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_down</td>
<td>cud1</td>
<td>do</td>
<td>Down one line</td>
</tr>
<tr>
<td>cursor_home</td>
<td>home</td>
<td>ho</td>
<td>Home cursor (if no cup)</td>
</tr>
<tr>
<td>cursor_invisible</td>
<td>civis</td>
<td>vi</td>
<td>Make cursor invisible</td>
</tr>
<tr>
<td>cursor_left</td>
<td>cub1</td>
<td>le</td>
<td>Move cursor left one space</td>
</tr>
<tr>
<td>cursor_mem_address</td>
<td>mrcup</td>
<td>CM</td>
<td>Memory relative cursor addressing</td>
</tr>
<tr>
<td>cursor_normal</td>
<td>cnorm</td>
<td>ve</td>
<td>Make cursor appear normal (undo vs/vi)</td>
</tr>
<tr>
<td>cursor_right</td>
<td>cufl</td>
<td>nd</td>
<td>Non-destructive space (cursor right)</td>
</tr>
<tr>
<td>cursor_to_ll</td>
<td>ll</td>
<td>ll</td>
<td>Last line, first column (if no cup)</td>
</tr>
<tr>
<td>cursor_up</td>
<td>cuu1</td>
<td>up</td>
<td>Upline (cursor up)</td>
</tr>
<tr>
<td>cursor_visible</td>
<td>cvvis</td>
<td>vs</td>
<td>Make cursor very visible</td>
</tr>
<tr>
<td>delete_character</td>
<td>dch1</td>
<td>dc</td>
<td>Delete character (*)</td>
</tr>
<tr>
<td>delete_line</td>
<td>dl1</td>
<td>dl</td>
<td>Delete line (*)</td>
</tr>
<tr>
<td>dis_status_line</td>
<td>dsl</td>
<td>ds</td>
<td>Disable status line</td>
</tr>
<tr>
<td>down_half_line</td>
<td>hd</td>
<td>hd</td>
<td>Half-line down (forward 1/2 linefeed)</td>
</tr>
<tr>
<td>ena_acs</td>
<td>enacs</td>
<td>eA</td>
<td>Enable alternate char set</td>
</tr>
<tr>
<td>enter_alt_charset_mode</td>
<td>smacs</td>
<td>as</td>
<td>Start alternate character set</td>
</tr>
<tr>
<td>enter_am_mode</td>
<td>smam</td>
<td>SA</td>
<td>Turn on automatic margins</td>
</tr>
<tr>
<td>enter_blink_mode</td>
<td>blink</td>
<td>mb</td>
<td>Turn on blinking</td>
</tr>
<tr>
<td>enter_bold_mode</td>
<td>bold</td>
<td>md</td>
<td>Turn on bold (extra bright) mode</td>
</tr>
<tr>
<td>enter_ca_mode</td>
<td>smcup</td>
<td>ti</td>
<td>String to begin programs that use cup</td>
</tr>
<tr>
<td>enter_delete_mode</td>
<td>smdc</td>
<td>dm</td>
<td>Delete mode (enter)</td>
</tr>
<tr>
<td>enter_dim_mode</td>
<td>dim</td>
<td>mh</td>
<td>Turn on half-bright mode</td>
</tr>
<tr>
<td>enter_insert_mode</td>
<td>smir</td>
<td>im</td>
<td>Insert mode (enter)</td>
</tr>
<tr>
<td>enter_protected_mode</td>
<td>prot</td>
<td>mp</td>
<td>Turn on protected mode</td>
</tr>
<tr>
<td>enter_reverse_mode</td>
<td>rev</td>
<td>mr</td>
<td>Turn on reverse video mode</td>
</tr>
<tr>
<td>enter_secure_mode</td>
<td>invis</td>
<td>mk</td>
<td>Turn on blank mode (chars invisible)</td>
</tr>
<tr>
<td>enter_standout_mode</td>
<td>smso</td>
<td>so</td>
<td>Begin standout mode</td>
</tr>
<tr>
<td>enter_underline_mode</td>
<td>smul</td>
<td>us</td>
<td>Start underscore mode</td>
</tr>
<tr>
<td>enter_xon_mode</td>
<td>smxon</td>
<td>SX</td>
<td>Turn on xon/xoff handshaking</td>
</tr>
<tr>
<td>erase_chars</td>
<td>ech</td>
<td>ec</td>
<td>Erase #1 characters (G)</td>
</tr>
<tr>
<td>exit_alt_charset_mode</td>
<td>rmacs</td>
<td>ae</td>
<td>End alternate character set</td>
</tr>
<tr>
<td>exit_am_mode</td>
<td>rmam</td>
<td>RA</td>
<td>Turn off automatic margins</td>
</tr>
<tr>
<td>exit_attribute_mode</td>
<td>sgr0</td>
<td>me</td>
<td>Turn off all attributes</td>
</tr>
<tr>
<td>exit_ca_mode</td>
<td>rmcup</td>
<td>te</td>
<td>String to end programs that use cup</td>
</tr>
<tr>
<td>exit_delete_mode</td>
<td>rmdc</td>
<td>ed</td>
<td>End delete mode</td>
</tr>
<tr>
<td>exit_insert_mode</td>
<td>rmir</td>
<td>ei</td>
<td>End insert mode</td>
</tr>
<tr>
<td>exit_standout_mode</td>
<td>rmso</td>
<td>se</td>
<td>End standout mode</td>
</tr>
<tr>
<td>exit_underline_mode</td>
<td>rmul</td>
<td>ue</td>
<td>End underscore mode</td>
</tr>
<tr>
<td>exit_xon_mode</td>
<td>rmxon</td>
<td>RX</td>
<td>Turn off xon/xoff handshaking</td>
</tr>
<tr>
<td>flash_screen</td>
<td>flash</td>
<td>vb</td>
<td>Visible bell (may not move cursor)</td>
</tr>
<tr>
<td>form_feed</td>
<td>ff</td>
<td>ff</td>
<td>Hardcopy terminal page eject (**)</td>
</tr>
<tr>
<td>from_status_line</td>
<td>fsl</td>
<td>fs</td>
<td>Return from status line</td>
</tr>
</tbody>
</table>

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**TERMINFO(TI_ENV)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cap-name</th>
<th>Term-cap</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>init_1string</td>
<td>is1</td>
<td>i1</td>
<td>Terminal initialization string</td>
</tr>
<tr>
<td>init_2string</td>
<td>is2</td>
<td>is</td>
<td>Terminal initialization string</td>
</tr>
<tr>
<td>init_3string</td>
<td>is3</td>
<td>i3</td>
<td>Terminal initialization string</td>
</tr>
<tr>
<td>init_file</td>
<td>if</td>
<td>if</td>
<td>Name of file containing is</td>
</tr>
<tr>
<td>init_prog</td>
<td>iprog</td>
<td>iP</td>
<td>Path name of program for init</td>
</tr>
<tr>
<td>insert_character</td>
<td>ich1</td>
<td>ic</td>
<td>Insert character</td>
</tr>
<tr>
<td>insert_line</td>
<td>il1</td>
<td>al</td>
<td>Add new blank line (*)</td>
</tr>
<tr>
<td>insert_padding</td>
<td>ip</td>
<td>ip</td>
<td>Insert pad after character inserted(*)</td>
</tr>
<tr>
<td>key_a1</td>
<td>ka1</td>
<td>K1</td>
<td>KEY_A1, Upper left of keypad</td>
</tr>
<tr>
<td>key_a3</td>
<td>ka3</td>
<td>K3</td>
<td>KEY_A3, Upper right of keypad</td>
</tr>
<tr>
<td>key_b2</td>
<td>kb2</td>
<td>K2</td>
<td>KEY_B2, Center of keypad</td>
</tr>
<tr>
<td>key_c1</td>
<td>kc1</td>
<td>K4</td>
<td>KEY_C1, Lower left of keypad</td>
</tr>
<tr>
<td>key_c3</td>
<td>kc3</td>
<td>K5</td>
<td>KEY_C3, Lower right of keypad</td>
</tr>
<tr>
<td>key_backspace</td>
<td>kbs</td>
<td>kb</td>
<td>KEY_BACKSPACE, Sent by backspace key</td>
</tr>
<tr>
<td>key_beg</td>
<td>kbeg</td>
<td>@1</td>
<td>KEY_BEG, Begin/innning key</td>
</tr>
<tr>
<td>key_btab</td>
<td>kcbt</td>
<td>kB</td>
<td>KEY_BTAB, Back tab key</td>
</tr>
<tr>
<td>key_cancel</td>
<td>kcan</td>
<td>@2</td>
<td>KEY_CANCEL, Cancel key</td>
</tr>
<tr>
<td>key_catab</td>
<td>ktbc</td>
<td>ka</td>
<td>KEY_CATAB, Sent by clear-all-tabs key</td>
</tr>
<tr>
<td>key_clear</td>
<td>kclr</td>
<td>kC</td>
<td>KEY_CLEAR, Sent by clear screen or erase key</td>
</tr>
<tr>
<td>key_close</td>
<td>kclo</td>
<td>@3</td>
<td>KEY_CLOSE, Close key</td>
</tr>
<tr>
<td>key_command</td>
<td>kcmd</td>
<td>@4</td>
<td>KEY_COMMAND, Cmd (command) key</td>
</tr>
<tr>
<td>key_copy</td>
<td>kcpy</td>
<td>@5</td>
<td>KEY_COPY, Copy key</td>
</tr>
<tr>
<td>key_create</td>
<td>kcrt</td>
<td>@6</td>
<td>KEY_CREATE, Create key</td>
</tr>
<tr>
<td>key_ctab</td>
<td>kctab</td>
<td>kt</td>
<td>KEY_CTAB, Sent by clear-tab key</td>
</tr>
<tr>
<td>key_dc</td>
<td>kdch1</td>
<td>kD</td>
<td>KEY_DC, Sent by delete character key</td>
</tr>
<tr>
<td>key_dl</td>
<td>kd1</td>
<td>kL</td>
<td>KEY_DL, Sent by delete line key</td>
</tr>
<tr>
<td>key_down</td>
<td>kcd1</td>
<td>kd</td>
<td>KEY_DOWN, Sent by terminal down arrow key</td>
</tr>
<tr>
<td>key_eic</td>
<td>krmir</td>
<td>kM</td>
<td>KEY_EIC, Sent by rmir or smir in insert mode</td>
</tr>
<tr>
<td>key_end</td>
<td>kend</td>
<td>@7</td>
<td>KEY_END, End key</td>
</tr>
<tr>
<td>key_enter</td>
<td>kent</td>
<td>@8</td>
<td>KEY_ENTER, Enter/send</td>
</tr>
<tr>
<td>key_eol</td>
<td>kel</td>
<td>kE</td>
<td>KEY_EOL, Sent by clear-to-end-of-line key</td>
</tr>
<tr>
<td>key_eos</td>
<td>ked</td>
<td>kS</td>
<td>KEY_EOS, Sent by clear-to-end-of-screen key</td>
</tr>
<tr>
<td>key_exit</td>
<td>kext</td>
<td>@9</td>
<td>KEY_EXIT, Sent by exit key</td>
</tr>
<tr>
<td>key_f0</td>
<td>kf0</td>
<td>k0</td>
<td>KEY_F(0), Sent by function key f0</td>
</tr>
<tr>
<td>key_f1</td>
<td>kf1</td>
<td>k1</td>
<td>KEY_F(1), Sent by function key f1</td>
</tr>
<tr>
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<td>Labels on function key f5 if not f5</td>
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<td>l6</td>
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## Variable Cap-name Term-cap Description Code

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cap-name</th>
<th>Term-cap</th>
<th>Description</th>
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<tbody>
<tr>
<td>tab</td>
<td>ht</td>
<td>ta</td>
<td>Tab to next 8 space hardware tab stop</td>
</tr>
<tr>
<td>to_status_line</td>
<td>tsl</td>
<td>ts</td>
<td>Go to status line, column #1</td>
</tr>
<tr>
<td>underline_char</td>
<td>uc</td>
<td>uc</td>
<td>Underscore one char and move past it</td>
</tr>
<tr>
<td>up_half_line</td>
<td>hu</td>
<td>hu</td>
<td>Half-line up (reverse 1/2 linefeed)</td>
</tr>
<tr>
<td>xoff_character</td>
<td>xoffc</td>
<td>XF</td>
<td>X-off character</td>
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<tr>
<td>xon_character</td>
<td>xonc</td>
<td>XN</td>
<td>X-on character</td>
</tr>
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</table>

### A Sample Entry

The following entry, which describes the `Concept-100` terminal, is among the more complex entries in the `terminfo` file.

```
concept100 | c100 | concept | c104 | c100-4p | concept 100,
            am, db, eo, in, mir, ul, xenl,
            cols=80, lines=24, pb=9600, vt=8,
            bel='G', blank=\EH, blink=\EC, clear=\L$<2*>,
            cnorm=\EW, cr=\M$<9>, cub1=\H, cud1=\J,
            cufl=E, cup=\Ea%p1' '%+%c%p2' '%+%c,
            cuu1=E; , cvvis=\EW, dch1=\E<A$<16*>, dim=\EE,
            dl1=\E$<3*>, ed=\E+C$<16*>, el=\E+$<16*>,
            flash=\Ek$<20>\EK, ht=\t$<8>, il1=\E*R$<3*>,
            ind=\J, .ind=\J$<9>, ip=$<16*>,
            is2=\EUF\E7\E5\E8\EI\ENH\EK\E0\Ec\0\Ec/47\E,
            kbs='h, kcub1=E>, kcud1=E<, kcuf1=E=, kcuu1=E; ,
            kf1=E5, kf2=E6, kf3=E7, khome=E?,
            prot=\EI, rep=\Er%p1%c%p2% ' '%+%c$.<2*>,
            rev=\ED, rmcup=\Ev\s\s\s\s<s6>\Ep\r'n,
            rmir=\E0, rmkx=\EX, rmmso=\Ed\Ee, rmul=\Eg,
            rmul=\Eg, sgr0=\EN0, smcup=\Ev\s\s8p\Ep\r,
            smir=\Ep, smkx=\EX, ssso=\EE\ED, smul=\Eg,
```

Entries may continue onto multiple lines by placing white space at the beginning of each line except the first. Lines beginning with "#" are taken as comment lines. Capabilities in `terminfo` are of three types: boolean capabilities which indicate that the terminal has some particular feature, numeric capabilities giving the size of the terminal or the size of particular features, and string capabilities which give a sequence that can be used to perform particular terminal operations.
Types of Capabilities

All capabilities have names. For instance, the fact that the Concept has automatic margins (i.e., an automatic return and linefeed when the end of a line is reached) is indicated by the capability `am`. Hence the description of the Concept includes `am`. Numeric capabilities are followed by the character `#` and then the value. Thus `cols`, which indicates the number of columns the terminal has, gives the value `80` for the Concept.

Finally, string-valued capabilities, such as `el` (clear to end of line sequence) are given by the two- to five-character capname, an `=` and then a string ending at the next following `,'. A delay in milliseconds may appear anywhere in such a capability, enclosed in `$<..>` brackets, as in `el=`\EK$<3>`, and padding characters are supplied by `puts()` [see CURSES(TLIB)] to provide this delay. The delay can be either a number, e.g., `20`, or a number followed by an `*`, i.e., `3*`. A `*` indicates that the padding required is proportional to the number of lines affected by the operation, and the amount given is the per-affected-unit padding required. (In the case of insert character, the factor is still the number of lines affected. This is always one unless the terminal has `in` and the software uses it.) When a `*` is specified, it is sometimes useful to give a delay of the form `3.5` to specify a delay per unit to tenths of milliseconds. (Only one decimal place is allowed.) If the terminal has `xon` defined, the padding information is advisory and will only be used for cost estimates or when the terminal is in raw mode.

A number of escape sequences are provided in the string-valued capabilities for easy encoding of characters there. Both `\E` and `\e` map to an ESCAPE character, `\x` maps to a control-x for any appropriate x, and the sequences `\n`, `\l`, `\r`, `\t`, `\b`, `\f`, and `\s` give a newline, linefeed, return, tab, backspace, formfeed, and space. Other escapes include `\` for caret(), `\` for backslash, `\`, for comma (,); `\` for colon (:), and `\0` for null. Finally, characters may be given as three octal digits after a backslash (e.g., `\123`).

Sometimes individual capabilities must be commented out. To do this, put a period before the capability name. For example, see the second `ind` in the example above. Note that capabilities are defined in a left-to-right order and therefore, a prior definition will override a later definition.

Basic Capabilities

The number of columns on each line for the terminal is given by the `cols` numeric capability. If the terminal is a CRT, then the number of lines on the screen is given by the `lines` capability. If the terminal wraps around to the beginning of the next line when it reaches the right margin, then it should have the `am` capability. If the terminal can clear its screen, leaving
the cursor in the home position, then this is given by the \texttt{clear} capability. If the terminal overstrikes (rather than clearing a position when a character is struck over) then it should have the \texttt{os} capability. If the terminal is a printing terminal, with no soft copy unit, give it both \texttt{hc} and \texttt{os}. (\texttt{os} applies to storage scope terminals, such as Tektronix 4010 series, as well as hardcopy and APL terminals.) If there is a code to move the cursor to the left edge of the current row, give this as \texttt{cr}. (Normally this will be carriage return, control M.) If there is a code to produce an audible signal (bell, beep, etc.) give this as \texttt{bel}. If the terminal uses the xon-xoff flow-control protocol, like most terminals, specify \texttt{xon}.

If there is a code to move the cursor one position to the left (such as backspace) that capability should be given as \texttt{cubl}. Similarly, codes to move to the right, up, and down should be given as \texttt{cufl}, \texttt{cuu1}, and \texttt{cud1}. These local cursor motions should not alter the text they pass over; for example, you would not normally use `\texttt{cubl=\textbackslash s}' because the space would erase the character moved over.

A very important point here is that the local cursor motions encoded in \texttt{terminfo} are undefined at the left and top edges of a CRT terminal. Programs should never attempt to backspace around the left edge, unless \texttt{bw} is given, and never attempt to go up locally off the top. In order to scroll text up, a program will go to the bottom left corner of the screen and send the \texttt{ind} (index) string. To scroll text down, a program goes to the top left corner of the screen and sends the \texttt{ri} (reverse index) string. The strings \texttt{ind} and \texttt{ri} are undefined when not on their respective corners of the screen.

Parameterized versions of the scrolling sequences are \texttt{indn} and \texttt{rin} which have the same semantics as \texttt{ind} and \texttt{ri} except that they take one parameter, and scroll that many lines. They are also undefined except at the appropriate edge of the screen.

The \texttt{am} capability tells whether the cursor sticks at the right edge of the screen when text is output, but this does not necessarily apply to a \texttt{cubl} from the last column. The only local motion which is defined from the left edge is if \texttt{bw} is given, then a \texttt{cubl} from the left edge will move to the right edge of the previous row. If \texttt{bw} is not given, the effect is undefined. This is useful for drawing a box around the edge of the screen, for example. If the terminal has switch selectable automatic margins, the \texttt{terminfo} file usually assumes that this is on; i.e., \texttt{am}. If the terminal has a command which moves to the first column of the next line, that command can be given as \texttt{nel} (newline). It does not matter if the command clears the remainder of
the current line, so if the terminal has no cr and if it may still be possible to craft a working nel out of one or both of them.

These capabilities suffice to describe hardcopy and glass-tty terminals. Thus the AT&T model 33 is described as

```
33|tty33|tty|model 33 teletype,
   bel=^G, cols#72, cr=^M, cud1=^J, hc,
   ind=^J, os,
```

while the Lear Siegler ADM-3 is described as

```
adm3|lsi adm3,
   am, bel=^G, clear=^Z, cols#80, cr=^M,
   cub1=^H, cud1=^J, ind=^J, lines#24,
```

Parameterized Strings

Cursor addressing and other strings requiring parameters in the terminal are described by a parameterized string capability. For example, to address the cursor, the **cup** capability is given, using two parameters: the row and column to address to. (Rows and columns are numbered from zero and refer to the physical screen visible to the user, not to any unseen memory.) If the terminal has memory relative cursor addressing, that can be indicated by **mrcup**.

The parameter mechanism uses a stack and special % codes to manipulate it in the manner of a Reverse Polish Notation calculator. Typically a sequence will push one of the parameters onto the stack and then print it in some format. Often more complex operations are necessary. Binary operations are in postfix form with the operands in the usual order. That is, to get x-5 one would use "%gx%{5}%-lI."

The % encodings have the following meanings:

- `%%` outputs ‘%’
- `%[[:flags][width][.precision]][doxXs]` as in printf(3), `flags` are `[+-#]` and space
- `%d` print pop() as a decimal number
TERMINFO(TI_ENV)

%3d  
print pop() in a field at least 3 spaces wide

%03d
%s  
use leading zeros to fill print pop() as a character string

%c  
print pop() gives %c
%p[1-9]  
push i_th parm
%P[a-z]  
set variable [a-z] to pop()
%g[a-z]  
get variable [a-z] and push it

%c'  
push char constant c
%n  
push decimal constant nn
%\  
push strlen(pop())
%+ %– %* %/ %m  
arithmetic (%m is mod):
push(pop() op pop())

%& %\ %^  
bit operations:
push(pop() op pop())
%== %> %<  
logical operations:
push(pop() op pop())
%A %O
%! %~  
logical operations: and, or
unary operations:
push(op pop())

%\i  
add 1 to first parm, if one parm present, or first two parms, if more than one parm present (for ANSI terminals)
TERMINFO(TI_ENV)

%? expr %t thenpart %e elsepart %; if-then-else, %e elsepart is optional; else-if's are possible:
%? c_1 %t b_1 %e c_2 %t b_2
%e c_3 %t b_3 %e c_4
%t b_4 %e b_5 %;
c_i are conditions, b_i are bodies.

If the "-" flag is used with " %[doxXs]", then a colon (:) must be placed between the "%" and the "-" to differentiate the flag from the binary "%-" operator, e.g. "%:-16.16s".

Consider the Hewlett-Packard 2645, which, to get to row 3 and column 12, needs to be sent \E&a12c03Y padded for 6 milliseconds. Note that the order of the rows and columns is inverted here, and that the row and column are printed as two digits. Thus its \cup capability is \cup=\E&a%p2%02dc%p1%02dY$<6>.

The Micro-Term ACT-IV needs the current row and column sent preceded by a \T, with the row and column simply encoded in binary, \cup=T%p1%c%p2%c. Terminals which use \%c need to be able to backspace the cursor (\cub1), and to move the cursor up one line on the screen (\cuu1). This is necessary because it is not always safe to transmit \n, \D, and \r, as the system may change or discard them. (The library routines dealing with terminfo set tty modes so that tabs are never expanded, so \t is safe to send. This turns out to be essential for the Ann Arbor 4080.)

A final example is the LSI ADM-3a, which uses row and column offset by a blank character, thus \cup=\E=%p1%\s'\%%c%p2%'\s'\%+%c. After sending \E='; this pushes the first parameter, pushes the ASCII value for a space (32), adds them (pushing the sum on the stack in place of the two previous values) and outputs that value as a character. Then the same is done for the second parameter. More complex arithmetic is possible using the stack.

Cursor Motions

If the terminal has a fast way to home the cursor (to very upper left corner of screen) then this can be given as \textbf{home}; similarly a fast way of getting to the lower left-hand corner can be given as \textbf{ll}; this may involve going up with \textbf{cuu1} from the home position, but a program should never do this itself (unless \textbf{ll} does) because it can make no assumption about the effect of moving up from the home position. Note that the home position is the same as addressing to (0,0): to the top left corner of the screen, not of memory.
(Thus, the \EH sequence on Hewlett-Packard terminals cannot be used for home without losing some of the other features of the terminal.)

If the terminal has row or column absolute cursor addressing, these can be given as single parameter capabilities hpa (horizontal position absolute) and vpa (vertical position absolute). Sometimes these are shorter than the more general two parameter sequence (as with the HP2645) and can be used in preference to cup. If there are parameterized local motions (e.g., move n spaces to the right), these can be given as cud, cub, cuf, and cuu with a single parameter indicating how many spaces to move. These are primarily useful if the terminal does not have cup, such as the Tektronix 4025.

**Area Clears**

If the terminal can clear from the current position to the end of the line, leaving the cursor where it is, this should be given as el. If the terminal can clear from the beginning of the line to the current position inclusive, leaving the cursor where it is, this should be given as ell. If the terminal can clear from the current position to the end of the display, then this should be given as ed. The ed capability is only defined from the first column of a line. (Thus, it can be simulated by a request to delete a large number of lines, if a true ed is not available.)

**Insert/Delete Line**

If the terminal can open a new blank line before the line where the cursor is, this should be given as ill; this is done only from the first position of a line. The cursor must then appear on the newly blank line. If the terminal can delete the line which the cursor is on, then this should be given as dll; this is done only from the first position on the line to be deleted. Versions of ill and dll, which take a single parameter and insert or delete that many lines, can be given as il and dl.

If the terminal has a settable destructive scrolling region (like the VT100), the command to set this can be described with the csr capability, which takes two parameters: the top and bottom lines of the scrolling region. The cursor position is undefined after using this command. It is possible to get the effect of insert or delete line using this command — the sc and re (save and restore cursor) commands are also useful. Inserting lines at the top or bottom of the screen can also be done using ri or ind on many terminals without a true insert/delete line, and is often faster even on terminals with those features.

To determine whether a terminal has destructive scrolling regions or non-destructive scrolling regions, create a scrolling region in the middle of the screen, place data on the bottom line of the scrolling region, move the
cursor to the top line of the scrolling region, and do a reverse index ri followed by a delete line dll or index ind. If the data that was originally on the bottom line of the scrolling region was restored into the scrolling region by the dll or ind, then the terminal has non-destructive scrolling regions. Otherwise, it has destructive scrolling regions. Do not specify csr if the terminal has non-destructive scrolling regions, unless ind, ri, indn, rin, dl, and dll all simulate destructive scrolling.

If the terminal has the ability to define a window as part of memory, which all commands affect, it should be given as the parameterized string wind. The four parameters are the starting and ending lines in memory and the starting and ending columns in memory, in that order.

If the terminal can retain display memory above, then the da capability should be given; if display memory can be retained below, then db should be given. These indicate that deleting a line or scrolling a full screen may bring non-blank lines up from below or that scrolling back with ri may bring down non-blank lines.

Insert/Delete Character

There are two basic kinds of intelligent terminals with respect to insert/delete character which can be described using terminfo. The most common insert/delete character operations affect only the characters on the current line and shift characters off the end of the line rigidly. Other terminals, such as the Concept 100 and the Perkin Elmer Owl, make a distinction between typed and untyped blanks on the screen, shifting upon an insert or delete only to an untyped blank on the screen which is either eliminated or expanded to two untyped blanks. You can determine the kind of terminal you have by clearing the screen and then typing text separated by cursor motions. Type “abc def” using local cursor motions (not spaces) between the “abc” and the “def”. Then position the cursor before the “abc” and put the terminal in insert mode. If typing characters causes the rest of the line to shift rigidly and characters to fall off the end, then your terminal does not distinguish between blanks and untyped positions. If the “abc” shifts over to the “def” which then move together around the end of the current line and onto the next as you insert, you have the second type of terminal, and should give the capability in, which stands for insert null. While these are two logically separate attributes (one line vs. multiline insert mode and special treatment of untyped spaces), we have seen no terminals whose insert mode cannot be described with the single attribute.

The terminfo database can describe both terminals which have an insert mode and terminals which send a simple sequence to open a blank position on the current line. Give as smir the sequence to get into insert mode.
Give as \texttt{rmir} the sequence to leave insert mode. Now give as \texttt{ich1} any sequence needed to be sent just before sending the character to be inserted. Most terminals with a true insert mode will not give \texttt{ich1}; terminals which send a sequence to open a screen position should give it here. (If your terminal has both, insert mode is usually preferable to \texttt{ich1}. Do not give both unless the terminal actually requires both to be used in combination.) If post insert padding is needed, give this as a number of milliseconds in \texttt{ip} (a string option). Any other sequence which may need to be sent after an insert of a single character may also be given in \texttt{ip}. If your terminal needs both to be placed into an ‘insert mode’ and a special code to precede each inserted character, then both \texttt{smir/rmir} and \texttt{ich1} can be given, and both will be used. The \texttt{ich} capability, with one parameter, \textit{n}, will repeat the effects of \texttt{ich1} \textit{n} times.

If padding is necessary between characters typed while not in insert mode, give this as a number of milliseconds padding in \texttt{rmp}.

It is occasionally necessary to move around while in insert mode to delete characters on the same line (e.g., if there is a tab after the insertion position). If your terminal allows motion while in insert mode you can give the capability \texttt{mir} to speed up inserting in this case. Omitting \texttt{mir} will affect only speed. Some terminals (notably Datamedia’s) must not have \texttt{mir} because of the way their insert mode works.

Finally, you can specify \texttt{dch1} to delete a single character, \texttt{dch} with one parameter, \textit{n}, to delete \textit{n} characters and delete mode by giving \texttt{smdc} and \texttt{rmde} to enter and exit delete mode (any mode the terminal needs to be placed in for \texttt{dch1} to work).

A command to erase \textit{n} characters (equivalent to outputting \textit{n} blanks without moving the cursor) can be given as \texttt{ech} with one parameter.

\section*{Highlighting, Underlining, and Visible Bells}

If your terminal has one or more kinds of display attributes, these can be represented in a number of different ways. You should choose one display form as \textit{standout mode}, representing a good, high contrast, easy-on-the-eyes format for highlighting error messages and other attention getters. (If you have a choice, reverse video plus half-bright is good, or reverse video alone; however, different users have different preferences on different terminals.) The sequences to enter and exit standout mode are given as \texttt{smso} and \texttt{rmso}, respectively. If the code to change into or out of standout mode leaves one or even two blank spaces on the screen, as the TeleVideo 912 and Teleray 1061 do, then \texttt{xmc} should be given to tell how many spaces are left.
Codes to begin underlining and end underlining can be given as `smul` and `rmul`, respectively. If the terminal has a code to underline the current character and move the cursor one space to the right, such as the Micro-Term MIME, this can be given as `uc`.

Other capabilities to enter various highlighting modes include `blink` (blinking), `bold` (bold or extra bright), `dim` (dim or half-bright), `invis` (blanking or invisible text), `prot` (protected), `rev` (reverse video), `sgr0` (turn off all attribute modes), `smacs` (enter alternate character set mode), and `rmacs` (exit alternate character set mode). Turning on any of these modes singly may or may not turn off other modes. If a command is necessary before alternate character set mode is entered, give the sequence in `enacs` (enable alternate-character-set mode).

If there is a sequence to set arbitrary combinations of modes, this should be given as `sgr` (set attributes), taking nine parameters. Each parameter is either 0 or non-zero, as the corresponding attribute is on or off. The nine parameters are, in order: standout, underline, reverse, blink, dim, bold, blank, protect, and alternate character set. Not all modes need be supported by `sgr`, only those for which corresponding separate attribute commands exist.

Terminals with the "magic cookie" glitch (`xmc`) deposit special "cookies" when they receive mode-setting sequences, which affect the display algorithm rather than having extra bits for each character. Some terminals, such as the Hewlett-Packard 2621, automatically leave standout mode when they move to a new line or the cursor is addressed. Programs using standout mode should exit standout mode before moving the cursor or sending a newline, unless the `msgr` capability, asserting that it is safe to move in standout mode, is present.

If the terminal has a way of flashing the screen to indicate an error quietly (a bell replacement) then this can be given as `flash`; it must not move the cursor. A good flash can be done by changing the screen into reverse video, pad 200 ms, then return the screen to normal video.

If the cursor needs to be made more visible than normal when it is not on the bottom line (to make, for example, a non-blinking underline into an easier to find block or blinking underline) give this sequence as `cvvis`. The boolean `chts` should also be given. If there is a way to make the cursor completely invisible, give that as `civis`. The capability `cnorm` should be given, which undoes the effects of both of these modes.
If the terminal needs to be in a special mode when running a program that uses these capabilities, the codes to enter and exit this mode can be given as `smcup` and `rmcup`. This arises, for example, from terminals like the Concept with more than one page of memory. If the terminal has only memory-relative cursor addressing and not screen-relative cursor addressing, a one screen-sized window must be fixed into the terminal for cursor addressing to work properly. This is also used for the Tektronix 4025, where `smcup` sets the command character to be the one used by `terminfo`. If the `smcup` sequence will not restore the screen after an `rmcup` sequence is output (to the state prior to outputting `rmcup`), specify `nrrme`.

If your terminal correctly generates underlined characters by using the underline character (with no special codes needed) even though it does not overstrike, then you should give the capability `ul`. For terminals where a character overstriking another displays both characters (typically a hard-copy terminal), give the capability `os`. If overstrikes are erasable with a blank, then this should be indicated by giving `eo`.

**Keypad**

If the terminal has a keypad that transmits codes when the keys are pressed, this information can be given. Note that it is not possible to handle terminals where the keypad only works in local (this applies, for example, to the unshifted Hewlett-Packard 2621 keys). If the keypad can be set to transmit or not transmit, give these codes as `smkx` and `rmkx`. Otherwise, the keypad is assumed to always transmit.

The codes sent by the left arrow, right arrow, up arrow, down arrow, and home keys can be given as `kcub1`, `kcuf1`, `kcuu1`, `kcud1`, and `khome`, respectively. If there are function keys such as `f0`, `f1`, ..., `f63`, the codes they send can be given as `kf0`, `kf1`, ..., `kf63`. If the first 11 keys have labels other than the default `f0` through `f10`, the labels can be given as `lf0`, `lf1`, ..., `lf10`. The codes transmitted by certain other special keys can be given: `kli` (home down), `kbs` (backspace), `ktbc` (clear all tabs), `ketab` (clear the tab stop in this column), `kclr` (clear screen or erase key), `kdch1` (delete character), `kdll` (delete line), `krmir` (exit insert mode), `kel` (clear to end of line), `ked` (clear to end of screen), `kich1` (insert character or enter insert mode), `kil1` (insert line), `knpp` (next page), `kpp` (previous page), `kind` (scroll forward/down), `kri` (scroll backward/up), `khts` (set a tab stop in this column). In addition, if the keypad has a 3-by-3 array of keys including the four arrow keys, the other five keys can be given as `kal`, `ka3`, `kb2`, `kc1`, and `kc3`. These keys are useful when the effects of a 3-by-3 directional pad are needed. Additional keys are defined above in the capabilities list.
Strings to program function keys can be given as pfkey, pfloc, and pfx. A string to program soft-screen labels can be given as pln. Each of these strings takes two parameters: the function key number to program (from 0 to 10) and the string to program it with. Function key numbers out of this range may program undefined keys in a terminal-dependent manner. The difference between the capabilities is that pfkey causes pressing the given key to be the same as the user typing the given string; pfloc causes the string to be executed by the terminal in local; and pfx causes the string to be transmitted to the computer. The capabilities nlab, lw, and lh define how many soft labels there are and their width and height. If there are commands to turn the labels on and off, give them in smin and rmin; smin is normally output after one or more pln sequences to make sure that the change becomes visible.

Tabs and Initialization

If the terminal has hardware tabs, the command to advance to the next tab stop can be given as ht (usually control I). A “backtab” command which moves leftward to the next tab stop can be given as cht. By convention, if the terminal modes indicate that tabs are being expanded by the computer rather than being sent to the terminal, programs should not use ht or cht even if they are present, since the user may not have the tab stops properly set. If the terminal has hardware tabs which are initially set every \( n \) spaces when the terminal is powered up, the numeric parameter it is given, showing the number of spaces the tabs are set to. This is normally used by tput init [see TPUT(TL_CMD)] to determine whether to set the mode for hardware tab expansion, and whether to set the tab stops. If the terminal has tab stops that can be saved in nonvolatile memory, the terminfo description can assume that they are properly set. If there are commands to set and clear tab stops, they can be given as tbc (clear all tab stops) and hts (set a tab stop in the current column of every row).

Other capabilities include is1, is2, and is3, initialization strings for the terminal, iprog, the pathname of a program to be run to initialize the terminal, and if, the name of a file containing long initialization strings. These strings are expected to set the terminal into modes consistent with the rest of the terminfo description. They must be sent to the terminal each time the user logs in and be output in the following order: run the program iprog, output is1; is2; set the margins using mge, smgl and smgr; set tabs using tbc and hts; print the file if; and finally output is3. This can be done using the init argument of the TPUT(TL_CMD) command.

Most initialization is done with is2. Special terminal modes can be set up without duplicating strings by putting the common sequences in is2 and special cases in is1 and is3. A pair of sequences that does a harder reset
from a totally unknown state can be analogously given as \texttt{rs1}, \texttt{rs2}, \texttt{rf}, and \texttt{rs3}, analogous to \texttt{is*} and \texttt{if}. (The method using files, \texttt{if} and \texttt{rf}, is not recommended; the recommended method is to use the initialization and reset strings.) These strings should be output when the terminal gets into an unreasonable state by using the \texttt{reset} argument to the \texttt{TPUT(TI_CMD)} command. Commands are normally placed in \texttt{rs*} and \texttt{rf} only if they produce annoying effects on the screen and are not necessary when logging in. For example, the command to set a terminal into 80-column mode would normally be part of \texttt{is2}, but on some terminals it causes an annoying glitch of the screen and is not normally needed since the terminal is usually already in 80-column mode. Therefore, the command is usually placed in \texttt{rs1}, not \texttt{is2}, for those terminals.

If a more complex sequence is needed to set the tabs than can be described by using \texttt{tbc} and \texttt{hts}, the sequence can be placed in \texttt{is2} or \texttt{if}.

If there are commands to set and clear margins, they can be given as \texttt{mgc} (clear all margins), \texttt{smgl} (set left margin), and \texttt{smgr} (set right margin).

\textbf{Delays}

Certain capabilities control padding in the tty driver. These are primarily needed by hardcopy terminals, and are used by \texttt{tput init} to set tty modes appropriately. Delays embedded in the capabilities \texttt{cr}, \texttt{ind}, \texttt{cubl}, \texttt{ff}, and \texttt{tab} can be used to set the appropriate delay bits in the tty driver. If \texttt{pb} (padding baud rate) is given, these values can be ignored at baud rates below the value of \texttt{pb}.

\textbf{Status Line}

If the terminal has an extra "status line" that is not normally used by software, this fact can be indicated. If the status line is viewed as an extra line below the bottom line, into which one can cursor address normally (such as the Heathkit h19's 25th line, or the 24th line of a VT100 which is set to a 23-line scrolling region), the capability \texttt{hs} should be given. Special strings to go to the beginning of the status line and to return from the status line can be given as \texttt{tsl} and \texttt{fsl}. (\texttt{fsl} must leave the cursor position in the same place it was before \texttt{tsl}. If necessary, the \texttt{sc} and \texttt{rc} strings can be included in \texttt{tsl} and \texttt{fsl} to get this effect.) The parameter \texttt{tsl} takes one parameter, which is the column number of the status line the cursor is to be moved to. If escape sequences and other special commands, such as \texttt{tab} and \texttt{el}, work while in the status line, the flag \texttt{eslok} can be given. A string which turns off the status line (or otherwise erases its contents) should be given as \texttt{dsl}. If the terminal has commands to save and restore the position of the cursor, give them as \texttt{sc} and \texttt{rc}. The status line is normally assumed
to be the same width as the rest of the screen, e.g., \texttt{cols}. If the status line is a different width (possibly because the terminal does not allow an entire line to be loaded) the width, in columns, can be indicated with the numeric parameter \texttt{wsl}.

\textbf{Line Graphics}

If the terminal has a line drawing alternate character set, the mapping of glyph to character would be given in \texttt{acsc}. The definition of this string is based on the alternate character set used in the DEC VT100 terminal, extended slightly with some characters from the AT&T 4410v1 terminal.

<table>
<thead>
<tr>
<th>glyph name</th>
<th>vt100+ character</th>
</tr>
</thead>
<tbody>
<tr>
<td>arrow pointing right</td>
<td>+</td>
</tr>
<tr>
<td>arrow pointing left</td>
<td>,</td>
</tr>
<tr>
<td>arrow pointing down</td>
<td>.</td>
</tr>
<tr>
<td>solid square block</td>
<td>0</td>
</tr>
<tr>
<td>lantern symbol</td>
<td>I</td>
</tr>
<tr>
<td>arrow pointing up</td>
<td>-</td>
</tr>
<tr>
<td>diamond</td>
<td>'</td>
</tr>
<tr>
<td>checker board (stipple)</td>
<td>a</td>
</tr>
<tr>
<td>degree symbol</td>
<td>f</td>
</tr>
<tr>
<td>plus/minus</td>
<td>g</td>
</tr>
<tr>
<td>board of squares</td>
<td>h</td>
</tr>
<tr>
<td>lower right corner</td>
<td>j</td>
</tr>
<tr>
<td>upper right corner</td>
<td>k</td>
</tr>
<tr>
<td>upper left corner</td>
<td>l</td>
</tr>
<tr>
<td>lower left corner</td>
<td>m</td>
</tr>
<tr>
<td>plus</td>
<td>n</td>
</tr>
<tr>
<td>scan line 1</td>
<td>o</td>
</tr>
<tr>
<td>horizontal line</td>
<td>q</td>
</tr>
<tr>
<td>scan line 9</td>
<td>s</td>
</tr>
<tr>
<td>left tee (\texttt{-})</td>
<td>t</td>
</tr>
<tr>
<td>right tee (\texttt{+})</td>
<td>u</td>
</tr>
<tr>
<td>bottom tee (\texttt{↓})</td>
<td>v</td>
</tr>
<tr>
<td>top tee (\texttt{↑})</td>
<td>w</td>
</tr>
<tr>
<td>vertical line</td>
<td>x</td>
</tr>
<tr>
<td>bullet</td>
<td>~</td>
</tr>
</tbody>
</table>
The best way to describe a new terminal's line graphics set is to add a third column to the above table with the characters for the new terminal that produce the appropriate glyph when the terminal is in the alternate character set mode. For example,

<table>
<thead>
<tr>
<th>glyph name</th>
<th>vt100+ char</th>
<th>new tty char</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper left corner</td>
<td>l</td>
<td>R</td>
</tr>
<tr>
<td>lower left corner</td>
<td>m</td>
<td>F</td>
</tr>
<tr>
<td>upper right corner</td>
<td>k</td>
<td>T</td>
</tr>
<tr>
<td>lower right corner</td>
<td>j</td>
<td>G</td>
</tr>
<tr>
<td>horizontal line</td>
<td>q</td>
<td>,</td>
</tr>
<tr>
<td>vertical line</td>
<td>x</td>
<td>.</td>
</tr>
</tbody>
</table>

Now, write down the characters left to right, as in \texttt{"acsc=IRmFkTJGq\,x."}.

**Miscellaneous**

If the terminal requires other than a null (zero) character as a pad, then this can be given as \texttt{pad}. Only the first character of the \texttt{pad} string is used. If the terminal does not have a pad character, specify \texttt{npc}.

If the terminal can move up or down half a line, this can be indicated with \texttt{hu} (half-line up) and \texttt{hd} (half-line down). This is primarily useful for superscripts and subscripts on hardcopy terminals. If a hardcopy terminal can eject to the next page (form feed), give this as \texttt{ff} (usually control L).

If there is a command to repeat a given character a given number of times (to save time transmitting a large number of identical characters) this can be indicated with the parameterized string \texttt{rep}. The first parameter is the character to be repeated and the second is the number of times to repeat it. Thus, \texttt{tparm(repeat_char, 'x', 10)} is the same as \texttt{xxxxxxxxxx}.

If the terminal has a settable command character, such as the Tektronix 4025, this can be indicated with \texttt{cmdch}. A prototype command character is chosen which is used in all capabilities. This character is given in the \texttt{cmdch} capability to identify it.

Terminal descriptions that do not represent a specific kind of known terminal, such as \texttt{switch}, \texttt{dialup}, \texttt{patch}, and \texttt{network}, should include the \texttt{gn} (generic) capability so that programs can complain that they do not know how to talk to the terminal. A line-turn-around sequence to be transmitted before doing reads should be specified in \texttt{rfi}.
If the terminal uses xon/xoff handshaking for flow control, give \texttt{xon}. Padding information should still be included so that routines can make better decisions about costs, but actual pad characters will not be transmitted. Sequences to turn on and off xon/xoff handshaking may be given in \texttt{smxon} and \texttt{rmxon}. If the characters used for handshaking are not \texttt{S} and \texttt{Q}, they may be specified with \texttt{xone} and \texttt{xoffe}.

If the terminal has more lines of memory than will fit on the screen at once, the number of lines of memory can be indicated with \texttt{lm}. A value of \texttt{lm\#0} indicates that the number of lines is not fixed, but that there is still more memory than fits on the screen.

Media copy strings which control an auxiliary printer connected to the terminal can be given as \texttt{mc0}: print the contents of the screen, \texttt{mc4}: turn off the printer, and \texttt{mc5}: turn on the printer. When the printer is on, all text sent to the terminal will be sent to the printer. It is undefined whether the text is also displayed on the terminal screen when the printer is on. A variation \texttt{mc5p} takes one parameter, and leaves the printer on for as many characters as the value of the parameter, then turns the printer off. The parameter should not exceed 255. If the text is not displayed on the terminal screen when the printer is on, specify \texttt{mc5i} (silent printer). All text, including \texttt{mc4}, is transparently passed to the printer while an \texttt{mc5p} is in effect.

\textbf{Special Cases}

The working model used by \texttt{term info} fits most terminals reasonably well. However, some terminals do not completely match that model, requiring special support by \texttt{term info}. These are not meant to be construed as deficiencies in the terminals; they are just differences between the working model and the actual hardware.

Terminals which can not display tilde characters, such as certain Hazeltine terminals, should indicate \texttt{hz}.

Terminals which ignore a linefeed immediately after an \texttt{am} wrap, such as the Concept 100, should indicate \texttt{xenl}. Those terminals whose cursor remains on the right-most column until another character has been received, rather than wrapping immediately upon receiving the right-most character, such as the VT100, should also indicate \texttt{xenl}.

If \texttt{el} is required to get rid of standout (instead of writing normal text on top of it), \texttt{xhp} should be given.
Those Teleray terminals whose tabs turn all characters moved over to blanks, should indicate xt (destructive tabs). This capability is also taken to mean that it is not possible to position the cursor on top of a "magic cookie"; therefore, to erase standout mode it is instead necessary to use delete and insert line.

The Beehive Superbee terminals, which do not transmit the escape or control C characters, should specify xsb, indicating that the f1 key is to be used for escape and f2 for control C.

**Similar Terminals**

If there are two very similar terminals, one can be defined as being just like the other with certain exceptions. The string capability use can be given with the name of the similar terminal. The capabilities given before use override those in the terminal type invoked by use. A capability can be cancelled by placing xx@ to the left of the capability definition, where xx is the capability. For example, the entry

```
att4424-2 |AT&T 4424 in display function
           group ii,
           rev@, sgr@, smul@, use=att4424,
```

defines an AT&T 4424 terminal that does not have the rev, sgr, and smul capabilities, and hence cannot do highlighting. This is useful for different modes for a terminal, or for different user preferences. More than one use capability may be given.

**FILES**

```
/usr/lib/terminfo/*/ Compiled terminal description database
```

**SEE ALSO**

CURSES(TI_LIB), PRINTF(BA_LIB), TIC(TI_CMD).

**USAGE**

Administrator and Application Program.

The most effective way to prepare a terminal description is by imitating the description of a similar terminal in terminfo and to build up a description gradually, using partial descriptions with VI(AU_CMD) to check that they are correct. To easily test a new terminal description the environment variable TERMININFO can be set to the pathname of a directory containing the compiled description, and programs will look there rather than in /usr/lib/terminfo. To get the padding for insert line right, a severe test is to comment out xon, edit a copy of a large file at 9600 baud with VI(AU_CMD), delete 16 or so lines from the middle of the screen, then hit the 'u' key several times quickly. If the terminal messes up, more padding is usually needed. A similar test can be used for insert character.
TERMINFO(TI_ENV)

LEVEL
   Level 1.
NAME
curses - CRT screen handling and optimization package

SYNOPSIS
#include <curses.h>

DESCRIPTION
The curses library routines give the user a terminal-independent method of
updating screens with reasonable optimization. A program using these rou­
tines must be compiled with the -lcurses option of cc.

In order to initialize the routines, the routine initscr() or newterm() must be called before any of the other routines that deal with windows and
screens are used. The routine endwin() must be called before exiting. To
get character-at-a-time input without echoing (most interactive, screen
oriented-programs want this), the following sequence should be used:

    initscr(), cbreak(), noecho();

Most programs would additionally use the sequence:

    nonl(), intrflush(stdscr, FALSE);
    keypad(stdscr, TRUE).

Before a curses program is run, a terminal's tabs stops should be set and its
initialization strings, if defined, must be output. This can be done by ex­
cuting the tput init command after the shell environment variable TERM
has been exported. See TERMINFO(TLENV) for further details.

The curses library permits manipulation of data structures called windows
which can be thought of as two-dimensional arrays of characters represent­
ing all or part of a CRT screen. A default window called stdscr is supplied,
which is the size of the terminal screen. Others may be created with
newwin(). Windows are referred to by variables declared as "WINDOW *
". These data structures are manipulated with routines described below,
among which the most basic are move() and addch(). (More general ver­
sions of these routines are included with names beginning with w, allowing
one to specify a window. The routines not beginning with w affect
stdscr.) Then refresh() is called, telling the routines to make the user's
CRT screen look like stdscr. The characters in a window are actually of
type chtype, so that other information about the character may also be
stored with each character.

Special windows called pads may also be manipulated. These are windows
which are not constrained to the size of the screen and whose contents need
not be completely displayed. See the description of newpad() under
"Window and Pad Manipulation" for more information.
In addition to drawing characters on the screen, video attributes may be included which cause the characters to show up in such modes as underlined or in reverse video on terminals that support such display enhancements. Line drawing characters may be specified to be output. On input, *curses* is also able to translate arrow and function keys that transmit escape sequences into single values. The video attributes, line drawing characters, and input values use names, defined in `<curses.h>`, such as `A_REVERSE`, `ACS_HLINE`, and `KEY_LEFT`.

The environment variables `LINES` and `COLUMNS` may also be set to override `terminfo`'s idea of how large a screen is. These may be used in an AT&T 5620 layer, for example, where the size of a screen is changeable.

If the environment variable `TERMINFO` is defined, any program using `curses` will check for a local terminal definition before checking in the standard place. For example, if `TERM` is set to "att4424", then the compiled terminal definition is found in `/usr/lib/terminfo/a/att4424`. (The "a" is copied from the first letter of "att4424" to avoid creation of huge directories.) However, if `TERMINFO` is set to `$HOME/myterms`, `curses` will first check `$HOME/myterms/a/att4424`, and if that fails, will then check `/usr/lib/terminfo/a/att4424`. This is useful for developing experimental definitions or when write permission in `/usr/lib/terminfo` is not available.

The integer variables `LINES` and `COLS` are defined in `<curses.h>` and will be filled in by `initscr()` with the size of the screen. The constants `TRUE` and `FALSE` have the values 1 and 0, respectively.

The `curses` routines also define the `WINDOW *` variable `curscr` which is used for certain low-level operations like clearing and redrawing a garbled screen. The `curscr` can be used in only a few routines. If the window argument to `clearok()` is `curscr`, the next call to `wrefresh()` with any window will cause the screen to be cleared and repainted from scratch. If the window argument to `wrefresh()` is `curscr`, the screen is immediately cleared and repainted from scratch. This is how most programs would implement a "repaint-screen" function. More information on using `curscr` is provided where its use is appropriate.

**Routines**

Many of the following routines have two or more versions. The routines prefixed with `w` require a `window` argument. The routines prefixed with `p` require a `pad` argument. Those without a prefix generally use `stdscr`.

The routines prefixed with `mv` require an `x` and `y` coordinate to move to before performing the appropriate action. The `mv` routines imply a call to `move` before the call to the other routine. The coordinate `y` always refers
The routines prefixed with `mvw` take both a `window` argument and `x` and `y` coordinates. The window argument is always specified before the coordinates.

In each case, `win` is the window affected and `pad` is the pad affected; `win` and `pad` are always of type `WINDOW`. Option setting routines require a boolean flag `bf` with the value `TRUE` or `FALSE`; `bf` is always of type `bool`. The variables `ch` and `attrs` below are always of type `chttype`. The types `WINDOW`, `bool`, and `chttype` are defined in `<curses.h>`. All other arguments are integers.

See the `RETURN VALUE` paragraph near the end of the TI_LIB section for information on the values returned by the routines described below.

### Overall Screen Manipulation

#### `WINDOW *initscr()`

The first routine called should almost always be `initscr()`. (The exceptions are `slk_init()`, `filter()`, and `ripoffline()`) This will determine the terminal type and initialize all curses data structures. `initscr()` also arranges that the first call to `refresh()` will clear the screen. If errors occur, `initscr()` will write an appropriate error message to standard error and exit; otherwise, a pointer to `stdscr()` is returned. If the program wants an indication of error conditions, `newterm()` should be used instead of `initscr()` — `initscr()` should only be called once per application.

#### `endwin()`

A program should always call `endwin()` before exiting or escaping from curses mode temporarily. This routine will restore tty modes, move the cursor to the lower left corner of the screen and reset the terminal into the proper non-visual mode. To resume after a temporary escape, call `refresh()` or `doupdate()`.

#### `SCREEN *newterm(type, outfd, infd)`

`char *type;`  
`FILE *outfd, *infd;`

A program which outputs to more than one terminal should use `newterm()` for each terminal instead of `initscr()`. A program which wants an indication of error conditions, so that it may continue to run in a line-oriented mode if the terminal cannot support a screen-oriented program, would also use this routine. The routine
newterm() should be called once for each terminal. It returns a variable of type SCREEN * which should be saved as a reference to that terminal. The arguments are the type of the terminal to be used in place of TERM, a file pointer for output to the terminal, and another file pointer for input from the terminal. The program must also call endwin() for each terminal being used before exiting from curses. If newterm() is called more than once for the same terminal, the first terminal referred to must be the last one for which endwin() is called.

SCREEN *set_term(new)
SCREEN *new;
This routine is used to switch between different terminals. The screen reference new becomes the new current terminal. The previous terminal is returned by the routine. This is the only routine which manipulates SCREEN pointers; all other routines affect only the current terminal.

Window and Pad Manipulation

refresh()
wrefresh(win)
WINDOW *win;
These routines (or prefresh(), pnoutrefesh(), wnoutrefresh(), or doupdate()) must be called to get any output on the terminal, as other routines merely manipulate data structures. The routine wrefresh() copies the named window to the physical terminal screen, taking into account what is already there in order to do optimizations. The refresh() routine is the same, using stdscr as a default screen. Unless leaveok() has been enabled, the physical cursor of the terminal is left at the location of the window’s cursor.

NOTE: refresh is a macro.

wnoutrefresh(win)
WINDOW *win;
doupdate()
These two routines allow multiple updates with more efficiency than wrefresh() alone. In addition to all of the window structures, curses keeps two data structures representing the terminal screen: a physical screen, describing what is actually on the screen, and a virtual screen, describing what the programmer wants to have on the screen.

The routine wrefresh() works by first calling wnoutrefresh(), which copies the named window to the virtual screen, and then calling
doupdate(), which compares the virtual screen to the physical screen and does the actual update. If the programmer wishes to output several windows at once, a series of calls to wrefresh() will result in alternating calls to wnoutrefresh() and doupdate(), causing several bursts of output to the screen. By first calling wnoutrefresh() for each window, it is then possible to call doupdate() once, resulting in only one burst of output, with probably fewer total characters transmitted and certainly less CPU time used.

WINDOW *newwin(nlines, ncols, begin_y, begin_x)
int nlines, ncols, begin_y, begin_x;
Create and return a pointer to a new window with the given number of lines, nlines, and columns, ncols. The upper left corner of the window is at line begin_y, column begin_x. If either nlines or ncols is zero, they will be defaulted to LINES — begin_y and COLS — begin_x. A new full-screen window is created by calling newwin(0,0,0,0).

mvwin(win, y, x)
WINDOW *win;
int y, x;
Move the window so that the upper left corner will be at position (x, y). If the move would cause the window to be off the screen, it is an error and the window is not moved. Moving subwindows is allowed, but should be avoided.

WINDOW *subwin(orig, nlines, ncols, begin_y, begin_x)
WINDOW *orig;
int nlines, ncols, begin_y, begin_x;
Create and return a pointer to a new window with the given number of lines, nlines, and columns, ncols. The window is at position (begin_y, begin_x) on the screen. (This position is relative to the screen, and not to the window orig.) The window is made in the middle of the window orig, so that changes made to one window will affect both windows. The subwindow shares memory with the window orig. When using this routine, it will be necessary to call touchwin() or touchline() on orig before calling wrefresh() on the subwindow.

delwin(win)
WINDOW *win;
Deletes the named window, freeing up all memory associated with it. Subwindows must be deleted before the main window.
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WINDOW *newpad(nlines, ncols)
int nlines, ncols;
Create and return a pointer to a new pad data structure with the
given number of lines, nlines, and columns, ncols. A pad is like a
window, except that it is not restricted by the screen size, and is not
necessarily associated with a particular part of the screen. Pads can
be used when a large window is needed, and only a part of the window
will be on the screen at one time. Automatic refreshes of pads (e.g.,
from scrolling or echoing of input) do not occur. It is not legal to call
wrefresh() with a pad as an argument; the routines prefresh() or
pnoutrefresh() should be called instead. Note that these routines
require additional parameters to specify the part of the pad to be
displayed and the location on the screen to be used for display.

WINDOW *subpad(orig, nlines, ncols, begin_y, begin_x)
WINDOW *orig;
int nlines, ncols, begin_y, begin_x;
Create and return a pointer to a subwindow within a pad with the
given number of lines, nlines, and columns, ncols. Unlike subwin(),
which uses screen coordinates, the window is at position (begin_x,
begin_y) on the pad. The window is made in the middle of the win­
dow orig, so that changes made to one window will affect both win­
dows. When using this routine, often it will be necessary to call
touchwin() or touchline() on orig before calling prefresh().

prefresh(pad, pminrow, pmincol, sminrow, smincol, smaxrow, smaxcol)
WINDOW *pad;
int pminrow, pmincol, sminrow, smincol, smaxrow, smaxcol;
pnoutrefresh(pad, pminrow, pmincol, sminrow, smincol, smaxrow, smaxcol)
WINDOW *pad;
int pminrow, pmincol, sminrow, smincol, smaxrow, smaxcol;
These routines are analogous to wrefresh() and wnoutrefresh() except that pads, instead of windows, are involved. The additional
parameters are needed to indicate what part of the pad and screen are
involved. pminrow and pmincol specify the upper left corner, in the
pad, of the rectangle to be displayed. sminrow, smincol, smaxrow,
and smaxcol specify the edges, on the screen, of the rectangle to be
displayed in. The lower right corner in the pad of the rectangle to be

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displayed is calculated from the screen coordinates, since the rectangles must be the same size. Both rectangles must be entirely contained within their respective structures. Negative values of \texttt{pminrow}, \texttt{pmincol}, \texttt{sminrow}, or \texttt{smincol} are treated as if they were zero.

Output

These routines are used to “draw” text on windows.

\begin{verbatim}
addch(ch)
chttype ch;
waddch(win, ch)
WINDOW *win;
chttype ch;
mvaddch(y, x, ch)
int y, x;
chttype ch;
mvwaddch(win, y, x, ch)
WINDOW *win;
int y, x;
chttype ch;
\end{verbatim}

The character \texttt{ch} is put into the window at the current cursor position of the window and the position of the window cursor is advanced. Its function is similar to that of \texttt{putchar}. At the right margin, an automatic newline is performed. At the bottom of the scrolling region, if \texttt{scrollok()} is enabled, the scrolling region will be scrolled up one line.

If \texttt{ch} is a tab, newline, or backspace, the cursor will be moved appropriately within the window. A newline also does a \texttt{clrtoeol()} before moving. Tabs are considered to be at every eighth column. If \texttt{ch} is another control character, it will be drawn in the \texttt{\~X} notation. Calling \texttt{winch()} after adding a control character will not return the control character, but instead will return the representation of the control character.

Video attributes can be combined with a character by or-ing them into the parameter. This will result in these attributes also being set. (The intent here is that text, including attributes, can be copied from one place to another using \texttt{inch()} and \texttt{addch()}.) See \texttt{standout()} below.

\textbf{NOTE:} \texttt{addch}, \texttt{mvaddch}, and \texttt{mvwaddch} are macros.
echochar(ch)
chttype ch;
wechochar(win, ch)
WINDOW *win;
chttype ch;
pechochar(pad, ch)
WINDOW *pad;
chttype ch;

These routines are functionally equivalent to a call to addch(ch) followed by a call to refresh(), a call to waddch(win, ch) followed by a call to wrefresh(win), or a call to waddch(pad, ch) followed by a call to prefresh(pad). The knowledge that only a single character is being output is taken into consideration and, for non-control characters, a considerable performance gain can be seen by using these routines instead of their equivalents. In the case of pechochar(), the last location of the pad on the screen is reused for the arguments to prefresh().

NOTE: echochar() is a macro.

addstr(str)
char *str;
waddstr(win, str)
WINDOW *win;
char *str;
mvaddstr(y, x, str)
int y, x;
char *str;
mvwaddstr(win, y, x, str)
WINDOW *win;
int y, x;
char *str;

These routines write all the characters of the null terminated character string str on the given window. It is equivalent to calling waddch() once for each character in the string.

NOTE: addstr, mvaddstr, and mvwaddstr are macros.
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attroff(attrs)
int attrs;
wattroff(win, attrs)
WINDOW *win;
int attrs;
attron(attrs)
int attrs;
wattron(win, attrs)
WINDOW *win;
int attrs;
attrset(attrs)
int attrs;
wattrset(win, attrs)
WINDOW *win;
int attrs;
standend()
wstandend(win)
WINDOW *win;
standout()
wstandout(win)
WINDOW *win;

These routines manipulate the current attributes of the named window. These attributes can be any combination of A_STANDOUT, A_REVERSE, A_BOLD, A_DIM, A_BLINK, A_UNDERLINE, and A_ALTCHARSET. These constants are defined in <curses.h> and can be combined with the C | (or) operator.

The current attributes of a window are applied to all characters that are written into the window with waddch(). Attributes are a property of the character, and move with the character through any scrolling and insert/delete line/character operations. To the extent possible on the particular terminal, they will be displayed as the graphic rendition of characters put on the screen.

The routine attrset(attrs) sets the current attributes of the given window to attrs. attroff(attrs) turns off the named attributes without turning on or off any other attributes. attron(attrs) turns on the named attributes without affecting any others. standout() is the same as attron(A_STANDOUT). standend() is the same as attrset(0), that is, it turns off all attributes.

NOTE: attroff, attron, attrset, standend and standout are macros.
beep()

flash()

These routines are used to signal the terminal user. beep() will sound the audible alarm on the terminal, if possible, and if not, will flash the screen (visible bell), if that is possible. flash() will flash the screen, and if that is not possible, will sound the audible signal. If neither signal is possible, nothing will happen. Nearly all terminals have an audible signal (bell or beep), but only some can flash the screen.

box(win, vert, hor)

WINDOW *win;

chtype vert, hor;

A box is drawn around the edge of the window. vert and hor are the characters the box is to be drawn with. If vert and hor are 0, then appropriate default characters, ACS_VLINE and ACS_HLINE, will be used.

erase()

werase(win)

WINDOW *win;

These routines copy blanks to every position in the window.

NOTE: erase is a macro.

clear()

wclear(win)

WINDOW *win;

These routines are like erase() and werase(), but they also call clearok(), arranging that the screen will be cleared completely on the next call to wrefresh() for that window and repainted from scratch.

NOTE: clear is a macro.

clrtothot()

wclrtobot(win)

WINDOW *win;

All lines below the cursor in this window are erased. Also, the current line to the right of the cursor, inclusive, is erased.

NOTE: clrtobot is a macro.
CURSES(TI_LIB)

clrtoeol()
wclrtoeol(win)
WINDOW *win;
The current line to the right of the cursor, inclusive, is erased.

NOTE: clrtoeol is a macro.
delay_output(ms)
int ms;
Insert ms millisecond pause in output. It is not recommended that
this routine be used extensively since padding characters are used
rather than a CPU pause.
delch()
wdelch(win)
WINDOW *win;
mvdelch(y, x)
int y, x;
mvwdelch(win, y, x)
WINDOW *win;
int y, x;
The character under the cursor in the window is deleted. All charac-
ters to the right on the same line are moved to the left one position
and the last character on the line is filled with a blank. The cursor
position does not change (after moving to y, x, if specified). (This
does not imply use of the hardware delete character feature.)

NOTE: delch, mvdelch, and mvwdelch are macros.
deleteIn()
wdeleteIn(win)
WINDOW *win;
The line under the cursor in the window is deleted. All lines below
the current line are moved up one line. The bottom line of the win-
dow is cleared. The cursor position does not change. (This does not
imply use of the hardware delete line feature.)

NOTE: deleteIn is a macro.
getyx(win, y, x)
WINDOW *win;
int y, x;

The cursor position of the window is placed in the two integer variables y and x. This is implemented as a macro, so no & is necessary before the variables.

NOTE: getyx is a macro.

getbegyx(win, y, x)
WINDOW *win;
int y, x;

getmaxyx(win, y, x)
WINDOW *win;
int y, x;

Like getyx(), these routines store the current beginning coordinates and size of the specified window.

NOTE: getbegyx and getmaxyx are macros.

insch(ch)
cttype ch;
winsch(win, ch)
WINDOW *win;
cttype ch;
mvinsch(y, x, ch)
int y, x;
cttype ch;
mvwinsch(win, y, x, ch)
WINDOW *win;
int y, x;
cttype ch;

The character ch is inserted before the character under the cursor. All characters to the right are moved one space to the right, possibly losing the rightmost character on the line. The cursor position does not change (after moving to y, x, if specified). (This does not imply use of the hardware insert character feature.)

NOTE: insch, mvinsch, and mvwinsch are macros.
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insertln()

winsertln(win)
WINDOW *win;
A blank line is inserted above the current line and the bottom line is
lost. (This does not imply use of the hardware insert line feature.)

NOTE: insertln is a macro.

move(y, x)
wmove(win, y, x)
WINDOW *win;
int y, x;
The cursor associated with the window is moved to line y and column
x. This does not move the physical cursor of the terminal until
refresh() is called. The position specified is relative to the upper left
corner of the window, which is (0,0).

NOTE: move is a macro.

overlay(srcwin, dstwin)
WINDOW *srcwin, *dstwin;
overwrite(srcwin, dstwin)
WINDOW *srcwin, *dstwin;
These routines overlay srcwin on top of dstwin. Scrwin and
dstwin are not required to be the same size; only text where the two
windows overlap is copied. The difference is that overlay() is non-
destructive (blanks are not copied) while overwrite() is destructive.

copywin(srcwin, dstwin, sminrow, smincol, dminrow, dmincol,
dmaxrow, dmaxcol, overlay)
WINDOW *srcwin, *dstwin;
int sminrow, smincol, dminrow, dmincol, dmaxrow, dmaxcol, overlay;
This routine provides a finer grain of control over the overlay() and
overwrite() routines. Like in the prefresh() routine, a rectangle is
specified in the destination window, (dminrow, dmincol) and
(dmaxrow, dmaxcol), and the upper-left-corner coordinates of the
source window, (sminrow, smincol). If the argument overlay is
true, then copying is non-destructive, as in overlay().

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printw(fmt [, arg] ...)  
char *fmt;

wprintw(win, fmt [, arg] ...)  
WINDOW *win;
char *fmt;

mvprintw(y, x, fmt [, arg] ...)  
int y, x;
char *fmt;

mvwprintw(win, y, x, fmt [, arg] ...)  
WINDOW *win;
int y, x;
char *fmt;

These routines are analogous to printf [see PRINTF(SA_LIB)]. The string which would be output by printf is instead output using waddstr() on the given window.

scroll(win)  
WINDOW *win;

The window is scrolled up one line. This involves moving the lines in the window data structure. As an optimization, if the window's scrolling region is the entire screen, the physical screen will be scrolled at the same time.

touchwin(win)  
WINDOW *win;

touchline(win, start, count)  
WINDOW *win;
int start, count;

Throw away all optimization information about which parts of the window have been touched, by pretending that the entire window has been drawn on. This is sometimes necessary when using overlapping windows, since a change to one window will affect the other window, but the records of which lines have been changed in the other window will not reflect the change. touchline() only pretends that count lines have been changed, beginning with line start.
Input

The following routines are used to obtain input from windows.

getch()
wgetch(win)
WINDOW *win;
mvgetch(y, x)
int y, x;
mvwgetch(win, y, x)
WINDOW *win;
int y, x;

A character is read from the terminal associated with the window. In
no delay mode, if there is no input waiting, the value ERR is returned.
In delay mode, the program will hang until the system passes text
through to the program. Depending on the setting of cbreak(), this
will be after one character (CBREAK mode), or after the first newline
(NOCBREAK mode). In HALF-DELAY mode, the program will hang
until a character is typed or the specified timeout has been reached.
Unless noecho() has been set, the character will also be echoed into
the designated window. No refresh() will occur between the move()
and the getch() done within the routines mvgetch() and
mvwgetch().

When using getch(), wgetch(), mvgetch(), or mvwgetch(), do not
set both NOBREAK mode (nocbreak()) and ECHO mode (echo()) at
the same time. Depending on the state of the tty driver when each
character is typed, the program may produce undesirable results.

If keypad() is TRUE, and a function key is pressed, the token for
that function key will be returned instead of the raw characters. Pos­
sible function keys are defined in <curses.h> with integers beginning
with 0401, whose names begin with KEY_. If a character is received
that could be the beginning of a function key (such as escape), curses
will set a timer. If the remainder of the sequence does not come in
within the designated time, the character will be passed through, oth­
otherwise the function key value will be returned. For this reason, on
many terminals, there will be a delay after a user presses the escape
key before the escape is returned to the program. (Use by a program­
ner of the escape key for a single character function is discouraged.)
Since tokens returned by these routines are outside of the ASCII
range, they are not printable.

NOTE: getch, mvgetch, and mvwgetch are macros.
getstr(str)
char *str;
wgetstr(win, str)
WINDOW *win;
char *str;
mvgetstr(y, x, str)
int y, x;
char *str;
mvwgetstr(win, y, x, str)
WINDOW *win;
int y, x;
char *str;

A series of calls to getch() is made, until a newline and carriage return is received. The resulting value is placed in the area pointed at by the character pointer str. The user's erase and kill characters are interpreted.

NOTE: getstr, mvgetstr, and mvwgetstr are macros.

flushinp()

Throws away any typeahead that has been typed by the user and has not yet been read by the program.

ungetch(ch)
chtpe ch;
Place ch back onto the input queue to be returned by the next call to wgetch().

chtpe inch()
chtpe winch(win)
WINDOW *win;
chtpe mvinch(y, x)
int y, x;
chtpe mvwinch(win, y, x)
WINDOW *win;
int y, x;

The character, of type chtpe, at the current position in the named window is returned. If any attributes are set for that position, their values will be OR'ed into the value returned. The predefined constants A_CHARTEXT and A_ATTRIBUTES, defined in <curses.h>, can be used with the & (logical and) operator to extract the character or attributes alone.

NOTE: inch, winch, mvinch, and mvwinch are macros.
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scanw(fmt [, arg] ...)
char *fmt;

wscanw(win, fmt [, arg] ...)
WINDOW *win;
char *fmt;

mvscanw(y, x, fmt [, arg] ...)
int y, x;
char *fmt;

mvwscanw(win, y, x, fmt [, arg] ...)
WINDOW *win;
int y, x;
char *fmt;

These routines correspond to scanf [see SCANF(BA_LIB)]. The
wgetstr() is called on the window, and the resulting line is used as
input for the scan. Fields which do not map to a variable in the fmt
field are lost. Users may interrogate the return value from these rou­
tines to determine the number of fields which were mapped in the
call.

Output Options Setting

These routines set options within curses that deal with output. All options
are initially FALSE, unless otherwise stated. It is not necessary to turn
these options off before calling endwin().

clearok(win, bf)
WINDOW *win;
bool bf;
    If enabled (bf is TRUE,) the next call to wrefresh() with this win­
dow will clear the screen completely and redraw the entire screen from
scratch. This is useful when the contents of the screen are uncertain,
or in some cases for a more pleasing visual effect.

idlok(win, bf)
WINDOW *win;
bool bf;
    If enabled (bf is TRUE), curses will consider using the hardware
insert/delete line feature of terminals so equipped. If disabled (bf is
FALSE), curses will very seldom use this feature. (The insert/delete
character feature is always considered.) This option should be
enabled only if the application needs insert/delete line, for example,
for a screen editor. It is disabled by default because insert/delete line
tends to be visually annoying when used in applications where it isn’t
really needed. If insert/delete line cannot be used, *curses* will redraw the changed portions of all lines.

```c
leaveok(win, bf)
WINDOW *win;
bool bf;
```

Normally, the hardware cursor is left at the location of the window cursor being refreshed. This option allows the cursor to be left wherever the update happens to leave it. It is useful for applications where the cursor is not used, since it reduces the need for cursor motions. If possible, the cursor is made invisible when this option is enabled.

```c
setscrreg(top, bot)
int top, bot;
```

These routines allow the user to set a software scrolling region in a window. *top* and *bot* are the line numbers of the top and bottom margin of the scrolling region. (Line 0 is the top line of the window.) If this option and `scrolllok()` are enabled, an attempt to move off the bottom margin line will cause all lines in the scrolling region to scroll up one line. Only the text of the window is scrolled. (Note that this has nothing to do with use of a physical scrolling region capability in the terminal, like that in the VT100. If `idlok()` is enabled and the terminal has either a scrolling region or insert/delete line capability, they will probably be used by the output routines.)

```c
scrolllok(win, bf)
WINDOW *win;
bool bf;
```

This option controls what happens when the cursor of a window is moved off the edge of the window or scrolling region, either from a newline on the bottom line, or typing the last character of the last line. If disabled, (*bf* is `FALSE`), the cursor is left on the bottom line. If enabled, (*bf* is `TRUE`), `wrefresh()` is called on the window, and then the physical terminal and window are scrolled up one line. [Note that in order to get the physical scrolling effect on the terminal, is is also necessary to call `idlok()`.]
nl()
nonl()

These routines control whether newline is translated into carriage return and linefeed on output, and whether return is translated into newline on input. Initially, the translations do occur. By disabling these translations using nonl(), curses is able to make better use of the linefeed capability, resulting in faster cursor motion.

NOTE: nl is a macro.

Input Options Setting
cbreak()
nocbreak()

These two routines put the terminal into and out of CBREAK mode, respectively. In this mode, characters typed by the user are immediately available to the program and erase/kill character-processing is not performed. When out of this mode, the tty driver will buffer characters typed until a newline or carriage return is typed. Interrupt and flow control characters are unaffected by this mode. Initially the terminal may or may not be in CBREAK mode, as it is inherited; therefore, a program should call cbreak() or nocbreak() explicitly. Most interactive programs using curses will set this mode.

Note that cbreak() overrides raw(). See getch() under "Input" for a discussion of how these routines interact with echo() and noecho().

def_prog_mode()
def_shell_mode()
saveterm()

Save the current terminal modes as the "program" (in curses) or "shell" (not in curses) state for use by the reset_prog_mode() and reset_shell_mode() routines. This is done automatically by initscr().

NOTE: The saveterm() routine is being replaced by def_prog_mode(), which provides the same functionality. Saveterm() is included here for compatibility and is supported at level 2.
echo()

noecho()

These routines control whether characters typed by the user are echoed by `getch()` as they are typed. Echoing by the tty driver is always disabled, but initially `getch()` is in ECHO mode, so characters typed are echoed. Initially, characters typed are echoed. Authors of most interactive programs prefer to do their own echoing in a controlled area of the screen, or not to echo at all, so they disable echoing by calling `noecho()`. See `getch()` under "Input" for a discussion of how these routines interact with `cbreak()` and `nocbreak()`.

halfdelay(tenths)

`HALF-DELAY` mode is similar to CBREAK mode in that characters typed by the user are immediately available to the program. However, after blocking for `tenths` tenths of seconds, ERR will be returned if nothing has been typed. `tenths` must be a number between 1 and 255. Use `nocbreak()` to leave HALF-DELAY mode.

intrflush(win, bf)

This option enables the keypad of the user's terminal. If enabled (bf is TRUE), the user can press a function key (such as an arrow key) and `wgetch()` will return a single value representing the function key, as in `KEY_LEFT`. (See FUNCTION KEYS below.) If disabled (bf is FALSE), `curses` will not treat function keys specially and the program would have to interpret the escape sequences itself. If the keypad in the terminal can be turned on (made to transmit) and off (made to work locally), turning on this option will cause the terminal keypad to be turned on when `wgetch()` is called. The default value for keypad is false.
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nodelay(win, bf)
WINDOW *win;
bool bf;
This option causes getch() to be a non-blocking call. If no input is ready, getch() will return ERR. If disabled (bf is FALSE), getch() will hang until a key is pressed.

raw()
noraw()
The terminal is placed into or out of RAW mode. RAW mode is similar to CBREAK mode, in that characters typed are immediately passed through to the user program. The differences are that in RAW mode, the interrupt, quit, suspend and flow control characters are passed through uninterpreted, instead of generating a signal. The behavior of the BREAK key depends on other bits in the tty driver that are not set by curses.

reset_prog_mode()
reset_shell_mode()
fixterm()
resetterm()
Restore the terminal to "program" (in curses) or "shell" (out of curses) state. These are done automatically by endwin() and doupdate() after an endwin(), so they would normally not be called before.

NOTE: The fixterm() routine is being replaced by reset_prog_mode() and the resetterm() routine is being replaced by reset_shell_mode(). fixterm() and resetterm() are included here for compatibility and are supported at level 2.

resetty()
savetty()
These routines save and restore the state of the terminal modes. savetty() saves the current state in a buffer and resetty() restores the state to what it was at the last call to savetty().

typeahead(fd)
int fd;
Curses does "line-breakout optimization" by looking for typeahead periodically while updating the screen. If input is found, and it is coming from a tty, the current update will be postponed until refresh() or doupdate() is called again. This allows faster response to commands typed in advance. Normally, the input FILE pointer
passed to \texttt{newterm()}, or \texttt{stdin} in the case that \texttt{initscr()} was used, will be used to do this typeahead checking. The \texttt{typeahead()} routine specifies that the file descriptor \texttt{fd} is to be used to check for typeahead instead. If \texttt{fd} is -1, then no typeahead checking will be done.

**Environment Queries**

\textbf{baudrate()}

Returns the output speed of the terminal. The number returned is in bits per second, for example 9600, and is an integer.

\textbf{char erasechar()}

The user's current erase character is returned.

\textbf{has_ic()}

True if the terminal has insert- and delete-character capabilities.

\textbf{has-il()}

True if the terminal has insert- and delete-line capabilities, or can simulate them using scrolling regions. This might be used to check to see if it would be appropriate to turn on physical scrolling using \texttt{scrollok()}.  

\textbf{char killchar()}

The user's current line kill character is returned.

\textbf{char *longname()}

This routine returns a pointer to a static area containing a verbose description of the current terminal. The maximum length of a verbose description is 128 characters. It is defined only after the call to \texttt{initscr()} or \texttt{newterm()}. The area is overwritten by each call to \texttt{newterm()} and is not restored by \texttt{set_term()}, so the value should be saved between calls to \texttt{newterm()} if \texttt{longname()} is going to be used with multiple terminals.

**Soft Labels**

\textit{Curses} will manipulate the set of soft function-key labels that exist on many terminals. For those terminals that do not have soft labels, \textit{curses} will take over the bottom line of \texttt{stdscr}, reducing the size of \texttt{stdscr} and the variable LINES. \textit{Curses} standardizes on 8 labels of up to 8 characters each.

\textbf{slk_init(fmt)}

\textbf{int fmt;}

In order to use soft labels, this routine is to be called before \texttt{initscr()} or \texttt{newterm()} is called. If \texttt{initscr()} winds up using a line from
stdscr to emulate the soft labels, then fmt determines how the labels are arranged on the screen. Setting fmt to 0 indicates that the labels are to be arranged in a 3-2-3 arrangement; 1 asks for a 4-4 arrangement.

```c
int slk_set(labnum, label, fmt)
int labnum;
char *label;
int fmt;
labnum is the label number, from 1 to 8. label is the string to be put on the label, up to 8 characters in length. A NULL string or a NULL pointer will put up a blank label. fmt is one of 0, 1 or 2, to indicate whether the label is to be left-justified, centered, or right-justified within the label.
```

slk_refresh()

slk_noutrefresh()
These routines correspond to the routines wrefresh() and wnoutrefresh(). Most applications would use slk_noutrefresh() because a wrefresh() will most likely soon follow.

char *slk_label(labnum)
int labnum;
The current label for label number labnum, with leading and trailing blanks stripped, is returned.

slk_clear()
The soft labels are cleared from the screen.

slk_restore()
The soft labels are restored to the screen after a slk_clear().

slk_touch()
All of the soft labels are forced to be output the next time a slk_noutrefresh() is performed.

**Termininfo Level Routines**

These low level routines must be called by programs that need to deal directly with the terminfo database to handle certain terminal capabilities, such as programming function keys. For all other functionality, curses routines are more suitable and their use is recommended.

Initially, setupterm() should be called. [Note that setupterm() is automatically called by initscr() and newterm().] This will define the set of terminal-dependent variables defined in TERMININFO(TI_ENV). The
terminfo variables lines and columns are initialized by setupterm() as follows. If the environment variables LINES and COLUMNS exist, their values are used. If the above environment variables do not exist and the program is running in a window, the current window size is used. Otherwise, the values for lines and columns specified in the terminfo database are used.

The header files <curses.h> and <term.h> should be included to get the definitions for these strings, numbers, and flags. Parameterized strings should be passed through tparm() to instantiate them. All terminfo strings [including the output of tparm()] should be printed with puts() or putp(). Before exiting, reset_shell_mode() should be called to restore the tty modes. Programs which use cursor addressing should output enter_ca_mode upon startup and should output exit_ca_mode before exiting. (Programs desiring shell escapes should call reset_shell_mode() and output exit_ca_mode before the shell is called and should output enter_ca_mode and call reset_prog_mode() after returning from the shell.)

setupterm(term, fildes, errret)
char *term;
int fildes;
int *errret;
setterm(term)
char *term;

Read in the terminfo database, initializing the terminfo structures, but do not set up the output virtualization structures used by curses. The terminal type is the character string term; if term is null, the environment variable TERM will be used. All output is to file descriptor fildes. If errret is not NULL, then setupterm() will return OK or ERR and store a status value in the integer pointed to by errret. A status of 1 in errret is normal, 0 means that the terminal could not be found, and -1 means that the terminfo database could not be found. If errret is NULL, setupterm() will print an error message upon finding an error and exit. Thus, the simplest call is setupterm ((char *) 0, 1, (int *) 0), which uses all the defaults.

NOTE: The setterm() routine is being replaced by setupterm(). The call setupterm(term, 1, (int *) 0) provides the same functionality as setterm(term). setterm() is included here for compatibility and is supported at level 2.
char *tparm(str, p1, p2, ..., p9)
char *str;
int p1, p2, p3, p4, p5, p6, p7, p8, p9;
Instantiate the string str with parms pi. A pointer is returned to the result of str with the parameters applied.

puts(str, affcnt, pute)
char *str;
int affcnt;
int (*pute)();
Apply padding information to the string str and output it. str must be a terminfo string variable or the return value from tparm(), tgetstr(), or tgoto(). affcnt is the number of lines affected, or 1 if not applicable. pute() is a putchar like routine to which the characters are passed, one at a time.

putp(str)
char *str;
A routine that calls puts(str, 1, putchar).

vidputs(attrs, pute)
int attrs;
int (*pute)();
Output the string to put the terminal in the video attribute mode attrs, which is any combination of the attributes listed below. The characters are passed to the putchar like routine pute.

vidattr(attrs)
int attrs;
Like vidputs(), except that it outputs through putchar.

mveur(oldrow, oldcol, newrow, newcol)
int oldrow, oldcol, newrow, newcol;
Low level cursor motion.

The following routines return the value of the capability corresponding to the terminfo capname passed to them, such as xenl.

The capname for each capability is given in the table column entitled capname code in the capabilities section of the terminfo(TI_ENV).

tigetflag(capname)
char *capname;
The value -1 is returned if capname is not a boolean capability.
tigetnum(capname)
char *capname;
The value -2 is returned if capname is not a numeric capability.

tigetstr(capname)
char *capname;
The value (char *) -1 is returned if capname is not a string capability.

char *boolnames, *boolcodes, *boolfnames
char *numnames, *numcodes, *numfnames
char *strnames, *strcodes, *strfnames
These null-terminated arrays contain the capnames, the termcap codes, and the full C names, for each of the terminfo variables.

Termcap Compatibility Routines
These routines were included as a conversion aid for programs that use the termcap library. Their parameters are the same and the routines are emulated using the terminfo database.

tgetent(bp, name)
char *bp, *name;
Look up termcap entry for name. The emulation ignores the buffer pointer bp.

tgetflag(id)
char id[2];
Get the boolean entry for id.

tgetnum(id)
char id[2];
Get numeric entry for id.

cchar *tgetstr(id, area)
cchar id[2];
cchar **area;
Return the string entry for id. tputs() should be used to output the returned string.
char *tgoto(cap, col, row)
char *cap;
int col, row;
Instantiate the parameters into the given capability. The output from this routine is to be passed to tputs().

.puts(str,affcnt,putc)
char *str;
int affcnt;
int (*putc)();
[See tputs() under Terminfo Level Routines above.]

Miscellaneous
char *unctrl(c)
chtype c;
This macro expands to a character string which is a printable representation of the character c. Control characters are displayed in the \X notation. Printing characters are displayed as is.
NOTE: unctrl is a macro, which is defined in <unctrl.h>.

char *keyname(c)
int c;
A character string corresponding to the key c is returned.

.gettmode()
No-op.
NOTE: .gettmode() is included here for compatibility and is supported at level 2.

int scr_dump(filename)
char *filename;
The current contents of the virtual screen are written to the file filename.

int scr_restore(filename)
char *filename;
The virtual screen is set to the contents of filename, which must have been written using scr_dump(). The next call to doupdate() will restore the screen to what it looked like in the dump file.

int scr_init(filename)
char *filename;
The contents of filename are read in and used to initialize the curses data structures about what the terminal currently has on its
screen. If the data is determined to be valid, *curses* will base its next update of the screen on this information rather than clearing the screen and starting from scratch. *scr_init()* would be used after *initscr()* or a *system* [see *SYSTEM(BA_LIB)*] call to share the screen with another process, which has done a *scr_dump()* after its *endwin()* call. The data will be declared invalid if the time-stamp of the tty is old or the *terminfo* capability *rmcup* exists.

**Attributes**

The following video attributes, defined in `<curses.h>`, can be passed to the routines *attron()*, *attroff()*, and *attrset()*, or OR'ed with the characters passed to *addch()*.  

- **A_STANDOUT**  
  Terminal's best highlighting mode  
- **A_UNDERLINE**  
  Underlining  
- **A_REVERSE**  
  Reverse video  
- **A_BLINK**  
  Blinking  
- **A_DIM**  
  Half bright  
- **A_BOLD**  
  Extra bright or bold  
- **A_ALTCCHARSET**  
  Alternate character set  
- **A_CHARTEXT**  
  Bit-mask to extract a character  
- **A_ATTRIBUTES**  
  Bit-mask to extract attributes

**Function Keys**

The following function keys, defined in `<curses.h>`, might be returned by *getch()* if *keypad()* has been enabled. Note that not all of these may be supported on a particular terminal if the terminal does not transmit a unique code when the key is pressed or the definition for the key is not present in the *terminfo* database.
<table>
<thead>
<tr>
<th>Name</th>
<th>Octal Value</th>
<th>Key name</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEY_BREAK</td>
<td>0401</td>
<td>Break key</td>
</tr>
<tr>
<td>KEY_DOWN</td>
<td>0402</td>
<td>The four arrow keys ...</td>
</tr>
<tr>
<td>KEY_UP</td>
<td>0403</td>
<td></td>
</tr>
<tr>
<td>KEY_LEFT</td>
<td>0404</td>
<td></td>
</tr>
<tr>
<td>KEY_RIGHT</td>
<td>0405</td>
<td>...</td>
</tr>
<tr>
<td>KEY_HOME</td>
<td>0406</td>
<td>Home key</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(upward+left arrow)</td>
</tr>
<tr>
<td>KEY_BACKSPACE</td>
<td>0407</td>
<td>Backspace</td>
</tr>
<tr>
<td>KEY_F0</td>
<td>0410</td>
<td>Function keys; space for 64 keys is reserved.</td>
</tr>
<tr>
<td>KEY_F(n)</td>
<td>(KEY_F0+(n))</td>
<td>Delete line</td>
</tr>
<tr>
<td>KEY_DL</td>
<td>0510</td>
<td>Delete line</td>
</tr>
<tr>
<td>KEY_IL</td>
<td>0511</td>
<td>Insert line</td>
</tr>
<tr>
<td>KEY_DC</td>
<td>0512</td>
<td>Delete character</td>
</tr>
<tr>
<td>KEY_IC</td>
<td>0513</td>
<td>Insert char or enter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>insert mode</td>
</tr>
<tr>
<td>KEY_EIC</td>
<td>0514</td>
<td>Exit insert char mode</td>
</tr>
<tr>
<td>KEY_CLEAR</td>
<td>0515</td>
<td>Clear screen</td>
</tr>
<tr>
<td>KEY_EOS</td>
<td>0516</td>
<td>Clear to end of screen</td>
</tr>
<tr>
<td>KEY_EOL</td>
<td>0517</td>
<td>Clear to end of line</td>
</tr>
<tr>
<td>KEY_SF</td>
<td>0520</td>
<td>Scroll 1 line forward</td>
</tr>
<tr>
<td>KEY_SR</td>
<td>0521</td>
<td>Scroll 1 line backward (reverse)</td>
</tr>
<tr>
<td>KEY_NPAGE</td>
<td>0522</td>
<td>Next page</td>
</tr>
<tr>
<td>KEY_PPAGE</td>
<td>0523</td>
<td>Previous page</td>
</tr>
<tr>
<td>KEY_STAB</td>
<td>0524</td>
<td>Set tab</td>
</tr>
<tr>
<td>KEY_CTAB</td>
<td>0525</td>
<td>Clear tab</td>
</tr>
<tr>
<td>KEY_CATAB</td>
<td>0526</td>
<td>Clear all tabs</td>
</tr>
<tr>
<td>KEY_ENTER</td>
<td>0527</td>
<td>Enter or send</td>
</tr>
<tr>
<td>KEY_SRESET</td>
<td>0530</td>
<td>Soft (partial) reset</td>
</tr>
<tr>
<td>KEY_RESET</td>
<td>0531</td>
<td>Reset or hard reset</td>
</tr>
<tr>
<td>KEY_PRINT</td>
<td>0532</td>
<td>Print or copy</td>
</tr>
<tr>
<td>Name</td>
<td>Octal Value</td>
<td>Key name</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>KEY_LL</td>
<td>0533</td>
<td>Home down or bottom (lower left)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Keypad is arranged like this:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A1 up A3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>left B2 right</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C1 down C3</td>
</tr>
<tr>
<td>KEY_A1</td>
<td>0534</td>
<td>Upper left of keypad</td>
</tr>
<tr>
<td>KEY_A3</td>
<td>0535</td>
<td>Upper right of keypad</td>
</tr>
<tr>
<td>KEY_B2</td>
<td>0536</td>
<td>Center of keypad</td>
</tr>
<tr>
<td>KEY_C1</td>
<td>0537</td>
<td>Lower left of keypad</td>
</tr>
<tr>
<td>KEY_C3</td>
<td>0540</td>
<td>Lower right of keypad</td>
</tr>
<tr>
<td>KEY_BTAB</td>
<td>0541</td>
<td>Back tab key</td>
</tr>
<tr>
<td>KEY_BEG</td>
<td>0542</td>
<td>Beg(inning) key</td>
</tr>
<tr>
<td>KEY_CANCEL</td>
<td>0543</td>
<td>Cancel key</td>
</tr>
<tr>
<td>KEY_CLOSE</td>
<td>0544</td>
<td>Close key</td>
</tr>
<tr>
<td>KEY_COMMAND</td>
<td>0545</td>
<td>Cmd (command) key</td>
</tr>
<tr>
<td>KEY_COPY</td>
<td>0546</td>
<td>Copy key</td>
</tr>
<tr>
<td>KEY_CREATE</td>
<td>0547</td>
<td>Create key</td>
</tr>
<tr>
<td>KEY_END</td>
<td>0550</td>
<td>End key</td>
</tr>
<tr>
<td>KEY_EXIT</td>
<td>0551</td>
<td>Exit key</td>
</tr>
<tr>
<td>KEY_FIND</td>
<td>0552</td>
<td>Find key</td>
</tr>
<tr>
<td>KEY_HELP</td>
<td>0553</td>
<td>Help key</td>
</tr>
<tr>
<td>KEY_MARK</td>
<td>0554</td>
<td>Mark key</td>
</tr>
<tr>
<td>KEY_MESSAGE</td>
<td>0555</td>
<td>Message key</td>
</tr>
<tr>
<td>KEY_MOVE</td>
<td>0556</td>
<td>Move key</td>
</tr>
<tr>
<td>KEY_NEXT</td>
<td>0557</td>
<td>Next object key</td>
</tr>
<tr>
<td>KEY_OPEN</td>
<td>0560</td>
<td>Open key</td>
</tr>
<tr>
<td>KEY.Options</td>
<td>0561</td>
<td>Options key</td>
</tr>
<tr>
<td>KEY_PREVIOUS</td>
<td>0562</td>
<td>Previous object key</td>
</tr>
<tr>
<td>KEY_REDO</td>
<td>0563</td>
<td>Redo key</td>
</tr>
<tr>
<td>KEY_REFERENCE</td>
<td>0564</td>
<td>Ref(ERENCE) key</td>
</tr>
<tr>
<td>KEY_REFRESH</td>
<td>0565</td>
<td>Refresh key</td>
</tr>
<tr>
<td>KEY_REPLACE</td>
<td>0566</td>
<td>Replace key</td>
</tr>
<tr>
<td>KEY_RESTART</td>
<td>0567</td>
<td>Restart key</td>
</tr>
<tr>
<td>KEY_RESUME</td>
<td>0570</td>
<td>Resume key</td>
</tr>
<tr>
<td>Name</td>
<td>Octal Value</td>
<td>Key name</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>KEY_SAVE</td>
<td>0571</td>
<td>Save key</td>
</tr>
<tr>
<td>KEY_SBEVG</td>
<td>0572</td>
<td>Shifted beginning key</td>
</tr>
<tr>
<td>KEY_SCANCEL</td>
<td>0573</td>
<td>Shifted cancel key</td>
</tr>
<tr>
<td>KEY_SCOMMAND</td>
<td>0574</td>
<td>Shifted command key</td>
</tr>
<tr>
<td>KEY_SCPY</td>
<td>0575</td>
<td>Shifted copy key</td>
</tr>
<tr>
<td>KEY_SCREATE</td>
<td>0576</td>
<td>Shifted create key</td>
</tr>
<tr>
<td>KEY_SDC</td>
<td>0577</td>
<td>Shifted delete char key</td>
</tr>
<tr>
<td>KEY_SDL</td>
<td>0600</td>
<td>Shifted delete line key</td>
</tr>
<tr>
<td>KEY_SELECT</td>
<td>0601</td>
<td>Select key</td>
</tr>
<tr>
<td>KEY_SEND</td>
<td>0602</td>
<td>Shifted end key</td>
</tr>
<tr>
<td>KEY_SEOL</td>
<td>0603</td>
<td>Shifted clear line key</td>
</tr>
<tr>
<td>KEY_SEXIT</td>
<td>0604</td>
<td>Shifted exit key</td>
</tr>
<tr>
<td>KEY_SFIN</td>
<td>0605</td>
<td>Shifted find key</td>
</tr>
<tr>
<td>KEY_SHelp</td>
<td>0606</td>
<td>Shifted help key</td>
</tr>
<tr>
<td>KEY_SHOME</td>
<td>0607</td>
<td>Shifted home key</td>
</tr>
<tr>
<td>KEY_SIC</td>
<td>0610</td>
<td>Shifted input key</td>
</tr>
<tr>
<td>KEY_SLEFT</td>
<td>0611</td>
<td>Shifted left arrow key</td>
</tr>
<tr>
<td>KEY_SMESAGE</td>
<td>0612</td>
<td>Shifted message key</td>
</tr>
<tr>
<td>KEY_SMOVE</td>
<td>0613</td>
<td>Shifted move key</td>
</tr>
<tr>
<td>KEY_SNEXT</td>
<td>0614</td>
<td>Shifted next key</td>
</tr>
<tr>
<td>KEY_SOPTIONS</td>
<td>0615</td>
<td>Shifted options key</td>
</tr>
<tr>
<td>KEY_SPRVIOUS</td>
<td>0616</td>
<td>Shifted prev key</td>
</tr>
<tr>
<td>KEY_SPRINT</td>
<td>0617</td>
<td>Shifted print key</td>
</tr>
<tr>
<td>KEY_SREDO</td>
<td>0620</td>
<td>Shifted redo key</td>
</tr>
<tr>
<td>KEY_SREPLACE</td>
<td>0621</td>
<td>Shifted replace key</td>
</tr>
<tr>
<td>KEY_SRIGHT</td>
<td>0622</td>
<td>Shifted right arrow</td>
</tr>
<tr>
<td>KEY_SRSUME</td>
<td>0623</td>
<td>Shifted resume key</td>
</tr>
<tr>
<td>KEY_SSAVE</td>
<td>0624</td>
<td>Shifted save key</td>
</tr>
<tr>
<td>KEY_SSUSPEND</td>
<td>0625</td>
<td>Shifted suspend key</td>
</tr>
<tr>
<td>KEY_SUNDO</td>
<td>0626</td>
<td>Shifted undo key</td>
</tr>
<tr>
<td>KEY_SUSPEND</td>
<td>0627</td>
<td>Suspend key</td>
</tr>
<tr>
<td>KEY_UNDO</td>
<td>0630</td>
<td>Undo key</td>
</tr>
</tbody>
</table>
LINE GRAPHICS

The following variables may be used to add line-drawing characters to the
screen with waddch(). When defined for the terminal, the variable will
have the A_ALTCCHARSET bit turned on. Otherwise, the default character
listed below will be stored in the variable. The names were chosen to be
consistent with the ‘‘VT100’’ nomenclature.

<table>
<thead>
<tr>
<th>Name</th>
<th>Default</th>
<th>Glyph Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS_ULCORNER</td>
<td>+</td>
<td>upper left corner</td>
</tr>
<tr>
<td>ACS_LLCORNER</td>
<td>+</td>
<td>lower left corner</td>
</tr>
<tr>
<td>ACS_URCORNER</td>
<td>+</td>
<td>upper right corner</td>
</tr>
<tr>
<td>ACS_LRCORNER</td>
<td>+</td>
<td>lower right corner</td>
</tr>
<tr>
<td>ACS_RTEE</td>
<td>+</td>
<td>right tee (⊥)</td>
</tr>
<tr>
<td>ACS_LTEE</td>
<td>+</td>
<td>left tee (⊥)</td>
</tr>
<tr>
<td>ACS_BTEE</td>
<td>+</td>
<td>bottom tee (⊥)</td>
</tr>
<tr>
<td>ACS_TTEE</td>
<td>+</td>
<td>top tee (↑)</td>
</tr>
<tr>
<td>ACS_HLINE</td>
<td>-</td>
<td>horizontal line</td>
</tr>
<tr>
<td>ACS_VLINE</td>
<td>!</td>
<td>vertical line</td>
</tr>
<tr>
<td>ACS_PLUS</td>
<td>+</td>
<td>plus</td>
</tr>
<tr>
<td>ACS_S1</td>
<td>-</td>
<td>scan line 1</td>
</tr>
<tr>
<td>ACS_S9</td>
<td>_</td>
<td>scan line 9</td>
</tr>
<tr>
<td>ACS_DIAMOND</td>
<td>+</td>
<td>diamond</td>
</tr>
<tr>
<td>ACS_CKBOARD</td>
<td>:</td>
<td>checker board (stipple)</td>
</tr>
<tr>
<td>ACS_DEGREE</td>
<td>'</td>
<td>degree symbol</td>
</tr>
<tr>
<td>ACS_PLMINUS</td>
<td>#</td>
<td>plus/minus</td>
</tr>
<tr>
<td>ACS_BULLET</td>
<td>o</td>
<td>bullet</td>
</tr>
<tr>
<td>ACS_LARROW</td>
<td>&lt;</td>
<td>arrow pointing left</td>
</tr>
<tr>
<td>ACS_RARROW</td>
<td>&gt;</td>
<td>arrow pointing right</td>
</tr>
<tr>
<td>ACS_DARROW</td>
<td>v</td>
<td>arrow pointing down</td>
</tr>
<tr>
<td>ACS_UARROW</td>
<td>-</td>
<td>arrow pointing up</td>
</tr>
<tr>
<td>ACS_BOARD</td>
<td>#</td>
<td>board of squares</td>
</tr>
<tr>
<td>ACS_LANTERN</td>
<td>#</td>
<td>lantern symbol</td>
</tr>
<tr>
<td>ACS_BLOCK</td>
<td>#</td>
<td>solid square block</td>
</tr>
</tbody>
</table>

RETURN VALUE

All routines return the integer ERR upon failure and an integer value other
than ERR upon successful completion. Unless otherwise noted in the
preceding routine descriptions.
CURSES(TI_LIB)

All macros return the value of the w version, except setsrreg(),
wsetscrreg(), getyx(), getbegyx(), getmaxyx(). The return values of
setsrreg(), wsetscrreg(), getyx(), getbegyx(), and getmaxyx() are
undefined (i.e., these should not be used as the right-hand side of assign­
ment statements).

Routines that return pointers always return \texttt{(type *) NULL} on error.

\textbf{SEE ALSO}
\texttt{TERMINFO(TI_ENV)}.

\textbf{USAGE}

Application Program.

The header file \texttt{<curses.h>} automatically includes the header files
\texttt{<stdio.h>} and \texttt{<unctrl.h>}.

\textbf{LEVEL}

Level 1: All routines except fixterm(), gettmode(), resetterm(), saveterm(),
setterm(), and the \texttt{termcap} compatibility routines tgetent(), tgetflag(), tget-
num(), tgetstr(), and tgoto().

Level 2: December 1, 1985 for fixterm(), gettmode(), resetterm(),
saveterm(), setterm(), and the \texttt{termcap} compatibility routines tgetent(),
tgetflag(), tgetnum(), tgetstr(), and tgoto().
NAME
tic - terminfo compiler

SYNOPSIS
tic [ -v[n] ] [ -c ] file

DESCRIPTION
The command tic translates a terminfo file from the source format into the compiled format. The results are placed in the directory /usr/lib/terminfo. The compiled format is necessary for use with the library routines described in CURSES(TI_LIB). The argument file contains one or more terminfo terminal descriptions in source format [see TERMINFO(TI_ENV)].

The option -v (verbose) causes tic to output trace information showing its progress. The optional integer n is a number from 1 to 10, inclusive, indicating the desired level of detail of information. If n is omitted, the default level is 1. If n is specified and greater than 1, the level of detail is increased.

The option -c only checks file for errors.

The command tic compiles all terminfo descriptions in the given file. Each description in the file describes the capabilities of a particular terminal. When a use=entry._name field is discovered in the terminal entry currently being compiled, tic duplicates the capabilities in entry._name for the current entry, with the exception of those capabilities that are explicitly referenced in the current entry.

If the environment variable TERMINFO is set, the compiled results are placed there instead of /usr/lib/terminfo.

Total compiled entries cannot exceed 4096 bytes. The name field cannot exceed 128 bytes.

FILES
/usr/lib/terminfo/?/* Compiled terminal description database

SEE ALSO
CURSES(TI_LIB), TERMINFO(TI_ENV).
USAGE

Administrator.

When an entry, e.g., `entry_name_1`, contains a `use=entry_name_2` field, any cancelled capabilities in `entry_name_2` must also appear in `entry_name_1` before `use=` for these capabilities to be cancelled in `entry_name_1`.

LEVEL

Level 1.
NAME
tput - initialize a terminal or query the terminfo database

SYNOPSIS
tput [-T type] capname [parms ...]
tput [-T type] init

tput [-T type] longname

tput [-T type] reset

DESCRIPTION
The command tput uses the terminfo database to make the values of
terminal-dependent capabilities and information available to the shell [see
SH(BU_CMD)], to initialize or reset the terminal, or return the long name of
the requested terminal type. The command tput outputs a string if the
attribute is of type string, or an integer if the attribute is of type integer. If
the attribute is of type boolean, tput simply sets the exit code (0 for TRUE
if the terminal has the capability, 1 for FALSE if it does not), and produces
no output.

-T type indicates the type of terminal. Normally this option is
unnecessary, as the default is taken from the environment
variable TERM. If -T is specified, then the shell variables
LINES and COLUMNS and the layer size will not be refer-
enced.

capname indicates the attribute from the terminfo database. [See
TERMINFO(TI_ENV)].

parms If the attribute is a string that takes parameters, the argu-
ments parms will be instantiated into the string. An all
numeric argument will be passed to the attribute as a number.

init If the terminfo database is present and an entry for the user's
terminal exists, then the following will occur: (1) if present,
the terminal's initialization strings will be output (is1, is2,
is3, if, iprog) (2) any delays (e.g., newline) specified in the
entry will be set in the tty driver (3) tabs expansion will be
turned on or off according to the specification in the entry,
and (4) if tabs are not expanded, standard tabs will be set
(every 8 spaces). If an entry does not contain the information
needed for any of the four above activities, that activity will
silently be skipped.
longname  If the *terminfo* database is present and an entry for the user’s terminal exists, then the long name of the terminal will be output. The long name is the last name in the first line of the terminal’s description in the *terminfo* database.

reset  *reset* behaves identically like *init* with the following exception. Instead of outputting initialization strings, the terminal’s reset strings will be output if present (*rs1*, *rs2*, *rs3*, *rf*). If the reset strings are not present, but initialization strings are, the initialization strings will be output.

**EXAMPLES**

```
tput clear
Echo clear-screen sequence for the current terminal.

tput cols
Print the number of columns for the current terminal.

tput -T450 cols
Print the number of columns for the 450 terminal.

bold=\'tput smso\'
offbold=\'tput rmso\'
Set the shell variables "bold" to begin standout mode sequence and "offbold" to end standout mode sequence for the current terminal. This might be followed by a prompt, e.g.:
\n```
echo "${bold}Name: ${offbold}\c"
```

```
tput hc
Set exit code to indicate if the current terminal is a hardcopy terminal.

tput cup 23 4
Print the sequence to move the cursor to row 23, column 4.

tput longname
Print the long name from the *terminfo* database for the type of terminal specified in the environmental variable TERM.

tput init
Initialize the terminal according to the type of terminal in the environmental variable TERM. This command should be included in everyone’s .profile after the environmental variable TERM has been exported.
```
TPUT(TI_CMD)

tput -T5620 reset
    Reset an AT&T 5620 terminal, overriding the type of terminal in the
    environmental variable TERM.

tput cup 0 0
    Send the sequence to move the cursor to row 0, column 0 (the upper
    left corner of the screen, usually known as the "home" cursor posi­
    tion).

FILES

/usr/lib/terminfo/?/*
    Compiled terminal description database
    terminfo(TI_ENV).

RETURN VALUE

If capname is of type boolean, a value of 0 is returned for TRUE and 1 for
FALSE.

If capname is of type string, a value of 0 is returned; if the capname is
defined for this terminal type (the value of capname is returned on stan­
dard output); a value of 1 is returned if capname is not defined for this
terminal type (a null value is returned on standard output).

If capname is of type integer, a value of 0 is returned if capname is
defined for this terminal type.

The following error codes are returned:
    2 usage error
    3 unknown terminal type or no terminfo database
    4 unknown terminfo capability capname
    (i.e., terminfo does not support a capability named capname).

SEE ALSO
    STTY(BU_CMD), TERMINFO(TI_ENV).

USAGE

Application Program.

tput init or tput reset may clear the user's screen.

LEVEL
    Level 1.
Part IV

Network Services Extension Definition
12.1 INTRODUCTION

The NETWORK SERVICES EXTENSION provides advanced standard interfaces to support networking applications. It is divided into three functional areas: OPEN SYSTEMS NETWORKING INTERFACES, STREAMS I/O INTERFACES, and the SHARED RESOURCE ENVIRONMENT. Consistent with the definition of Conforming Systems (see section 1.2.2), a conforming system must support all components defined for each of these three functional areas.

The OPEN SYSTEMS NETWORKING INTERFACES section describes functions that provide a protocol independent application interface to networking services based on the service definitions of the OSI (Open Systems Interconnection) Reference Model. Application developers access the functions that provide services at a particular level and need not care about the protocol implementation that is providing those services. The functions defined at this time provide the services of the OSI Transport Layer. These services provide end-to-end data transmission using the services of an underlying network. Applications written using the transport interface are independent of the underlying protocols. By providing media and protocol independence, the interface enables networking applications to have the flexibility to run in various protocol environments.

The STREAMS I/O INTERFACES section describes the interfaces that enable a user to directly access protocol modules that are implemented in the kernel using the streams framework. Streams provides a uniform mechanism for implementing network services in the kernel by defining standard interfaces for device drivers and protocol modules.

The SHARED RESOURCE ENVIRONMENT section describes new capabilities for sharing and administering resources among interconnected machines. These new capabilities are collectively known as Remote File Sharing. Using Remote File Sharing, files that physically reside on a remote machine can be accessed as if they were on the local machine; the capabilities described here provide the interface for accessing and managing Remote File Sharing. New utilities provide the basic functionality, while additional functionality is added to the Base System, the BASIC UTILITIES EXTENSION, and the ADMINISTERED SYSTEM EXTENSION.
The components of the NETWORK SERVICES EXTENSION are new in System V Release 3. The NETWORK SERVICES EXTENSION is dependent upon the Base System as defined for System V Release 3.
Chapter 13
Open Systems Networking Interfaces

13.1 INTRODUCTION

The OPEN SYSTEMS NETWORKING INTERFACES section of the NETWORK SERVICES EXTENSION describes functions that provide a protocol independent application interface to networking services based on the service definitions of the OSI (Open Systems Interconnection) Reference Model. Application developers access the functions that provide services at a particular level and need not care about the protocol implementation that is providing those services.

The functions defined at this time provide the services of the OSI Transport Layer. These services provide end-to-end data transmission using the services of an underlying network. Applications written using the transport interface are independent of the underlying protocols. By providing media and protocol independence, the interface enables networking applications to have the flexibility to run in various protocol environments.

This section of the extension is dependent upon the Base System.

13.2 FUTURE DIRECTIONS

As interfaces to other layers of the OSI Reference Model become defined for System V, the functions providing services of these layers will be included in the OPEN SYSTEMS NETWORKING INTERFACES library.

13.3 DESCRIPTION

LIBRARY ROUTINES

<table>
<thead>
<tr>
<th>t_accept</th>
<th>t_error</th>
<th>t_look</th>
<th>t_recv</th>
<th>t_snd</th>
<th>t_snddis</th>
</tr>
</thead>
<tbody>
<tr>
<td>t_alloc</td>
<td>t_free</td>
<td>t_open</td>
<td>t_revc</td>
<td>t_sndrel</td>
<td>t_snddis</td>
</tr>
<tr>
<td>t_bind</td>
<td>t_getinfo</td>
<td>t_optmgmt</td>
<td>t_recvdata</td>
<td>t_snd</td>
<td>t SNDdata</td>
</tr>
<tr>
<td>t_close</td>
<td>t_getstate</td>
<td>t_rcv</td>
<td>t_sndrel</td>
<td>t SND</td>
<td>t SNDdata</td>
</tr>
<tr>
<td>t_connect</td>
<td>t_listen</td>
<td>t_recvconnect</td>
<td>t SND</td>
<td>t SND</td>
<td>t SNDdata</td>
</tr>
</tbody>
</table>

HEADER FILES

`tiuser.h`
13.4 DEFINITIONS

Transport user
The user-level application or protocol that is accessing the services of the transport interface.

Active transport user
The transport user that initiates a connection.

Passive transport user
The transport user that listens for an incoming connect indication.

Transport provider
The transport protocol that provides the services of the transport interface.

Transport endpoint
The communication path, which is identified by a file descriptor, between a transport user and a specific transport provider.

Protocol address
The address, also known as the Transport Service Access Point (TSAP) address, that identifies the transport user. This interface places no structure or semantics on an address.

Connection mode
A circuit-oriented mode of transfer in which data is passed from one user to another over an established connection in a reliable, sequenced fashion.

Connectionless mode
A mode of transfer in which data is passed from one user to another in self-contained units with no logical relationship required among multiple units.

Synchronous execution
The mode of execution in which transport service functions wait for specific asynchronous events to occur before returning control to the user.
Asynchronous execution

The mode of execution in which transport service functions do not wait for specific asynchronous events to occur before returning control to the user, but instead return immediately if the event is not pending.

TSDU

The Transport Service Data Unit, which is the user data transmitted over a transport connection and whose identity is preserved from one end of a transport connection to the other (i.e., a message).

ETSDU

The Expedited Transport Service Data Unit, which is the expedited data transmitted over a transport connection and whose identity is preserved from one end of a transport connection to the other (i.e., an expedited message).

netbuf structure

The netbuf structure is used by many of the library functions and is defined by the <tiuser.h> header file. This structure includes the following members:

- unsigned int maxlen; /* max buffer length */
- unsigned int len; /* length of data in buffer */
- char *buf; /* pointer to data buffer */

13.5 EFFECTS ON THE BASE SYSTEM

Components in the Base System may return a new value for errno as listed below. An application that checks the value of errno must include the header file <errno.h>.

The following symbolic name defines an additional error return condition:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPROTO</td>
<td>Protocol Error</td>
</tr>
</tbody>
</table>

13.6 EFFECTS ON THE SOFTWARE DEVELOPMENT EXTENSION

In a software development environment, a program file.c that accesses any function defined in this part of the extension must be compiled in one of the following ways:

```
cc file.c -lnsl_s
```

or

```
cc file.c -lnsl
```
13.7 TRANSPORT SERVICE INTERFACE

The Open Systems Networking Interfaces provide the services of strategic levels of the Open Systems Interconnection (OSI) Reference Model [1]. The services currently defined in this library conform to those services specified in the ISO Transport Service Definition document [2] for both connection-mode and connectionless-mode transport services. Functions to support services of other layers of the OSI Reference Model will be added to this library as deemed necessary.

13.7.1 Overview

A set of functions has been defined to provide a transport service interface for user processes and to be independent of any specific transport protocol. This transport service enables two user processes to transfer data between them over a communications channel.

In order to properly use the library functions that are defined, certain rules must be followed. This overview is intended to describe the relationship among the functions and show how a developer would write an application using these functions. State tables are included to show the allowable sequences of function calls given a particular state and event.

The remainder of this interface description refers to the concept of a transport endpoint. This endpoint specifies a communications path between a transport user and a specific transport provider, and is identified by a local file descriptor (fd). In other words, a transport endpoint is manifested as an open device special file. A transport provider is defined to be the transport protocol that provides the services of the transport layer. All requests to the transport provider must pass through a transport endpoint. The file descriptor fd is returned by the function T_OPEN(NS_LIB) and is used as an argument to subsequent functions to identify the transport endpoint.
Modes of Service
The transport service interface supports two modes of service: connection mode and connectionless mode. A single transport endpoint may not support both modes of service simultaneously.

The connection-mode transport service is circuit-oriented and enables data to be transferred over an established connection in a reliable, sequenced manner. This service enables the negotiation of the parameters and options that govern the transfer of data. It provides an identification mechanism that avoids the overhead of address transmission and resolution during the data transfer phase. It also provides a context in which successive units of data, transferred between peer users, are logically related. This service is attractive to applications that require relatively long-lived, datastream-oriented interactions.

In contrast, the connectionless-mode transport service is message-oriented and supports data transfer in self-contained units with no logical relationship required among multiple units. These units are also known as datagrams. This service requires only a preexisting association between the peer users involved, which determines the characteristics of the data to be transmitted. No dynamic negotiation of parameters and options is supported by this service. All the information required to deliver a unit of data (e.g., destination address) is presented to the transport provider, together with the data to be transmitted, in a single service access which need not relate to any other service access. Also, each unit of data transmitted is entirely self-contained, and can be independently routed by the transport provider. This service is attractive to applications that involve short-term request/response interactions, exhibit a high level of redundancy, are dynamically reconfigurable, or do not require guaranteed, in-sequence delivery of data.

Error Handling
Two levels of error are defined for the transport interface. The first is the library error level. Each library function has one or more error returns. Failures are indicated by a return value of -1. An external integer, t_errno, holds the specific error number when such a failure occurs. This value is set when errors occur but is not cleared on successful library calls, so it should be tested only after an error has been indicated. A diagnostic function, T_ERROR(NS_LIB), is provided for printing out information on the current transport error. The state of the transport provider may change if a transport error occurs.

The second level of error is the operating system service routine level. A special library level error number has been defined called TSYSERR which is generated by each library function when an operating system service routine fails or some general error occurs. When a function sets t_errno to TSYSERR, the specific system error may be accessed through the external variable errno.
A new system error, EPROTO, has been defined to support System V networking. This error is generated by the transport provider when a protocol error has occurred. If the error is severe, it may cause the file descriptor and transport endpoint to be unusable. To continue in this case, all users of the file must close it. Then the file may be re-opened and initialized.

**Synchronous and Asynchronous Execution Modes**

The transport service interface is inherently asynchronous; various events may occur independent of the actions of a transport user. For example, a user may be sending data over a transport connection when an asynchronous disconnect indication arrives. The user must somehow be informed that the connection has been broken.

The transport service interface supports two execution modes for handling asynchronous events: synchronous mode and asynchronous mode. In the synchronous mode of operation, the transport functions wait for specific events before returning control to the user. While waiting, the user cannot perform other tasks. For example, a function that attempts to receive data in synchronous mode will wait until data arrives before returning control to the user. This is the default mode of execution. It is useful for user processes that want to wait for events to occur, or for user processes that have no other useful work to perform.

The asynchronous mode of operation, on the other hand, provides a mechanism for notifying a user of some event without forcing the user to wait for that event. The handling of networking events in an asynchronous manner is seen as a desirable capability of the transport interface. This would enable users to perform useful work while waiting for a particular event. For example, a function that attempts to receive data in asynchronous mode will return control to the user immediately if no data is available. The user may then periodically poll for incoming data until it arrives. The asynchronous mode is intended for those applications that expect long delays between events and have other tasks that they can perform in the meantime.

The two execution modes are not provided through separate interfaces or different functions. Instead, functions that process incoming events have two modes of operation: synchronous and asynchronous. The desired mode is specified through the O_NDELAY flag, which may be set when the transport provider is initially opened, or before any specific function or group of functions is executed using the FCNTL(BA_OS) operating system service routine. The effect of this flag is completely specified in the description of each function.
Eight asynchronous events are defined in the transport service interface to cover both connection-mode and connectionless-mode service. They are represented as separate bits in a bitmask using the following defined symbolic names:

**T_LISTEN** This event occurs when a connect request from a remote user is received by a transport provider (connection-mode service only).

**T_CONNECT** This event occurs when a connect confirmation is received by a transport provider (connection-mode service only).

**T_DATA** This event occurs when normal data is received by a transport provider.

**T_EXDATA** This event occurs when expedited data is received by a transport provider (connection-mode service only).

**T_DISCONNECT** This event occurs when a disconnect indication is received by a transport provider (connection-mode service only).

**T_ORDREL** This event occurs when an orderly release indication is received by a transport provider (connection-mode service with orderly release only).

**T_ERROR** This event occurs when a fatal error is generated by the transport provider, thus making the transport endpoint inaccessible.

**T_UDERR** This event occurs when an error is found in a previously sent data unit (connectionless-mode service only).

A process that issues functions in synchronous mode must still be able to recognize certain asynchronous events immediately and act on them if necessary. This is handled through a special transport error **TLOOK** which is returned by a function when an asynchronous event occurs. The **T_LOOK(NS_LIB)** function is then invoked to identify the specific event that has occurred when this error is returned.

Asynchronous processing is accomplished through polling. The polling capability enables processes to do useful work and periodically poll for one of the above asynchronous events. This facility is provided by setting **O_NDELAY** for the appropriate function(s) and by using the **T_LOOK(NS_LIB)** function to do the polling.
13.7.2 Overview of the Connection-mode Service

The connection-mode transport service consists of four phases of communication: initialization/de-initialization, connection establishment, data transfer, and connection release. A state machine is described in the section Transport Service Interface Sequence of Functions and Figure 13-8 that defines the legal sequence in which functions from each phase may be issued.

Initialization/De-initialization Phase

Before a user can attempt to establish a transport connection, the environment of the user must be initialized. Specifically, the user must create a local communication path to the transport provider (i.e., create the transport endpoint), obtain necessary protocol-specific information, and activate the transport endpoint. A transport endpoint is viewed as active when the transport provider may accept or request connections associated with the endpoint.

After a connection has been released, the transport user must de-initialize the associated transport endpoint, thereby freeing the resource for future use.

The functions that support initialization/de-initialization tasks are described below. All such functions provide local management functions; no information is sent over the network.

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_OPEN(NS_LIB)</td>
<td>This function creates a transport endpoint and returns protocol-specific information associated with that endpoint. It also returns a file descriptor that serves as the local identifier of the endpoint.</td>
</tr>
<tr>
<td>T_BIND(NS_LIB)</td>
<td>This function associates a protocol address with a given transport endpoint, thereby activating the endpoint. It also directs the transport provider to begin accepting connect indications if so desired.</td>
</tr>
<tr>
<td>T_OPTMGMT(NS_LIB)</td>
<td>This function enables the user to get or negotiate protocol options with the transport provider.</td>
</tr>
<tr>
<td>T_UNBIND(NS_LIB)</td>
<td>This function disables a transport endpoint such that no further request destined for the given endpoint will be accepted by the transport provider.</td>
</tr>
<tr>
<td>T_CLOSE(NS_LIB)</td>
<td>This function informs the transport provider that the user is finished with the transport endpoint, and frees any local resources associated with that endpoint.</td>
</tr>
</tbody>
</table>

The following functions are also local management functions, but can be issued during any phase of communication.
T_GETINFO(NS_LIB) This function returns protocol-specific information associated with the specified transport endpoint.

T_GETSTATE(NS_LIB) This function returns the current state of the transport endpoint.

T_SYNC(NS_LIB) This function synchronizes the data structures managed by the transport library with the transport provider.

TALLOC(NS_LIB) This function allocates storage for the specified library data structure.

T_FREE(NS_LIB) This function frees storage for a library data structure that was allocated by T_ALLOC(NS_LIB).

T_ERROR(NS_LIB) This function prints out a message describing the last error encountered during a call to a transport library function.

T_LOOK(NS_LIB) This function returns the current event associated with the given transport endpoint.

Connection Establishment Phase
This phase enables two transport users to establish a transport connection between them. In the connection establishment scenario, one user is considered active and initiates the conversation, while the second user is passive and waits for a transport user to request a connection.

The active user requests a connection and then receives a response from the called user. The passive user waits for connect indications (i.e., indications of a connect request) and then either accepts or rejects the request. The functions that support these operations are:

T_CONNECT(NS_LIB) This function requests a connection to the transport user at a specified destination, and waits for the remote user's response. This function may be executed in either synchronous or asynchronous mode. In synchronous mode, the function waits for the remote user's response before returning control to the local user. In asynchronous mode, the function initiates connection establishment but returns control to the local user before a response arrives.

T_RECVCONNECT(NS_LIB) This function enables an active transport user to determine the status of a previously sent connect request. If the request was accepted, the connection establishment phase will be complete on return from
Data Transfer Phase
This function is used in conjunction with `T_CONNECT(NS_LIB)` to establish a connection in an asynchronous manner.

`T_LISTEN(NS_LIB)` This function enables the passive transport user to receive connect indications from other transport users.

`T_ACCEPT(NS_LIB)` This function is issued by the passive user to accept a particular connect request after an indication has been received.

Once a transport connection has been established between two users, data may be transferred back and forth over the connection. Two functions have been defined to support data transfer in connection mode as follows:

`T_SND(NS_LIB)` This function enables transport users to send either normal or expedited data over a transport connection.

`T_RCV(NS_LIB)` This function enables transport users to receive either normal or expedited data on a transport connection.

Connection Release Phase
Two forms of connection release are supported in the connection-mode transport interface: abortive and orderly. An abortive release may be invoked from either the connection establishment phase or the data transfer phase. When in the connection establishment phase, a transport user may use the abortive release to reject a connect request. In the data transfer phase, either user may abort a connection at any time. The abortive release is not negotiated by the transport users and it takes effect immediately on request. The user on the other side of the connection is notified when a connection is aborted. The transport provider may also initiate an abortive release, in which case both users are informed that the connection no longer exists. There is no guarantee of delivery of user data once an abortive release has been initiated.

The orderly release capability is an optional feature of the connection-mode service. If supported by the underlying transport provider, orderly release may be invoked from the data transfer phase to enable two users to gracefully release a connection. The procedure for orderly release prevents the loss of data that may occur during an abortive release.
The functions that support connection release are:

T_SNDDIS(NS_LIB) This function can be issued by either transport user to initiate the abortive release of a transport connection. It may also be used to reject a connect request during the connection establishment phase.

T_RCVDIS(NS_LIB) This function identifies the reason for the abortive release of a connection, where the connection is released by the transport provider or another transport user.

T_SNDREL(NS_LIB) (Optional). This function can be issued by either transport user to initiate an orderly release. The connection remains intact until both users issue this function and T_RCVREL(NS_LIB).

T_RCVREL(NS_LIB) (Optional). This function is issued when a user is notified of an orderly release request, as a means of informing the transport provider that the user is aware of the remote user's actions.

13.7.3 Overview of the Connectionless-mode Service

The connectionless-mode transport service consists of two phases of communication: initialization/de-initialization and data transfer. A brief description of each phase and its associated functions is presented below. A state machine is described in the section Transport Service Interface Sequence of Functions and Figure 13-7 that defines the legal sequence in which functions from each phase may be issued.

Initialization/De-initialization Phase

Before a user can attempt to transfer data in connectionless mode, the environment of the user must be initialized. Specifically, the user must create a local communication path to the transport provider (i.e., create the transport endpoint), obtain necessary protocol-specific information, and activate the transport endpoint. A transport connection endpoint is viewed as active when a transport user may send or receive data units through that endpoint.

When a transport user no longer wishes to send or receive data units through a given transport endpoint, they must de-initialize the endpoint, thereby freeing the resource for future use.

The functions that support the initialization/de-initialization tasks are the same functions used in the connection-mode service.
Data Transfer Phase
Once a transport endpoint has been activated, a user is free to send and receive data units through that endpoint in connectionless mode as follows:

T_SNDUDATA This function enables transport users to send a self-contained data unit to the user at the specified protocol address.

T_RCVUDATA This function enables transport users to receive data units from other users.

T_RCVUDERR This function enables transport users to retrieve error information associated with a previously sent data unit.

13.7.4 Transport Service Interface Sequence of Functions
Figures 13-2 through 13-8 are included to describe the possible states of the transport provider as seen by the transport user, describe the incoming and outgoing events that may occur on any connection, and identify the allowable sequence of function calls. Given a current state and event, the transition to the next state is shown as well as any actions that must be taken by the transport user.

The allowable sequence of functions is described in Figures 13-6, 13-7, and 13-8. The support functions, T_GETSTATE(NS_LIB), T_GETINFO(NS_LIB), T_ALLOCN(SLIB), T_FREE(NS_LIB), T_LOOK(NS_LIB), and T_SYNC(NS_LIB) are excluded from the state tables because they do not affect the state of the interface. Each of these functions may be issued from any state except the uninitialized state. Similarly, the T_ERROR(NS_LIB) function has been excluded from the state table because it does not affect the state of the interface.

The following are rules regarding the maintenance of the state of the interface.

• It is the responsibility of the transport provider to keep record of the state of the interface as seen by the transport user.

• The transport provider must never process a function that places the interface out of state.

• If the user issues a function out of sequence, the transport provider should indicate this where possible through an error return on that function. The state should not change. In this case, if any data is passed with the function when not in the T_DATAEXFER state, that data will not be accepted or forwarded by the transport provider.

• The uninitialized state (T_UNINIT) of a transport endpoint is the initial state, and the endpoint must be initialized and bound before the transport provider may view it as active.
• The uninitialized state is also the final state, and the transport endpoint must be viewed as unused by the transport provider. The T_CLOSE(NS_LIB) function will close the transport provider and free the transport library resources for another endpoint.

• According to the state table in Figure 13-6, T_CLOSE(NS_LIB) should only be issued from the T_UNBND state. If it is issued from any other state and no other user has that endpoint open, the action will be abortive, the transport endpoint will be successfully closed, and the library resources will be freed for another endpoint. When T_CLOSE(NS_LIB) is issued, the transport provider must ensure that the address associated with the specified transport endpoint has been unbound from that endpoint. Also, the provider should send appropriate disconnects if T_CLOSE(NS_LIB) is not issued from the unbound state.

The following rules apply only to the connection-mode transport service:

• The transport connection release phase can be initiated at any time during the connection establishment phase or data transfer phase.

• The only time the state of a transport service interface of a transport endpoint may be transferred to another transport endpoint is when the T_ACCEPT(NS_LIB) function specifies such action. The following rules then apply to the cooperating transport endpoints:
  — The endpoint that is to accept the current state of the interface must be bound to an appropriate protocol address and must be in the T_IDLE state.
  — The user transferring the current state of an endpoint must have correct permissions for the use of the protocol address bound to the accepting transport endpoint.
  — The endpoint that transfers the state of the transport interface is placed into the T_IDLE state by the transport provider after the completion of the transfer if there are no more outstanding connect indications.

13.7.5 Guidelines for Writing Protocol-Independent Software

A primary goal of the user-level transport interface is that it be independent of any particular transport protocol. More importantly, the interface was designed to enable users to write programs that had no knowledge of the particular transport protocol to which they would interface. This will enable networking applications to be run in different protocol environments without change.
The user-level transport interface will support protocol-independence for applications if the following guidelines are followed:

1. In the connection-mode service, the concept of a transport service data unit (TSDU) may not be supported by all transport providers. The user should make no assumptions about the preservation of logical data boundaries across a connection.

2. The protocol-specific service limits returned on the T_OPEN(NS_LIB) and T_GETINFO(NS_LIB) functions must not be exceeded. It is the responsibility of the user to access these limits and then adhere to the limits throughout the communication process.

3. The user program should not look at or change options that are specific to the underlying protocol. The T_OPTMGMT(NS_LIB) function enables a user to access default protocol options from the transport provider, which may then be blindly passed as an argument on the appropriate connect establishment function. Optionally, the user can choose not to pass options as an argument on connect establishment functions.

4. Protocol-specific addressing issues should be hidden from the user program. The user program should not specify any protocol address on the T_BIND(NS_LIB) function, but instead should allow T_BIND(NS_LIB) to assign an address to the user. In this way, details concerning protocol-specific addressing are hidden from the user.

   Similarly, the user must have some way of accessing destination addresses in an invisible manner, such as through a name server. However, the details for doing so are outside the scope of this interface specification.

5. The reason codes associated with T_RCVDIS(NS_LIB) are protocol-dependent. The user should not interpret this information if protocol-independence is a concern.

6. The error codes associated with T_RCVUDERR(NS_LIB) are protocol-dependent. The user should not interpret this information if protocol-independence is a concern.

7. The names of devices should not be hard-coded into programs. While software may be written for a particular class of service (e.g., connectionless-mode service), it should not be written to depend on any attribute of the underlying protocol.
8. The optional orderly release facility of the connection-mode service [i.e., \texttt{T\_SNDREL(NS\_LIB)} and \texttt{T\_RCVREL(NS\_LIB)}] should not be used by programs targeted for multiple protocol environments. This facility is not supported by all connection-based transport protocols. In particular, its use will prevent programs from successfully communicating with ISO open systems.

13.7.6 Example

The following example (Figure 13-1) shows the allowable sequence of functions of an active user and passive user communicating using a connection-mode transport service. This example is not meant to show all the functions that must be called but rather to highlight the important functions that request a particular service. Blank lines are used to indicate that a function would be issued by one user prior to the issuance of a related function by the remote user. For example, the active user issues \texttt{T\_CONNECT(NS\_LIB)} to request a connection and the passive user would receive an indication of the connect request [via the return from \texttt{T\_LISTEN(NS\_LIB)}] and then would issue the \texttt{T\_ACCEPT(NS\_LIB)}.

The state diagram that follows shows the flow of the events through the various states. The active user is represented by a solid line and the passive user is represented by a dashed line. This example shows a successful connection being established and terminated using connection-mode transport service without orderly release. For a detailed description of all possible states and events, see Figure 13-8.
Figure 13-1: Example of a Sequence of Transport Functions
The following table (Figure 13-2) describes all possible states of the transport provider as seen by the transport user. The service type may be connection-mode, connection-mode with orderly release, or connectionless-mode.

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
<th>Service Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_UNINIT</td>
<td>uninitialized - initial and final state of interface</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_CLTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>T_UNBND</td>
<td>unbound</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_CLTS</td>
</tr>
<tr>
<td>T_IDLE</td>
<td>no connection established</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_CLTS</td>
</tr>
<tr>
<td>T_OUTCON</td>
<td>outgoing connection pending for active user</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_CLTS</td>
</tr>
<tr>
<td>T_INCON</td>
<td>incoming connection pending for passive user</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>T_DATAFER</td>
<td>data transfer</td>
<td>T_COTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>T_OUTREL</td>
<td>outgoing orderly release (waiting for orderly release indication)</td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>T_INREL</td>
<td>incoming orderly release (waiting to send orderly release request)</td>
<td>T_COTS_ORD</td>
</tr>
</tbody>
</table>

Figure 13-2: Transport Interface States
Outgoing Events

The following outgoing events correspond to the successful return of the specified user-level transport functions, where these functions send a request or response to the transport provider.

In Figure 13-3, some events (e.g., acceptX) are distinguished by the context in which they occur. The context is based on the values of the following:

- `ocnt` count of outstanding connect indications
- `fd` file descriptor of the current transport endpoint
- `resfd` file descriptor of the transport endpoint where a connection will be accepted
<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Service Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>opened</td>
<td>successful return of <code>t_open</code></td>
<td>T_COTS, T_COTS_ORD, T_CLTS</td>
</tr>
<tr>
<td>bind</td>
<td>successful return of <code>t_bind</code></td>
<td>T_COTS, T_COTS_ORD, T_CLTS</td>
</tr>
<tr>
<td>optmgmt</td>
<td>successful return of <code>t_optmgmt</code></td>
<td>T_COTS, T_COTS_ORD, T_CLTS</td>
</tr>
<tr>
<td>unbind</td>
<td>successful return of <code>t_unbind</code></td>
<td>T_COTS, T_COTS_ORD, T_CLTS</td>
</tr>
<tr>
<td>closed</td>
<td>successful return of <code>t_close</code></td>
<td>T_COTS, T_COTS_ORD, T_CLTS</td>
</tr>
<tr>
<td>connect1</td>
<td>successful return of <code>t_connect</code> in synchronous mode</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>connect2</td>
<td>TNODATA error on <code>t_connect</code> in asynchronous mode, or TLOOK error due to a disconnect indication arriving on the transport endpoint.</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>accept1</td>
<td>successful return of <code>t_accept</code> with <code>ocnt == 1, fd == resfd</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>accept2</td>
<td>successful return of <code>t_accept</code> with <code>ocnt == 1, fd != resfd</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>accept3</td>
<td>successful return of <code>t_accept</code> with <code>ocnt &gt; 1</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>snd</td>
<td>successful return of <code>t_snd</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>snddis1</td>
<td>successful return of <code>t_snddis</code> with <code>ocnt &lt;= 1</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>snddis2</td>
<td>successful return of <code>t_snddis</code> with <code>ocnt &gt; 1</code></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>sndrel</td>
<td>successful return of <code>t_sndrel</code></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>sndudata</td>
<td>successful return of <code>t_sndudata</code></td>
<td>T_CLTS</td>
</tr>
</tbody>
</table>

Figure 13-3: Transport Interface Outgoing Events
Incoming Events

The following incoming events correspond to the successful return of the specified user-level transport functions, where these functions retrieve data or event information from the transport provider. The only incoming event not associated directly with the return of a function on a given transport endpoint is *pass_conn*, which occurs when a user transfers a connection to another transport endpoint. This event occurs on the endpoint that is being passed the connection, despite the fact that no function is issued on that endpoint. *Pass_conn* is included in the state tables to describe what happens when a user accepts a connection on another transport endpoint.

In Figure 13-4, the *rcvdis* events are distinguished by the context in which they occur. The context is based on the value of *ocnt*, which is the count of outstanding connect indications on the current transport endpoint.

<table>
<thead>
<tr>
<th>Incoming Event</th>
<th>Description</th>
<th>Service Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>listen</td>
<td>successful return of <em>t_listen</em></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recvconnect</td>
<td>successful return of <em>t_recvconnect</em></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recv</td>
<td>successful return of <em>t_recv</em></td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recvdis1</td>
<td>successful return of <em>t_recvdis</em> with <em>ocnt</em> &lt;= 0</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recvdis2</td>
<td>successful return of <em>t_recvdis</em> with <em>ocnt</em> == 1</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recvdis3</td>
<td>successful return of <em>t_recvdis</em> with <em>ocnt</em> &gt; 1</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
<tr>
<td>recvrel</td>
<td>successful return of <em>t_recvrel</em></td>
<td>T_COTS_ORD</td>
</tr>
<tr>
<td>recvudata</td>
<td>successful return of <em>t_recvudata</em></td>
<td>T_CLTS</td>
</tr>
<tr>
<td>recvuderr</td>
<td>successful return of <em>t_recvuderr</em></td>
<td>T_CLTS</td>
</tr>
<tr>
<td>pass_conn</td>
<td>receive a passed connection</td>
<td>T_COTS, T_COTS_ORD</td>
</tr>
</tbody>
</table>

Figure 13-4: Transport Interface Incoming Events
Transport User Actions

Some state transitions are accompanied by a list of actions the transport user must take. These actions are represented by the notation [n], where n is the number of the specific action as described in Figure 13-5.

[1] Set the count of outstanding connect indications to zero.

[2] Increment the count of outstanding connect indications.


[4] Pass a connection to another transport endpoint as indicated in \texttt{T\_ACCEPT(NS\_LIB)}.

Figure 13-5: Transport Interface User Actions
State Tables

Figures 13-6 and 13-7 describe the possible next states, given the current state and event. The state is that of the transport provider as seen by the transport user.

The contents of each box represent the next state given the current state (column) and the current incoming or outgoing event (row). An empty box represents a state/event combination that is invalid. Along with the next state, each box may include an action list (as specified in Figure 13-5). The transport user must take the specific actions in the order specified in the state table.

A separate table is shown for initialization/de-initialization, data transfer in connectionless mode, and connection/release/data-transfer in connection mode.
### Figure 13-6: Initialization/De-initialization State Table

<table>
<thead>
<tr>
<th>Event</th>
<th>T_UNINIT</th>
<th>T_UNBND</th>
<th>T_IDLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>opened</td>
<td>T_UNBND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bind</td>
<td></td>
<td>T_IDLE[1]</td>
<td></td>
</tr>
<tr>
<td>optmgmt</td>
<td></td>
<td>T_IDLE</td>
<td></td>
</tr>
<tr>
<td>unbind</td>
<td></td>
<td></td>
<td>T_UNBND</td>
</tr>
<tr>
<td>closed</td>
<td></td>
<td>T_UNINIT</td>
<td></td>
</tr>
</tbody>
</table>

### Figure 13-7: Data-Transfer State Table for Connectionless-mode Service

<table>
<thead>
<tr>
<th>Event</th>
<th>T_IDLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>sndudata</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>rcvudata</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>rcvuderr</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>state event</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>connect1</td>
<td>T_DATAFER</td>
</tr>
<tr>
<td>connect2</td>
<td>T_OUTCON</td>
</tr>
<tr>
<td>rcvconnect</td>
<td></td>
</tr>
<tr>
<td>accept1</td>
<td></td>
</tr>
<tr>
<td>accept2</td>
<td></td>
</tr>
<tr>
<td>accept3</td>
<td></td>
</tr>
<tr>
<td>snd</td>
<td></td>
</tr>
<tr>
<td>rcv</td>
<td></td>
</tr>
<tr>
<td>snddis1</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>snddis2</td>
<td></td>
</tr>
<tr>
<td>rcvdis1</td>
<td>T_IDLE</td>
</tr>
<tr>
<td>rcvdis2</td>
<td></td>
</tr>
<tr>
<td>rcvdis3</td>
<td></td>
</tr>
<tr>
<td>sndrel</td>
<td></td>
</tr>
<tr>
<td>rcvrel</td>
<td></td>
</tr>
<tr>
<td>pass_conn</td>
<td>T_DATAFER</td>
</tr>
</tbody>
</table>

Figure 13-8: Connection/Release/Data-Transfer State Table for Connection-mode Service
REFERENCES


NAME
t_accept – accept a connect request

SYNOPSIS
#include <tiuser.h>

int t_accept(fd, resfd, call)
    int fd;
    int resfd;
    struct t_call *call;

DESCRIPTION
This function is issued by a transport user to accept a connect request. Fd identifies the local transport endpoint where the connect indication arrived, resfd specifies the local transport endpoint where the connection is to be established, and call contains information required by the transport provider to complete the connection. Call points to a t_call structure which contains the following members:

    struct netbuf addr;
    struct netbuf opt;
    struct netbuf udata;
    int sequence;

In call, addr is the address of the caller, opt indicates any protocol-specific parameters associated with the connection, udata points to any user data to be returned to the caller, and sequence is the value returned by T_LISTEN(NS_LIB) that uniquely associates the response with a previously received connect indication.

A transport user may accept a connection on either the same, or on a different, local transport endpoint than the one on which the connect indication arrived. If the same endpoint is specified (i.e., resfd=fd), the connection can be accepted unless the following condition is true: The user has received other indications on that endpoint but has not responded to them [with t_accept or T_SNDDIS(NS_LIB)]. For this condition, t_accept will fail and set t_errno to TBADF.

If a different transport endpoint is specified (resfd!=fd), the endpoint must be bound to a protocol address and must be in the T_IDLE state [see T_GETSTATE(NS_LIB)] before the t_accept is issued.

For both types of endpoints, t_accept will fail and set t_errno to TLOOK if there are indications (e.g., a connect or disconnect) waiting to be received on that endpoint.
T_ACCEPT(NS_LIB)

The values of parameters specified by opt and the syntax of those values are protocol specific. The udata argument enables the called transport user to send user data to the caller and the amount of user data must not exceed the limits supported by the transport provider as returned in the connect field of the info argument of T_OPEN(NS_LIB) or T_GETINFO(NS_LIB). If the len field of udata is zero, no data will be sent to the caller.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The file descriptor fd or resfd does not refer to a transport endpoint, or the user is illegally accepting a connection on the same transport endpoint on which the connect indication arrived.

[TOUTSTATE] The function was issued in the wrong sequence on the transport endpoint referenced by fd, or the transport endpoint referred to by resfd is not in the appropriate state.

[TACCES] The user does not have permission to accept a connection on the responding transport endpoint or use the specified options.

[TBADOPT] The specified options were in an incorrect format or contained illegal information.

[TBADDATA] The amount of user data specified was not within the bounds allowed by the transport provider.

[TBADSEQ] An invalid sequence number was specified.

[TLOOK] An asynchronous event has occurred on the transport endpoint referenced by fd and requires immediate attention.

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
Upon successful completion, a value of 0 is returned. Otherwise, a value of -1 is returned, and t_errno is set to indicate the error.

SEE ALSO
T_CONNECT(NS_LIB), T_GETSTATE(NS_LIB), T_LISTEN(NS_LIB), T_OPEN(NS_LIB), T_RCVCONNECT(NS_LIB).
NAME
t_alloc - allocate a library structure

SYNOPSIS
#include <tiuser.h>

char *t_alloc(fd, struct_type, fields)
int fd;
int struct_type;
int fields;

DESCRIPTION
The t_alloc function dynamically allocates memory for the various tran­
sport function argument structures as specified below. This function will
allocate memory for the specified structure, and will also allocate memory
for buffers referenced by the structure.

The structure to allocate is specified by struct_type, and must be one of
the following:

T BIND struct t_bind
T CALL struct t_call
T OPTMGMT struct t_optmgmt
T DIS struct t_discon
T UNITDATA struct t_unitdata
T UDERROR struct t_uderr
T INFO struct t_info

where each of these structures may subsequently be used as an argument to
one or more transport functions.

Each of the above structures, except T_INFO, contains at least one field of
type "struct netbuf". For each field of this type, the user may specify
that the buffer for that field should be allocated as well. The length of the
buffer allocated will be based on the size information returned in the info
argument of T_OPEN(NS_LIB) or T_GETINFO(NS_LIB). The relevant
fields of the info argument are described in the following list. The fields
argument specifies which buffers to allocate, where the argument is the
bitwise-OR of any of the following:

T_ADDR The addr field of the t_bind, t_call, t_unitdata, or
t_uderr structures (size obtained from info_addr).
T_ALLOC(NS_LIB)

T_OPT  The opt field of the t_optmgmt, t_call, t_unitdata, or t_uderr structures (size obtained from info_options).

T_UDATA  The udata field of the t_call, t_discon, or t_unitdata structures (for T_CALL, size is the maximum value of info_connect and info_discon; for T_DIS, size is the value of info_discon; for T_UNITDATA, size is the value of info_tsd).

T_ALL  All relevant fields of the given structure.

For each field specified in fields, t_alloc will allocate memory for the buffer associated with the field, and initialize the len field to zero and the buf pointer and maxlen field accordingly. Because the length of the buffer allocated will be based on the same size information that is returned to the user on T_OPEN(NS_LIB) and T_GETINFO(NS_LIB), fd must refer to the transport endpoint through which the newly allocated structure will be passed. In this way the appropriate size information can be accessed. If the size value associated with any specified field is -1 or -2 [see T_OPEN(NS_LIB) or T_GETINFO(NS_LIB)], t_alloc will be unable to determine the size of the buffer to allocate and will fail, setting t_errno to TSYSERR and errno to EINVAL. For any field not specified in fields, buf will be set to NULL and maxlen will be set to zero.

Use of t_alloc to allocate structures will help ensure the compatibility of user programs with future releases of the transport interface functions.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF]  The specified file descriptor does not refer to a transport endpoint.

[TSYSERR]  A system error has occurred during execution of this function.

RETURN VALUE
On successful completion, t_alloc returns a pointer to the newly allocated structure. On failure, NULL is returned.

SEE ALSO
T_FREE(NS_LIB), T_GETINFO(NS_LIB), T_OPEN(NS_LIB).
NAME
t_bind - bind an address to a transport endpoint

SYNOPSIS
#include <tiuser.h>

int t_bind(fd, req, ret)
int fd;
struct t_bind *req;
struct t_bind *ret;

DESCRIPTION
This function associates a protocol address with the transport endpoint
specified by fd and activates that transport endpoint. In connection mode,
the transport provider may begin accepting or requesting connections on
the transport endpoint. In connectionless mode, the transport user may
send or receive data units through the transport endpoint.

The req and ret arguments point to a t_bind structure containing the fol­
lowing members:

    struct netbuf addr;
    unsigned qlen;

The addr field of the t_bind structure specifies a protocol address and the
qlen field is used to indicate the maximum number of outstanding connect
indications.

Req is used to request that an address, represented by the netbuf struc­
ture, be bound to the given transport endpoint. Len specifies the number
of bytes in the address and buf points to the address buffer. Maxlen has
no meaning for the req argument. On return, ret contains the address
that the transport provider actually bound to the transport endpoint; this
may be different from the address specified by the user in req. In ret, the
user specifies maxlen which is the maximum size of the address buffer and
buf which points to the buffer where the address is to be placed. On
return, len specifies the number of bytes in the bound address and buf
points to the bound address. If maxlen is not large enough to hold the
returned address, an error will result.

If the requested address is not available, or if no address is specified in req
(the len field of addr in req is zero) the transport provider will assign an
appropriate address to be bound, and will return that address in the addr
The user can compare the addresses in `req` and `ret` to determine whether the transport provider bound the transport endpoint to a different address than that requested.

`Req` may be `NULL` if the user does not wish to specify an address to be bound. Here, the value of `qlen` is assumed to be zero, and the transport provider must assign an address to the transport endpoint. Similarly, `ret` may be `NULL` if the user does not care what address was bound by the provider and is not interested in the negotiated value of `qlen`. It is valid to set `req` and `ret` to `NULL` for the same call, in which case the provider chooses the address to bind to the transport endpoint and does not return that information to the user.

The `qlen` field has meaning only when initializing a connection-mode service. It specifies the number of outstanding connect indications the transport provider should support for the given transport endpoint. An outstanding connect indication is one that has been passed to the transport user by the transport provider. A value of `qlen` greater than zero is only meaningful when issued by a passive transport user that expects other users to call it. The value of `qlen` will be negotiated by the transport provider and may be changed if the transport provider cannot support the specified number of outstanding connect indications. On return, the `qlen` field in `ret` will contain the negotiated value.

This function allows more than one transport endpoint to be bound to the same protocol address (however, the transport provider must support this capability also), but it is not allowable to bind more than one protocol address to the same transport endpoint. If a user binds more than one transport endpoint to the same protocol address, only one endpoint can be used to listen for connect indications associated with that protocol address. In other words, only one `t_bind` for a given protocol address may specify a value of `qlen` greater than zero. In this way, the transport provider can identify which transport endpoint should be notified of an incoming connect indication. If a user attempts to bind a protocol address to a second transport endpoint with a value of `qlen` greater than zero, the transport provider will assign another address to be bound to that endpoint. If a user accepts a connection on the transport endpoint that is being used as the listening endpoint, the bound protocol address will be found to be busy for the duration of that connection. No other transport endpoints may be bound for listening while that initial listening endpoint is in the data transfer phase. This will prevent more than one transport endpoint bound to the same protocol address from accepting connect indications.
ERRORS
On failure, \texttt{t_errno} is set to one of the following:

- \texttt{[TBADF]} The specified file descriptor does not refer to a trans-
  sport endpoint.
- \texttt{[TOUTSTATE]} The function was issued in the wrong sequence.
- \texttt{[TBADADDR]} The specified protocol address was in an incorrect for-
  mat or contained illegal information.
- \texttt{[TNOADDR]} The transport provider could not allocate an address.
- \texttt{[TACCES]} The user does not have permission to use the specified
  address.
- \texttt{[TBUFOVFLW]} The number of bytes allowed for an incoming argu-
  ment is not sufficient to store the value of that argument. The provider's
  state will change to \texttt{T_IDLE} and the information to be returned in
  \texttt{ret} will be discarded.
- \texttt{[TSYSERR]} A system error has occurred during execution of this
  function.

RETURN VALUE
\texttt{T_bind} returns 0 on success and -1 on failure, and \texttt{t_errno} is set to indi-
 cate the error.

SEE ALSO
\texttt{T_ALLOC(NS_LIB)}, \texttt{T_OPEN(NS_LIB)}, \texttt{T_OPTMGMT(NS_LIB)},
\texttt{T_UNBIND(NS_LIB)}. 
T_CLOSE(NS_LIB)

NAME
t_close - close a transport endpoint

SYNOPSIS
#include <tiuser.h>

int t_close(fd)
int fd;

DESCRIPTION
The t_close function informs the transport provider that the user is fin­
ished with the transport endpoint specified by fd, and frees any local
library resources associated with the endpoint. In addition, t_close closes
the file associated with the transport endpoint.

T_close should be called from the T_UNBND state [see
T_GETSTATE(NS_LIB)]. However, this function does not check state infor­
mation, so it may be called from any state to close a transport endpoint. If
this occurs, the local library resources associated with the endpoint will be
freed automatically. In addition, CLOSE(BA_OS) will be issued for that file
descriptor; the close will be abortive if no other process has that file open,
and will break any transport connection that may be associated with that
endpoint.

ERRORS
On failure, t_errno is set to the following:

[TBADF] The specified file descriptor does not refer to a transport
endpoint.

RETURN VALUE
T_close returns 0 on success and -1 on failure, and t_errno is set to indi­
cate the error.

SEE ALSO
T_GETSTATE(NS_LIB), T_OPEN(NS_LIB), T_UNBIND(NS_LIB).
NAME
t_connect - establish a connection with another transport user

SYNOPSIS
#include <tiuser.h>

int t_connect(fd, sndcall, recvcall)
int fd;
struct t_call *sndcall;
struct t_call *recvcall;

DESCRIPTION
This function enables a transport user to request a connection to the specified destination transport user. Fd identifies the local transport endpoint where communication will be established, while sndcall and recvcall point to a t_call structure which contains the following members:

struct netbuf addr;
struct netbuf opt;
struct netbuf udata;
int sequence;

Sndcall specifies information needed by the transport provider to establish a connection and recvcall specifies information that is associated with the newly established connection.

In sndcall, addr specifies the protocol address of the destination transport user, opt presents any protocol-specific information that might be needed by the transport provider, udata points to optional user data that may be passed to the destination transport user during connection establishment, and sequence has no meaning for this function.

On return in recvcall, addr returns the protocol address associated with the responding transport endpoint, opt presents any protocol-specific information associated with the connection, udata points to optional user data that may be returned by the destination transport user during connection establishment, and sequence has no meaning for this function.

The opt argument implies no structure on the options that may be passed to the transport provider. The transport provider is free to specify the structure of any options passed to it. These options are specific to the underlying protocol of the transport provider. The user may choose not to negotiate protocol options by setting the len field of opt to zero. In this case, the provider may use default options.
The **udata** argument enables the caller to pass user data to the destination transport user and receive user data from the destination user during connection establishment. However, the amount of user data must not exceed the limits supported by the transport provider as returned in the **connect** field of the **info** argument of `T_OPEN(NSLIB)` or `T_GETINFO(NSLIB)`. If the **len** of **udata** is zero in **sndcall**, no data will be sent to the destination transport user.

On return, the **addr**, **opt**, and **udata** fields of **rcvcall** will be updated to reflect values associated with the connection. Thus, the **maxlen** field of each argument must be set before issuing this function to indicate the maximum size of the buffer for each. However, **rcvcall** may be NULL, in which case no information is given to the user on return from `t_connect`.

By default, `t_connect` executes in synchronous mode, and will wait for the destination user's response before returning control to the local user. A successful return (i.e., return value of zero) indicates that the requested connection has been established. However, if `O_NDELAY` is set [via `T_OPEN(NSLIB)` or `FCNTL(BA_OS)`], `t_connect` executes in asynchronous mode. In this case, the call will not wait for the remote user's response, but will return control immediately to the local user and return -1 with **t_errno** set to **TNODATA** to indicate that the connection has not yet been established. In this way, the function simply initiates the connection establishment procedure by sending a connect request to the destination transport user. The `T_RCVCONNECT(NSLIB)` function is used in conjunction with `t_connect` to determine the status of the requested connection.

**ERRORS**

On failure, **t_errno** is set to one of the following:

- **[TBADF]** The specified file descriptor does not refer to a transport endpoint.
- **[TOUTSTATE]** The function was issued in the wrong sequence.
- **[TNODATA]** `O_NDELAY` was set, so the function successfully initiated the connection establishment procedure, but did not wait for a response from the remote user.
- **[TBADADDR]** The specified protocol address was in an incorrect format or contained illegal information.
- **[TBADEPOPT]** The specified protocol options were in an incorrect format or contained illegal information.
The amount of user data specified was not within the bounds allowed by the transport provider.

The user does not have permission to use the specified address or options.

The number of bytes allocated for an incoming argument is not sufficient to store the value of that argument. If executed in synchronous mode, the provider's state, as seen by the user, changes to T_DATAxFER, and the connect indication information to be returned in recvall is discarded.

An asynchronous event has occurred on this transport endpoint and requires immediate attention.

This function is not supported by the underlying transport provider.

A system error has occurred during execution of this function.

T_connect returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO
T_ACCEPT(NS_LIB), T_ALLOC(NS_LIB), T_GETINFO(NS_LIB),
T_LISTEN(NS_LIB), T_OPEN(NS_LIB), T_OPTMGMT(NS_LIB),
T_RECVCONNECT(NS_LIB).
T_ERROR(NS_LIB)

NAME
t_error - produce error message

SYNOPSIS
#include <tiuser.h>

    void t_error(errmsg)
    char *errmsg;
    extern int t_errno;
    extern char *t_errlist[];
    extern int t_nerr;

DESCRIPTION
The t_error function produces a message on the standard error output which describes the last error encountered during a call to a transport function. The argument string errmsg is a user-supplied error message that gives context to the error.

T_error prints the user-supplied error message followed by a colon and a standard error message for the current error defined in t_errno. If t_errno is TSYSERR, t_error will also print a standard error message for the current value contained in errno [see INTRO(BA_OS)].

To simplify variant formatting of messages, the array of message strings t_errlist is provided; t_errno can be used as an index in this table to get the message string without the newline. T_nerr is the largest message number provided for in the t_errlist table.

T_errno is only set when an error occurs and is not cleared on successful calls.

EXAMPLE
If a TCONNECT(NS_LIB) function fails on transport endpoint fd2 because a bad address was given, the following call might follow the failure:

    t_error("t_connect failed on fd2");

The diagnostic message to be printed would look like:

    t_connect failed on fd2: Incorrect transport address format

where "Incorrect transport address format" identifies the specific error that occurred, and "t_connect failed on fd2" tells the user which function failed on which transport endpoint.
NAME

t_free - free a library structure

SYNOPSIS

#include <tiuser.h>

int t_free(ptr, struct_type)
    char *ptr;
    int struct_type;

DESCRIPTION

The t_free function frees memory previously allocated by T_ALLOC(NS_LIB). This function will free memory for the specified structure, and will also free memory for buffers referenced by the structure.

Ptr points to one of the seven structure types described for T_ALLOC(NS_LIB), and struct_type identifies the type of that structure which must be one of the following:

T_BIND        struct t_bind
T_CALL        struct t_call
T_OPTSMGMT    struct t_optmgmt
T_DIS         struct t_discon
T_UNITDATA    struct t_unitdata
T_UDERROR     struct t_uderr
T_INFO        struct t_info

where each of these structures is used as an argument to one or more transport functions.

T_free will check the addr, opt, and udata fields of the given structure (as appropriate) and free the buffers pointed to by the buf field of the netbuf structure. If buf is NULL, t_free will not attempt to free memory. After all buffers are freed, t_free will free the memory associated with the structure pointed to by ptr.

Undefined results will occur if ptr or any of the buf pointers points to a block of memory that was not previously allocated by T_ALLOC(NS_LIB).
T_FREE(NS_LIB)

ERRORS
On failure, t_errno is set to the following:

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
T_free returns 0 on success and -1 on failure, and t_errno is set to indi-
cate the error.

SEE ALSO
T_ALLOC(NS_LIB).
NAME

t_getinfo - get protocol-specific service information

SYNOPSIS

#include <tiuser.h>

int t_getinfo(fd, info)
int fd;
struct t_info *info;

DESCRIPTION

This function returns the current characteristics of the underlying transport protocol associated with file descriptor fd. The info structure is used to return the same information returned by T_OPEN(NS_LIB). This function enables a transport user to access this information during any phase of communication.

This argument points to a t_info structure which contains the following members:

long addr;  /* max size of the transport protocol */
            /* address */
long options;  /* max number of bytes of */
            /* protocol-specific options */
long tsdu;  /* max size of a transport service data */
            /* unit (TSDU) */
long etsdu;  /* max size of an expedited transport */
            /* service data unit (ETSDU) */
long connect;  /* max amount of data allowed on */
            /* connection establishment functions */
long discon;  /* max amount of data allowed on */
            /* t_snddis and t_rcvdis functions */
long servtype;  /* service type supported by the */
            /* transport provider */

The values of the fields have the following meanings:

addr    A value greater than or equal to zero indicates the maximum size of a transport protocol address; a value of -1 specifies that there is no limit on the address size; and a value of -2 specifies that the transport provider does not provide user access to transport protocol addresses.

options A value greater than or equal to zero indicates the maximum number of bytes of protocol-specific options supported by the provider; a value of -1 specifies that there is no limit on the option size; and a value of -2 specifies that
the transport provider does not support user-settable options.

**tsdu**
A value greater than zero specifies the maximum size of a transport service data unit (TSDU); a value of zero specifies that the transport provider does not support the concept of TSDU, although it does support the sending of a data stream with no logical boundaries preserved across a connection; a value of -1 specifies that there is no limit on the size of a TSDU; and a value of -2 specifies that the transfer of normal data is not supported by the transport provider.

**etsdu**
A value greater than zero specifies the maximum size of an expedited transport service data unit (ETSDU); a value of zero specifies that the transport provider does not support the concept of ETSDU, although it does support the sending of an expedited data stream with no logical boundaries preserved across a connection; a value of -1 specifies that there is no limit on the size of an ETSDU; and a value of -2 specifies that the transfer of expedited data is not supported by the transport provider.

**connect**
A value greater than or equal to zero specifies the maximum amount of data that may be associated with connection establishment functions; a value of -1 specifies that there is no limit on the amount of data sent during connection establishment; and a value of -2 specifies that the transport provider does not allow data to be sent with connection establishment functions.

**discon**
A value greater than or equal to zero specifies the maximum amount of data that may be associated with the T_SNDDIS(NS_LIB) and T_RCVDIS(NS_LIB) functions; a value of -1 specifies that there is no limit on the amount of data sent with these abortive release functions; and a value of -2 specifies that the transport provider does not allow data to be sent with the abortive release functions.

**servtype**
This field specifies the service type supported by the transport provider, as described below.

If a transport user is concerned with protocol independence, the above sizes may be accessed to determine how large the buffers must be to hold each piece of information. Alternatively, the T_ALLOC(NS_LIB) function may be used to allocate these buffers. An error will result if a transport user
exceeds the allowed data size on any function. The value of each field may change as a result of option negotiation, and T_GETINFO(NS_LIB) enables a user to retrieve the current characteristics of the underlying transport protocol.

The **servtype** field of info specifies one of the following values on return:

- **T_COTS** The transport provider supports a connection-mode service but does not support the optional orderly release facility.
- **T_COTS_ORD** The transport provider supports a connection-mode service with the optional orderly release facility.
- **T_CLTS** The transport provider supports a connectionless-mode service. For this service type, T_OPEN(NS_LIB) will return -2 for etsdu, connect, and discon.

**ERRORS**

On failure, t_errno is set to one of the following:

- **TBADFD** The specified file descriptor does not refer to a transport endpoint.
- **TSYSERR** A system error has occurred during execution of this function.

**RETURN VALUE**

T_getinfo returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

**SEE ALSO**

T_OPEN(NS_LIB).
T_GETSTATE(NS_LIB)

NAME
t_getstate – get the current state

SYNOPSIS
#include <tiuser.h>

int t_getstate(fd)
int fd;

DESCRIPTION
The t_getstate function returns the current state of the provider associated with the transport endpoint specified by fd.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a transport endpoint.

[TSTATECHNG] The transport provider is undergoing a state change or t_getstate was called after an exec, t_sync sequence.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
T_getstate returns the current state on successful completion and -1 on failure and t_errno is set to indicate the error. The current state is one of the following:

T_UNBND unbound
T_IDLE idle
T_OUTCON outgoing connection pending
T_INCON incoming connection pending
T_DATAXFER data transfer
T_OUTREL outgoing orderly release (waiting for an orderly release indication)
T_INREL incoming orderly release (waiting to send an orderly release request)

If the provider is undergoing a state transition when t_getstate is called, the function will fail.

SEE ALSO
T_OPEN(NS_LIB).
T_LISTEN(NS_LIB)

NAME
    t_listen – listen for a connect request

SYNOPSIS
    #include <tuser.h>

    int t_listen(fd, call)
    int fd;
    struct t_call *call;

DESCRIPTION
    This function listens for a connect request from a calling transport user. Fd
    identifies the local transport endpoint where connect indications arrive,
    and on return, call contains information describing the connect indication. Call
    points to a t_call structure which contains the following members:

        struct netbuf addr;
        struct netbuf opt;
        struct netbuf udata;
        int sequence;

    In call, addr returns the protocol address of the calling transport user, opt
    returns protocol-specific parameters associated with the connect request, udata
    returns any user data sent by the caller on the connect request, and sequence
    is a number that uniquely identifies the returned connect indication. The value of sequence
    enables the user to listen for multiple connect indications before responding to any of them.

    Since this function returns values for the addr, opt, and udata fields of call, the maxlen
    field of each must be set before issuing the t_listen to indicate the maximum size of the buffer for each.

    By default, t_listen executes in synchronous mode and waits for a connect
    indication to arrive before returning to the user. However, if O_NDELAY
    is set [via T_OPEN(NS_LIB) or FCNTL(BA_OS)], t_listen executes asynchro-
    nously, reducing to a poll for existing connect indications. If none are
    available, it returns -1 and sets t_errno to TNODATA.

ERRORS
    On failure, t_errno is set to one of the following:

    [TBADF] The specified file descriptor does not refer to a transport endpoint.

    [TBUFOVFLW] The number of bytes allocated for an incoming argument is not sufficient to store the value of that argument. The provider’s state, as seen by the
user, changes to T_INCON, and the connect indication information to be returned in call is discarded.

[TNODATA] O_NDELAY was set, but no connect indications had been queued.

[TLOOK] An asynchronous event has occurred on this transport endpoint and requires immediate attention.

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function.

CAVEATS
If a user issues t_listen in synchronous mode on a transport endpoint that was not bound for listening [i.e., qlen was zero on T_BIND(NS_LIB)], the call will wait forever because no connect indications will arrive on that endpoint.

RETURN VALUE
T_listen returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO
T_ACCEPT(NS_LIB), T_ALLOCA(NS_LIB), T_BIND(NS_LIB), T_CONNECT(NS_LIB), T_OPEN(NS_LIB), T_RCVCCONNECT(NS_LIB).
NAME
t_look - look at the current event on a transport endpoint

SYNOPSIS
#include <tiuser.h>

int t_look(fd)
int fd;

DESCRIPTION
This function returns the current event on the transport endpoint specified by fd. This function enables a transport provider to notify a transport user of an asynchronous event when the user is issuing functions in synchronous mode. Certain events require immediate notification of the user and are indicated by a specific error, TLOOK, on the current or next function to be executed.

This function also enables a transport user to poll a transport endpoint periodically for asynchronous events.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a transport endpoint.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
Upon success, t_look returns a value that indicates which of the allowable events has occurred, or returns zero if no event exists. One of the following events is returned:

T_LISTEN connection indication received
T_CONNECT connect confirmation received
T_DATA normal data received
T_EXDATA expedited data received
T_DISCONNECT disconnect received
T_ERROR fatal error indication
T_UDERR datagram error indication
T_ORDREL orderly release indication
On failure, -1 is returned, and `t_errno` is set to indicate the error.

SEE ALSO

T_OPEN(NS_LIB).
NAME
t_open - establish a transport endpoint

SYNOPSIS
#include <tiuser.h>
#include <fcntl.h>

int t_open(path, oflag, info)
char *path;
int oflag;
struct t_info *info;

DESCRIPTION
T_open must be called as the first step in the initialization of a transport endpoint. This function establishes a transport endpoint by opening a UNIX system file that identifies a particular transport provider (i.e., transport protocol) and returning a file descriptor that identifies that endpoint. For example, opening the file /dev/iso_cots identifies an OSI connection-oriented transport layer protocol as the transport provider.

Path points to the path name of the file to open, and oflag identifies any open flags [as in OPEN(BA_OS)]. Oflag may be constructed from O_NDELAY or-ed with either O_RDONLY, O_WRONLY, or O_RDWR. These flags are defined by the header file <fcntl.h>. T_open returns a file descriptor that will be used by all subsequent functions to identify the particular local transport endpoint.

This function also returns various default characteristics of the underlying transport protocol by setting fields in the t_info structure. This argument points to a t_info which contains the following members:

long addr; /* max size of the transport protocol */
    /* address */
long options; /* max number of bytes of */
    /* protocol-specific options */
long tsdu; /* max size of a transport service data */
    /* unit (TSDU) */
long etsdu; /* max size of an expedited transport */
    /* service data unit (ETSDU) */
long connect; /* max amount of data allowed on */
    /* connection establishment functions */
long discon; /* max amount of data allowed on */
    /* t_snddis and t_rcvdis functions */
long servtype; /* service type supported by the */
    /* transport provider */
The values of the fields have the following meanings:

**addr**
A value greater than or equal to zero indicates the maximum size of a transport protocol address; a value of -1 specifies that there is no limit on the address size; and a value of -2 specifies that the transport provider does not provide user access to transport protocol addresses.

**options**
A value greater than or equal to zero indicates the maximum number of bytes of protocol-specific options supported by the provider; a value of -1 specifies that there is no limit on the option size; and a value of -2 specifies that the transport provider does not support user-settable options.

**tsdu**
A value greater than zero specifies the maximum size of a transport service data unit (TSDU); a value of zero specifies that the transport provider does not support the concept of TSDU, although it does support the sending of a data stream with no logical boundaries preserved across a connection; a value of -1 specifies that there is no limit on the size of a TSDU; and a value of -2 specifies that the transfer of normal data is not supported by the transport provider.

**etsdu**
A value greater than zero specifies the maximum size of an expedited transport service data unit (ETSDU); a value of zero specifies that the transport provider does not support the concept of ETSDU, although it does support the sending of an expedited data stream with no logical boundaries preserved across a connection; a value of -1 specifies that there is no limit on the size of an ETSDU; and a value of -2 specifies that the transfer of expedited data is not supported by the transport provider.

**connect**
A value greater than or equal to zero specifies the maximum amount of data that may be associated with connection establishment functions; a value of -1 specifies that there is no limit on the amount of data sent during connection establishment; and a value of -2 specifies that the transport provider does not allow data to be sent with connection establishment functions.

**discon**
A value greater than or equal to zero specifies the maximum amount of data that may be associated with the T_SNDDIS(NS_LIB) and T_RCVDIS(NS_LIB) functions; a value
of -1 specifies that there is no limit on the amount of data sent with these abortive release functions; and a value of -2 specifies that the transport provider does not allow data to be sent with the abortive release functions.

**servtype**

This field specifies the service type supported by the transport provider, as described below.

If a transport user is concerned with protocol independence, the above sizes may be accessed to determine how large the buffers must be to hold each piece of information. Alternatively, the `T_ALLOC(NS_LIB)` function may be used to allocate these buffers. An error will result if a transport user exceeds the allowed data size on any function.

The **servtype** field of **info** specifies one of the following values on return:

**T_COTS**

The transport provider supports a connection-mode service but does not support the optional orderly release facility.

**T_COTS_ORD**

The transport provider supports a connection-mode service with the optional orderly release facility.

**T_CLTS**

The transport provider supports a connectionless-mode service. For this service type, `t_open` will return -2 for `etsdu, connect, and discon`.

A single transport endpoint may support only one of the above services at one time.

If **info** is set to NULL by the transport user, no protocol information is returned by `t_open`.

**ERRORS**

On failure, `t_errno` is set to the following:

**[TSYSERR]**

A system error has occurred during execution of this function.

**RETURN VALUE**

`T_open` returns a valid file descriptor on success and -1 on failure, and `t_errno` is set to indicate the error.

**SEE ALSO**

`OPEN(5)`.
NAME

t_optmgmt - manage options for a transport endpoint

SYNOPSIS

#include <tiuser.h>

int t_optmgmt(fd, req, ret)
int fd;
struct t_optmgmt *req;
struct t_optmgmt *ret;

DESCRIPTION

The t_optmgmt function enables a transport user to retrieve, verify, or negotiate protocol options with the transport provider. Fd identifies a bound transport endpoint.

The req and ret arguments point to a t_optmgmt structure containing the following members:

struct netbuf opt;
long flags;

The opt field identifies protocol options and the flags field is used to specify the action to take with those options.

The options are represented by a netbuf structure in a manner similar to the address in T_BIND(NS_LIB). Req is used to request a specific action of the provider and to send options to the provider. Len specifies the number of bytes in the options, buf points to the options buffer, and maxlen has no meaning for the req argument. The transport provider may return options and flag values to the user through ret. For ret, maxlen specifies the maximum size of the options buffer and buf points to the buffer where the options are to be placed. On return, len specifies the number of bytes of options returned. Maxlen has no meaning for the req argument, but must be set in the ret argument to specify the maximum number of bytes the options buffer can hold. The actual structure and content of the options is imposed by the transport provider.

The flags field of req must specify one of the following actions:

T_NEGOTIATE This action enables the user to negotiate the values of the options specified in req with the transport provider. The provider will evaluate the requested options and negotiate the values, returning the negotiated values through ret.
T_OPTMGMT(NS_LIB)

T_CHECK  This action enables the user to verify whether the options specified in req are supported by the transport provider. On return, the flags field of ret will have either T_SUCCESS or T_FAILURE set to indicate to the user whether the options are supported. These flags are only meaningful for the T_CHECK request.

T_DEFAULT  This action enables a user to retrieve the default options supported by the transport provider into the opt field of ret. In req, the len field of opt must be zero and the buf field may be NULL.

If issued as part of the connectionless-mode service, t_optmgmt may block due to flow control constraints. The function will not complete until the transport provider has processed all previously sent data units.

ERRORS  On failure, t_errno is set to one of the following:

[TBADF]  The specified file descriptor does not refer to a transport endpoint.

[TOUTSTATE]  The function was issued in the wrong sequence.

[TACCES]  The user does not have permission to negotiate the specified options.

[TBADOPT]  The specified protocol options were in an incorrect format or contained illegal information.

[TBADFLAG]  An invalid flag was specified.

[TBUFOVFLW]  The number of bytes allowed for an incoming argument is not sufficient to store the value of that argument. The information to be returned in ret will be discarded.

[TSYSERR]  A system error has occurred during execution of this function.

RETURN VALUE  T_optmgmt returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO  T_ALLOC(NS_LIB), T_GETINFO(NS_LIB), T_OPEN(NS_LIB).
**NAME**

`t_rcv` - receive data or expedited data sent over a connection

**SYNOPSIS**

```c
t_int t_rcv(fd, buf, nbytes, flags)
int fd;
char *buf;
unsigned nbytes;
int *flags;
```

**DESCRIPTION**

This function receives either normal or expedited data. `fd` identifies the local transport endpoint through which data will arrive, `buf` points to a receive buffer where user data will be placed, and `nbytes` specifies the size of the receive buffer. `Flags` may be set on return from `t_rcv` and specifies optional flags as described below.

By default, `t_rcv` operates in synchronous mode and will wait for data to arrive if none is currently available. However, if `O_NDELAY` is set via `T_OPEN(NS_LIB)` or `FCNTL(BC_OS)`, `t_rcv` will execute in asynchronous mode and will fail if no data is available. (See `TNODATA` below.)

On return from the call, if `T_MORE` is set in `flags` this indicates that there is more data and the current transport service data unit (TSDU) or expedited transport service data unit (ETSDU) must be received in multiple `t_rcv` calls. Each `t_rcv` with the `T_MORE` flag set indicates that another `t_rcv` must follow immediately to get more data for the current TSDU. The end of the TSDU is identified by the return of a `t_rcv` call with the `T_MORE` flag not set. If the transport provider does not support the concept of a TSDU as indicated in the `info` argument on return from `T_OPEN(NS_LIB)` or `T_GETINFO(NS_LIB)`, the `T_MORE` flag is not meaningful and should be ignored.

On return, the data returned is expedited data if `T_EXPEDITED` is set in `flags`. If the number of bytes of expedited data exceeds `nbytes`, `t_rcv` will set `T_EXPEDITED` and `T_MORE` on return from the initial call. Subsequent calls to retrieve the remaining ETSU will have `T_EXPEDITED` set on return. The end of the ETSU is identified by the return of a `t_rcv` call with the `T_MORE` flag not set.

If expedited data arrives after part of a TSDU has been retrieved, receipt of the remainder of the TSDU will be suspended until the ETSU has been processed. Only after the full ETSU has been retrieved (`T_MORE` not set) will the remainder of the TSDU be available to the user.
ERRORS
On failure, \texttt{t_errno} is set to one of the following:

\begin{itemize}
\item \texttt{[TBADF]} The specified file descriptor does not refer to a transport endpoint.
\item \texttt{[TNODATA]} \texttt{O\_NDELAY} was set, but no data is currently available from the transport provider.
\item \texttt{[TLOOK]} An asynchronous event has occurred on this transport endpoint and requires immediate attention.
\item \texttt{[TNOTSUPPORT]} This function is not supported by the underlying transport provider.
\item \texttt{[TSYSERR]} A system error has occurred during execution of this function.
\end{itemize}

RETURN VALUE
On successful completion, \texttt{t\_rcv} returns the number of bytes received; it returns \(-1\) on failure, and \texttt{t_errno} is set to indicate the error.

SEE ALSO
\texttt{T\_OPEN(NS\_LIB)}, \texttt{T\_SND(NS\_LIB)}.
NAME
t_rcvconnect - receive the confirmation from a connect request

SYNOPSIS
#include <tiuser.h>

int t_rcvconnect(fd, call)
int fd;
struct t_call *call;

DESCRIPTION
This function enables a calling transport user to determine the status of a
previously sent connect request and is used in conjunction with
T_CONNECT(NS_LIB) to establish a connection in asynchronous mode. The
connection will be established on successful completion of this function.

Fd identifies the local transport endpoint where communication will be
established, and call contains information associated with the newly esta­
blished connection. Call points to a t_call structure which contains the
following members:

struct netbuf addr;
struct netbuf opt;
struct netbuf udata;
int sequence;

In call, addr returns the protocol address associated with the responding
transport endpoint, opt presents any protocol-specific information associ­
ated with the connection, udata points to optional user data that may be
returned by the destination transport user during connection establishment,
and sequence has no meaning for this function.

The maxlen field of each argument must be set before issuing this function
to indicate the maximum size of the buffer for each. However, call may be
NULL, in which case no information is given to the user on return from
t_rcvconnect. By default, t_rcvconnect executes in synchronous mode
and waits for the connection to be established before returning. On return,
the addr, opt, and udata fields reflect values associated with the connec­
tion.

If O_NDELAY is set [via T_OPEN(NS_LIB) or FCNTL(BA_OS)],
t_rcvconnect executes in asynchronous mode, and reduces to a poll for
existing connect confirmations. If none are available, t_rcvconnect fails
and returns immediately without waiting for the connection to be esta­
blished. (See TNODATA below.) T_rcvconnect must be re-issued at a
later time to complete the connection establishment phase and retrieve the information returned in call.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a transport endpoint.

[TBUFOVFLW] The number of bytes allocated for an incoming argument is not sufficient to store the value of that argument and the connect information to be returned in call will be discarded. The provider's state, as seen by the user, will be changed to DATAXFER.

[TNODATA] O_NDELAY was set, but a connect confirmation has not yet arrived.

[TLOOK] An asynchronous event has occurred on this transport connection and requires immediate attention.

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
T_rcvconnect returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO
T_ACCEPT(NS_LIB), T_ALLOC(NS_LIB), T_BIND(NS_LIB), T_CONNECT(NS_LIB), T_LISTEN(NS_LIB), T_OPEN(NS_LIB).
NAME
   t_rcvdis - retrieve information from disconnect

SYNOPSIS
   #include <tiuser.h>

   t_rcvdis(fd, discon)
   int fd;
   struct t_discon *discon;

DESCRIPTION
   This function is used to identify the cause of a disconnect, and to retrieve
   any user data sent with the disconnect. Fd identifies the local transport
   endpoint where the connection existed, and discon points to a t_discon
   structure containing the following members:

   struct netbuf udata;
   int reason;
   int sequence;

   Reason specifies the reason for the disconnect through a protocol­
   dependent reason code, udata identifies any user data that was sent with
   the disconnect, and sequence may identify an outstanding connect indica­
   tion with which the disconnect is associated. Sequence is only meaningful
   when t_rcvdis is issued by a passive transport user who has executed one
   or more T_LISTEN(NS_LIB) functions and is processing the resulting connect
   indications. If a disconnect indication occurs, sequence can be used to
   identify which of the outstanding connect indications is associated with the
   disconnect.

   If a user does not care if there is incoming data and does not need to know
   the value of reason or sequence, discon may be NULL and any user data
   associated with the disconnect will be discarded. However, if a user has
   retrieved more than one outstanding connect indication [via
   T_LISTEN(NS_LIB)] and discon is NULL, the user will be unable to identify
   with which connect indication the disconnect is associated.

ERRORS
   On failure, t_errno is set to one of the following:

   [TBADF]     The specified file descriptor does not refer to a
               transport endpoint.

   [TNODIS]    No disconnect indication currently exists on the
               specified transport endpoint.
The number of bytes allocated for incoming data is not sufficient to store the data. The provider's state, as seen by the user, will change to T_IDLE, and the disconnect indication information to be returned in discon will be discarded.

This function is not supported by the underlying transport provider.

A system error has occurred during execution of this function.

T_rcvdis returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO
T_ALLOC(NS_LIB), T_CONNECT(NS_LIB), T_LISTEN(NS_LIB), T_OPEN(NS_LIB), T_SNDDIS(NS_LIB).
T__RCVREL(NS__LIB)

NAME
t_rcvrel – acknowledge receipt of an orderly release indication

SYNOPSIS
#include <tiuser.h>

t_rcvrel(fd)
int fd;

DESCRIPTION
This function is used to acknowledge receipt of an orderly release indica­
tion. Fd identifies the local transport endpoint where the connection
exists. After receipt of this indication, the user may not attempt to receive
more data because such an attempt will block forever. However, the user
may continue to send data over the connection if T__SNDREL(NS__LIB) has
not been issued by the user.

This function is an optional service of the transport provider, and is only
supported if the transport provider returned service type T__COTS_ORD on
T__OPEN(NS__LIB) or T__GETINFO(NS__LIB).

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a
transport endpoint.

[TNOREL] No orderly release indication currently exists on
the specified transport endpoint.

[TLOOK] An asynchronous event has occurred on this tran­
sport endpoint and requires immediate attention.

[TNOTSUPPORT] This function is not supported by the underlying
transport provider.

[TSYSERR] A system error has occurred during execution of
this function.

RETURN VALUE
T__rcvrel returns 0 on success and -1 on failure with t_errno set to indi­
cate the error.

SEE ALSO
T__OPEN(NS__LIB), T__SNDREL(NS__LIB).
NAME
t_rcvudata - receive a data unit

SYNOPSIS
#include <tiuser.h>

int t_rcvudata(fd, unitdata, flags)
int fd;
struct t_unitdata *unitdata;
int *flags;

DESCRIPTION
This function is used in connectionless mode to receive a data unit from another transport user. Fd identifies the local transport endpoint through which data will be received, unitdata holds information associated with the received data unit, and flags is set on return to indicate that the complete data unit was not received. Unitdata points to a t_unitdata structure containing the following members:

    struct netbuf addr;
    struct netbuf opt;
    struct netbuf udata;

The maxlen field of addr, opt, and udata must be set before issuing this function to indicate the maximum size of the buffer for each.

On return from this call, addr specifies the protocol address of the sending user, opt identifies protocol-specific options that were associated with this data unit, and udata specifies the user data that was received.

By default, t_rcvudata operates in synchronous mode and will wait for a data unit to arrive if none is currently available. However, if O_NDELAY is set [via T_OPEN(NS_LIB) or FCNTL(BA_OS)], t_rcvudata will execute in asynchronous mode and will fail if no data units are available.

If the buffer defined in the udata field of unitdata is not large enough to hold the current data unit, the buffer will be filled and T_MORE will be set in flags on return to indicate that another t_rcvudata should be issued to retrieve the rest of the data unit. Subsequent t_rcvudata call(s) will return zero for the length of the address and options until the full data unit has been received.
T__RCVUDATA(NS__LIB)

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a transport endpoint.

[TNODATA] O__NDELAY was set, but no data units are currently available from the transport provider.

[TBUFOVFLW] The number of bytes allocated for the incoming protocol address or options is not sufficient to store the information. The unit data information to be returned in unitdata will be discarded.

[TLOOK] An asynchronous event has occurred on this transport endpoint and requires immediate attention.

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE
T__rcvudata returns 0 on successful completion and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO
T__ALLOC(NS__LIB), T__RCVUDERR(NS__LIB), T__SNDUDATA(NS__LIB).
NAME
t_rcvuderr - receive a unit data error indication

SYNOPSIS
#include <tiuser.h>

int t_rcvuderr(fd, uderr)
int fd;
struct t_uderr *uderr;

DESCRIPTION
This function is used in connectionless mode to receive information con­
cerning an error on a previously sent data unit, and should only be issued
following a unit data error indication. It informs the transport user that a
data unit with a specific destination address and protocol options produced
an error. Fd identifies the local transport endpoint through which the
error report will be received, and uderr points to a t_uderr structure con­
taining the following members:

    struct netbuf addr;
    struct netbuf opt;
    long error;

The maxlen field of addr and opt must be set before issuing this function
to indicate the maximum size of the buffer for each.

On return from this call, the addr structure specifies the destination proto­
col address of the erroneous data unit, the opt structure identifies
protocol-specific options that were associated with the data unit, and error
specifies a protocol-dependent error code.

If the user does not care to identify the data unit that produced an error,
uderr may be set to NULL, and t_rcvuderr will simply clear the error
indication without reporting any information to the user.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a
transport endpoint.

[TNOUDERR] No unit data error indication currently exists on
the specified transport endpoint.

[TBUFOVFLW] The number of bytes allocated for the incoming
protocol address or options is not sufficient to store
the information. The unit data error information
to be returned in uderr will be discarded.
T__RCVUDERR(NS__LIB)

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function.

RETURN VALUE

T__rcvuderr returns 0 on successful completion and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO

T__RCVUDATA(NS__LIB), T__SNDUDATA(NS__LIB).
NAME
t_snd - send data or expedited data over a connection

SYNOPSIS
#include <tiuser.h>

int t_snd(fd, buf, nbytes, flags)
int fd;
char *buf;
unsigned nbytes;
int flags;

DESCRIPTION
This function is used to send either normal or expedited data. Fd identifies
the local transport endpoint over which data should be sent, buf points
to the user data, nbytes specifies the number of bytes of user data to be
sent, and flags specifies any optional flags described below.

By default, t_snd operates in synchronous mode and may wait if flow con­
trol restrictions prevent the data from being accepted by the local transport
provider at the time the call is made. However, if O_NDELEY is set [via
T_OPEN(NS_LIB) or FCNTL(BA_OS)], t_snd will execute in asynchronous
mode, and will fail immediately if there are flow control restrictions.

On successful completion, t_snd returns the number of bytes accepted by
the transport provider. Normally this will equal the number of bytes speci­
fied in nbytes. However, if O_NDELEY is set, it is possible that only part
of the data will actually be accepted by the transport provider. In this case,
t_snd will set T_MORE for the data that was sent (see below) and will
return a value that is less than the value of nbytes. If nbytes is zero, no
data will be passed to the provider, and t_snd will return zero.

If T_EXPEDITED is set in flags, the data will be sent as expedited data
and will be subject to the interpretations of the transport provider.

If T_MORE is set in flags, or as described above, this indicates to the
transport provider that the transport service data unit (TSDU) (or expedited
transport service data unit - ETSDU) is being sent through multiple t_snd
calls. Each t_snd with the T_MORE flag set indicates that another t_snd
will follow with more data for the current TSDU. The end of the TSDU (or
ETSDU) is identified by a t_snd call with the T_MORE flag not set. Use
of T_MORE enables a user to break up large logical data units without los­
ing the boundaries of those units at the other end of the connection. The
flag implies nothing about how the data is packaged for transfer below the
transport interface. If the transport provider does not support the concept
of a TSDU as indicated in the info argument on return from
T\_SND(NS\_LIB)

T\_OPEN(NS\_LIB) or T\_GETINFO(NS\_LIB), the T\_MORE flag is not meaningful and should be ignored.

The size of each TSDU or ETSDU must not exceed the limits of the transport provider as returned in the TSDU or ETSDU fields of the info argument of T\_OPEN(NS\_LIB) or T\_GETINFO(NS\_LIB). Failure to comply will result in protocol error EPROTO. (See TSYSERR below.)

If t\_snd is issued from the T\_IDLE state, the provider may silently discard the data. If t\_snd is issued from any state other than T\_DATA\_AXFER, T\_INREL, or T\_IDLE, the provider will generate an EPROTO error.

ERRORS

On failure, t\_errno is set to one of the following:

[TBADDF] The specified file descriptor does not refer to a transport endpoint.

[TFLOW] O\_NDELAY was set, but the flow control mechanism prevented the transport provider from accepting data at this time.

[TNOTSUP] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function. An EPROTO error may not cause t\_snd to fail until a subsequent access of the transport endpoint.

RETURN VALUE

On successful completion, t\_snd returns the number of bytes accepted by the transport provider; it returns -1 on failure, and t\_errno is set to indicate the error.

SEE ALSO

T\_OPEN(NS\_LIB), T\_RCV(NS\_LIB).
NAME
t_snddis – send user-initiated disconnect request

SYNOPSIS
#include <tiuser.h>

int t_snddis(fd, call)
int fd;
struct t_call *call;

DESCRIPTION
This function is used to initiate an abortive release on an already estab­
hlished connection or to reject a connect request. Fd identifies the local
transport endpoint of the connection, and call specifies information associ­
ated with the abortive release. Call points to a t_call structure which con­
tains the following members:

struct netbuf addr;
struct netbuf opt;
struct netbuf udata;
int sequence;

The values in call have different semantics, depending on the context of
the call to t_snddis. When rejecting a connect request, call must be non-
NULL and contain a valid value of sequence to uniquely identify the
rejected connect indication to the transport provider. The addr and opt
fields of call are ignored. In all other cases, call need only be used when
data is being sent with the disconnect request. The addr, opt, and
sequence fields of the t_call structure are ignored. If the user does not
wish to send data to the remote user, the value of call may be NULL.

Udata specifies the user data to be sent to the remote user. The amount of
user data must not exceed the limits supported by the transport provider as
returned in the discon field of the info argument of T_OPEN(NS_LIB) or
T_GETINFO(NS_LIB). If the len field of udata is zero, no data will be sent
to the remote user.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a
transport endpoint.

[TOUTSTATE] The function was issued in the wrong sequence.
The transport provider’s outgoing queue may be
flushed, so data may be lost.
The amount of user data specified was not within the bounds allowed by the transport provider. The transport provider's outgoing queue will be flushed, so data may be lost.

An invalid sequence number was specified, or a NULL call structure was specified when rejecting a connect request. The transport provider's outgoing queue will be flushed, so data may be lost.

An asynchronous event has occurred on this transport endpoint and requires immediate attention.

This function is not supported by the underlying transport provider.

A system error has occurred during execution of this function.

RETURN VALUE

T_snndis returns 0 on success and -1 on failure, and t_errno is set to indicate the error.

SEE ALSO

T_CONNECT(NS_LIB), T_GETINFO(NS_LIB), T_LISTEN(NS_LIB), T_OPEN(NS_LIB).
NAME
t_sndrel - initiate an orderly release

SYNOPSIS
#include <tiuser.h>

int t_sndrel(fd)
int fd;

DESCRIPTION
This function is used to initiate an orderly release of a transport connection
and indicates to the transport provider that the transport user has no more
data to send. Fd identifies the local transport endpoint where the connec­tion
exists. After issuing t_sndrel, the user may not send any more data
over the connection. However, a user may continue to receive data if an
orderly release indication has been received.

This function is an optional service of the transport provider and is only
supported if the transport provider returned service type T_COTS_ORD on
T_OPEN(NS_LIB) or T_GETINFO(NS_LIB).

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a
transport endpoint.

[TFLOW] O_NDELA Y was set, but the flow control mechan­
ism prevented the transport provider from accept­
ing the function at this time.

[TNOTSUPPORT] This function is not supported by the underlying
transport provider.

[TSYSERR] A system error has occurred during execution of
this function.

RETURN VALUE
T_sndrel returns 0 on success and -1 on failure, and t_errno is set to
indicate the error.

SEE ALSO
T_OPEN(NS_LIB), T_RCVREL(NS_LIB).
**T SNDUDATA(NS_LIB)**

**NAME**

tsndudata - send a data unit

**SYNOPSIS**

```c
#include <tiuser.h>

int t_sndudata(fd, unitdata)
int fd;
struct t_unitdata *unitdata;
```

**DESCRIPTION**

This function is used in connectionless mode to send a data unit to another transport user. `Fd` identifies the local transport endpoint through which data will be sent, and `unitdata` points to a `t_unitdata` structure containing the following members:

```c
struct netbuf addr;
struct netbuf opt;
struct netbuf udata;
```

In `unitdata`, `addr` specifies the protocol address of the destination user, `opt` identifies protocol-specific options that the user wants associated with this request, and `udata` specifies the user data to be sent. The user may choose not to specify what protocol options are associated with the transfer by setting the `len` field of `opt` to zero. In this case, the provider may use default options.

If the `len` field of `udata` is zero, no data unit will be passed to the transport provider; `t sndudata` will not send zero-length data units.

By default, `t sndudata` operates in synchronous mode and may wait if flow control restrictions prevent the data from being accepted by the local transport provider at the time the call is made. However, if `O NDELAY` is set [via `T_OPEN(NS_LIB)` or `FCNTL(BA_OS)`], `t sndudata` will execute in asynchronous mode and will fail under such conditions.

If `t sndudata` is issued from an invalid state, or if the amount of data specified in `udata` exceeds the TSDU size as returned in the `tsdu` field of the `info` argument of `T_OPEN(NS_LIB)` or `T_GETINFO(NS_LIB)`, the provider will generate an `EPROTO` protocol error. (See `TSYSERR` below.) If `t sndudata` is issued before the destination user has activated its transport endpoint [see `T_BIND(NS_LIB)`], the data unit may be discarded.
ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a transport endpoint.

[TFLOW] O_NDELAY was set, but the flow control mechanism prevented the transport provider from accepting data at this time.

[TNOTSUPPORT] This function is not supported by the underlying transport provider.

[TSYSERR] A system error has occurred during execution of this function. An EPROTO error may not cause t_sndudata to fail until a subsequent access of the transport endpoint.

RETURN VALUE
T_sndudata returns 0 on successful completion and -1 on failure; t_errno is set to indicate the error.

SEE ALSO
T_ALLOC(NS_LIB), T_RCVUDATA(NS_LIB), T_RCVUDERR(NS_LIB).
**T_SYNC(NS_LIB)**

**NAME**

t_sync - synchronize transport library

**SYNOPSIS**

```c
#include <tiuser.h>

int t_sync(fd)
int fd;
```

**DESCRIPTION**

For the transport endpoint specified by `fd`, `t_sync` synchronizes the data structures managed by the transport library with information from the underlying transport provider. In doing so, it can convert a raw file descriptor [obtained via OPEN(BA_OS), DUP(BA_OS), or as a result of a FORK(BA_OS) and EXEC(BA_OS)] to an initialized transport endpoint, assuming that file descriptor referenced a transport provider. This function also allows two cooperating processes to synchronize their interaction with a transport provider.

For example, if a process forks a new process and issues an `exec`, the new process must issue a `t_sync` to build the private library data structure associated with a transport endpoint and to synchronize the data structure with the relevant provider information.

It is important to remember that the transport provider treats all users of a transport endpoint as a single user. If multiple processes are using the same endpoint, they should coordinate their activities so as not to violate the state of the provider. `T_sync` returns the current state of the provider to the user, thereby enabling the user to verify the state before taking further action. This coordination is only valid among cooperating processes; it is possible that a process or an incoming event could change the provider's state after a `t_sync` is issued.

If the provider is undergoing a state transition when `t_sync` is called, the function will fail.

**ERRORS**

On failure, `t_errno` is set to one of the following:

- **[TBADF]** The specified file descriptor does not refer to a transport endpoint.
- **[TSTATECHNG]** The transport provider is undergoing a state change.
- **[TSYSERR]** A system error has occurred during execution of this function.
RETURN VALUE

T.sync returns the state of the transport provider on successful completion and -1 on failure; t_errno is set to indicate the error. The state returned is one of the following:

T_UNBND unbound
T_IDLE idle
T_OUTCON outgoing connection pending
T_INCON incoming connection pending
T_DATAXFER data transfer
T_OUTREL outgoing orderly release (waiting for an orderly release indication)
T_INREL incoming orderly release (waiting for an orderly release request)

SEE ALSO

DUP(BA_OS), EXEC(BA_OS), FORK(BA_OS), OPEN(BA_OS).
T.UNBIND(NS_LIB)

NAME
t_unbind - disable a transport endpoint

SYNOPSIS
#include <tiuser.h>

int t_unbind(fd)
int fd;

DESCRIPTION
The t_unbind function disables the transport endpoint specified by fd
which was previously bound by T_BIND(NS_LIB). On completion of this
call, no further data or events destined for this transport endpoint will be
accepted by the transport provider.

ERRORS
On failure, t_errno is set to one of the following:

[TBADF] The specified file descriptor does not refer to a trans­
port endpoint.

[TOUTSTATE] The function was issued in the wrong sequence.

[TLOOK] An asynchronous event has occurred on this transport
endpoint.

[TSYSERR] A system error has occurred during execution of this
function.

RETURN VALUE
T_unbind returns 0 on success and -1 on failure, and t_errno is set to
indicate the error.

SEE ALSO
T_BIND(NS_LIB).
14.1 INTRODUCTION
The STREAMS I/O INTERFACES section of the NETWORK SERVICES EXTENSION describes the interfaces that enable a user to directly access protocol modules that are implemented in the kernel using the STREAMS framework. STREAMS provides a uniform mechanism for implementing network services in the kernel by defining standard interfaces for device drivers and protocol modules.

This extension is dependent on the Base System.

14.2 DESCRIPTION

OPERATING SYSTEM SERVICE ROUTINES
getmsg poll putmsg

HEADER FILES
poll.h stropts.h

ERROR CONDITIONS
EBADMSG Trying to read unreadable message
ENOSR Out of stream resources
ENOSTR Device not a stream
EPROTO Protocol error occurred
ETIME Timer expired

14.3 DEFINITIONS
Stream
A stream is a full-duplex connection between a user process and an open device or pseudo-device. The stream itself exists entirely within the kernel and provides a general character I/O interface for user processes. It optionally includes one or more intermediate processing modules that are interposed between the user-process end of the stream and the device driver (or pseudo-device driver) end of the stream.
Module and Driver

A STREAMS component may be a module or a driver that conforms to the rules specified for STREAMS. A STREAMS device driver or pseudo-device driver is always "opened" and may be "linked" if it is a multiplexing driver. A STREAMS module is any other type of software module such as a line discipline or protocol module and is always "pushed" onto the stream.

Stream Head and Stream End

The stream head is the beginning of the stream and is at the kernel/user boundary. This is also known as the upstream end of the stream.

The stream end is the driver end of the stream and is also known as the downstream end of the stream.

Data generated as a result of a system call and destined for the driver end of the stream moves downstream; and data moving from the driver end of the stream toward the stream head is moving upstream. Also, an intermediate Module A is said to be upstream from Module B when it is interposed between Module B and the stream head (upstream) end of the stream, and downstream from Module B when it is between Module B and the driver end of the stream.

Queue

Each STREAMS module contains two queues, one for messages moving in each direction. A queue structure is defined for STREAMS and is important to the module implementer.

STREAMS Messages

STREAMS I/O is based on messages. Message types are classified according to their queueing priority and may be non-priority messages or priority messages. Non-priority messages are always placed at the end of the queue following all other messages in the queue. Priority messages are always placed at the head of a queue but after any other priority messages already in the queue. Priority messages are used to send control and data information outside the normal flow control constraints. A user may access STREAMS messages that contain a data part, control part, or both. The data part is that information which is sent out over the network and the control information is used by the local STREAMS modules. The other types of messages are used between modules and are not accessible to users.
**strbuf Structure**

The `strbuf` structure is used to contain data or control information and is used by the `getmsg`, `putmsg`, and `ioctl` operating system service routines. This structure is defined by the header file `stropts.h` and includes the following members:

```c
int maxlen; /* maximum buffer length */
int len;    /* length of data */
char *buf;  /* ptr to data buffer */
```

**14.4 EFFECTS ON THE BASE SYSTEM**

Components in the Base System may return a new value for `errno` as listed below. An application that checks the value of `errno` must include the header file `<errno.h>`.

The following symbolic names define additional error return conditions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBADMSG</td>
<td>Trying to read unreadable message</td>
</tr>
<tr>
<td>ENOSR</td>
<td>Out of stream resources</td>
</tr>
<tr>
<td>ENOSTR</td>
<td>Device not a stream</td>
</tr>
<tr>
<td>EPROTO</td>
<td>Protocol error</td>
</tr>
<tr>
<td>ETIME</td>
<td>Timer expired</td>
</tr>
</tbody>
</table>

These errors may be returned by the operating system service routines `open`, `close`, `read`, `write`, `ioctl`, `getmsg`, `putmsg`, and `poll` only when accessing STREAMS devices and as described in the detailed definitions of the components that follow the detailed overview.

A new signal has been defined by the header file `<signal.h>`. This signal is used to support asynchronous processing of events on STREAMS devices.

The following symbolic name defines the additional signal:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGPOLL</td>
<td>Signals STREAMS events</td>
</tr>
</tbody>
</table>
14.5 OVERVIEW

STREAMS is a general, flexible facility for development of UNIX system communication services. It supports development ranging from complete networking protocol suites to individual device drivers by defining standard interfaces for character input/output within the kernel. The standard interfaces and associated tools enable modular, portable development and easy integration of high performance network services and their components. STREAMS provides a broad framework that does not impose any specific network architecture. It implements a user interface consistent and compatible with the character I/O mechanism that is also available in the UNIX system.

The power of STREAMS resides in its modularity. The design reflects the layering characteristics of contemporary networking architectures such as Open Systems Interconnection (OSI), Systems Network Architecture (SNA), Transmission Control Protocol/Internet Protocol (TCP/IP), and Xerox* Network Systems (XNS). For these protocol suites, developers have traditionally faced problems arising from lack of relevant standard interfaces in the UNIX system. STREAMS defines standard mechanisms for implementing protocols in "modules". Each module represents a set of processing functions and communicates with other modules via a standard interface. From user level, kernel resident modules can be dynamically selected and interconnected to implement any rational processing sequence. Modularity allows these advantages:

- User level programs can be independent of underlying protocols and physical communication media.
- Network architectures and higher level protocols can be independent of underlying protocols, drivers, and physical communication media. This enables customers to retain their investment in application software as they migrate to different networking environments.

* Xerox is a registered trademark of Xerox Corporation.
• Higher level services can be created by selecting and connecting lower level services and protocols.

• Protocol module portability is enhanced by well defined structure and interface standards.

Implementing networking facilities and communication components under STREAMS allows efficient, open ended products.

"STREAMS" refers to the mechanism consisting of operating system service routines, kernel resources and kernel utility routines. A stream, as illustrated in Figure 14-1, is a full duplex processing and data transfer path in the kernel that is created through an application of the STREAMS mechanism.

Figure 14-1: Basic Stream

A stream implements a connection between a driver in kernel space and a process in user space. It provides a general character input/output (I/O) interface for user processes. STREAMS I/O is based on messages. Messages flow in both directions in a stream. Each module represents processing functions to be
performed on the contents of messages flowing into the module on the stream. Each module is self-contained and functionally isolated from any other component in the stream except its two neighboring components. A module communicates with its neighbors by passing messages. The module receives the message, inspects the type, and processes it or just passes it on. A module can function, for example as, a communication protocol, line discipline, or data filter.

There are many message types used by STREAMS modules and these are classified according to queueing priority. Non-priority messages are always placed at the end of the queue following all other messages in the queue. Priority messages are always placed at the head of a queue but after any other priority messages already in the queue. Priority messages are used to send control and data information outside the normal flow control constraints. However, to prevent congestion and resource waste due to lack of flow control with this message type, only one priority message may be placed in the stream head read queue at a time. A user may access STREAMS messages that contain a data portion, control portion, or both. The data portion is that information which is sent out over the network and the control information is used by the local STREAMS modules. The other types of messages are used between modules and not accessible to users. Messages containing only a data portion are accessible via putmsg, getmsg, read, and write routines. Messages containing a control portion with or without a data portion are accessible via calls to putmsg and getmsg.

The interface between a user process and STREAMS is compatible with the existing character I/O facilities, and both are available in the UNIX system.

14.6 ACCESSING STREAMS

User access to STREAMS is provided through a set of operating system service routines. These include the traditional open, close, read, write, and ioctl operating system service routines as well as the new routines putmsg, getmsg, and poll.

14.6.1 Setting Up a Stream

Like conventional drivers, the STREAMS-based driver occupies a node in the file system and may be "opened" and "closed". When a STREAMS-based device is opened, a stream is automatically set up. As shown in Figure 14-2, this "open" sets up a stream with an internal module called the "stream head" closest to the user and the device driver downstream from the stream head.
The stream then consists of the stream head and a driver. To add other modules to the stream, the user calls the `ioctl` operating system service routine to "PUSH" a module.

The syntax for this `ioctl` command is

```
ioctl (fd, I_PUSH, "name")
```

where `fd` is the file descriptor of the open stream, `I_PUSH` is the command, and "name" is the name of the module to be pushed. The number of modules that may be pushed onto a stream is a configurable quantity. A new module is always pushed just below the stream head so the order of "pushes" is important. After the module is pushed, the stream looks as shown in Figure 14-3.

**Figure 14-2: Setting Up a Stream**
Figure 14-3: Before and After a Module is Pushed

The user may "POP" modules off a stream using the ioctl command

\[ \text{ioctl (fd, I\_POP, 0)} \]

This routine removes the module most recently added to the stream designated by the file descriptor \(fd\); this is always the intermediate module closest to the stream head. At the user level, drivers are operationally distinct from other modules; drivers are explicitly opened by device path name, while modules are "pushed" onto the stream by module name. Device path names are ordinary UNIX system file names, but pushable modules' names are internal to the system and are not opened or closed.

14.6.2 Sending and Receiving STREAMS Messages

In order to send and receive STREAMS messages that contain control information, the new routines getmsg and putmsg must be used. These differ from read and write in that the traditional routines can access non-priority STREAMS messages containing only data, while getmsg and putmsg can access priority and non-priority messages containing a control portion, data portion, or both.
The control portion is used to carry interface information between modules and drivers.

As an example, the transport functions of the OPEN SYSTEMS NETWORKING INTERFACES use putmsg to send service requests (e.g., to establish a connection), with or without data, to the underlying STREAMS-based transport protocol. Getmsg is used by the transport functions to receive information back.

14.6.3 Polling STREAMS

The poll routine provides users with a mechanism for multiplexing input/output over a set of file descriptors that reference open STREAMS. It identifies those STREAMS on which a user can send or receive messages or on which certain events have occurred. The syntax for poll is as follows:

```c
int poll (pollfds, nfds, timeout)
```

where nfds specifies the number of file descriptors to be examined, timeout specifies the number of msec that poll should wait for an event to occur, and pollfds is an array of pollfd structures where each structure contains the following members:

```c
int fd; /* file descriptor */
short events; /* requested events */
short revents; /* returned events */
```

These structures specify the file descriptors to be examined and the events of interest for each file descriptor. Fd specifies an open file descriptor and events and revents are bitmasks constructed by or-ing any combination of the event specific to the poll operating system service routine.

For each element of the array pointed to by fds, poll examines the given file descriptor for the event(s) specified in events. The number of file descriptors to be examined is specified by nfds.

The results of the poll query are stored in the revents field in the pollfd structure. Bits are set in the revents bitmask to indicate which of the requested events are true. If none are true, none of the specified bits is set in revents when the poll call returns.

If none of the defined events have occurred on any selected file descriptor, poll waits at least timeout msec for an event to occur on any of the selected file descriptors. If the value of timeout is 0, poll returns immediately, effectively polling the file descriptors. If the value of timeout is -1, poll blocks until a requested event occurs or until the call is interrupted.
MULTIPLEXING IN STREAMS

Until now, STREAMS has been described as linear connections of modules, where each invocation of a module is connected to at most a single upstream module and a single downstream module. While this configuration is suitable for many applications, others require the ability to multiplex STREAMS in a variety of configurations. Typical examples are internetworking protocols, which might route data over several subnetworks, or terminal window facilities.

STREAMS provides the capability to dynamically build, maintain, and dismantle multiplexing configurations. Two types of multiplexing are supported by STREAMS. The first type allows user processes to connect multiple STREAMS to a single driver from above. This configuration can be established by opening multiple minor devices of the same driver, and does not require any special STREAMS facilities. The second multiplexing type allows user processes to connect multiple STREAMS below a pseudo-driver. This configuration must contain a multiplexing pseudo-driver recognized by STREAMS as having special characteristics. A special set of ioctl commands is used to establish this multiplexing configuration. STREAMS allows a user to build complex, multi-level configurations by cascading multiplexing STREAMS below one another.

14.7.1 Setting Up a Multiplexer

A multiplexing driver is a pseudo-device, and is treated like any other software driver. It owns a node in the UNIX system file system, and is opened just like any other STREAMS device driver. The open call establishes a single stream "above" the multiplexer, and the process that opened the multiplexer is returned a file descriptor that can be used to access the stream that was opened. The file descriptor fd0 in Figure 14-4 is an example of this.

Next, one of the drivers that is to exist "below" the multiplexer is opened. Once again, this is a driver, and is opened like any other UNIX system device. An open operating system service routine is used to open the driver, a stream is established between the driver and a stream head, and the process that issued the open call is returned a file descriptor that can be used to access the stream connected to the driver (e.g., fd1 in Figure 14-4).

If the eventual multiplexing configuration is to have intermediate protocol or line-discipline modules in the stream between the driver just opened and the multiplexer (e.g., between the MUX driver and Driver1 in the "After" section of Figure 14-4), these modules should be added at this time to the stream just opened, using the L_PUSH ioctl command. The "push" operation must be done before the driver is attached below the multiplexer because, once connected, ioctl commands cannot be issued to the bottom driver in the normal way.
The driver that was just opened is then connected below the multiplexing driver that was opened first. This is done using the \texttt{L\_LINK} command of the \texttt{ioctl} operating system service routine; the complete sequence is given here:

\begin{verbatim}
  fd0 = open("/dev/Muxdriver", oflag);
  fd1 = open("/dev/driver1", oflag);
  mux_id = ioctl(fd0, I\_LINK, fd1);
\end{verbatim}

Here, the argument \texttt{fd0} is the file descriptor for the stream connected to the multiplexing driver, and \texttt{fd1} is the file descriptor for the stream connected to another driver. It should be noted that the placement of the first argument (\texttt{fd0}) and the third argument (\texttt{fd1}) is important; the first argument \textbf{must} be the file descriptor of the stream connected to the multiplexing driver. (See Figure 14-4.) The value \texttt{mux\_id} is returned by the operating system service routine; it is used by the multiplexing module to identify the stream just connected.

Figure 14-4 shows two drivers and a multiplexing driver before and after the two drivers have been linked below the multiplexer.
Figure 14-4: A Multiplexing Configuration Before and After 2 L_LINK ioctls
Other device drivers are opened and linked below the multiplexing driver in the same way, as in the example shown in Figure 14-4:

```c
/* open another driver */
fd2 = open("/dev/driver2", oflag);
/* link it below the MUX */
mux_id2 = ioctl(fd0, I_LINK, fd2);
```

The number of STREAMS that can be "linked" to a multiplexer depends on the particular multiplexer, and it is the responsibility of the multiplexer to keep track of the STREAMS linked to it. However, only one L_LINK operation is allowed for each "lower" stream; a single stream cannot be linked below two multiplexers simultaneously.

The order in which the STREAMS in the multiplexing configuration are opened is unimportant. It is only necessary that the two STREAMS referenced as arguments to the L_LINK ioctl are both open when the ioctl L_LINK command is issued. Once the configuration is established, the file descriptors that point to the "bottom" device drivers (e.g., fd1 and fd2 in Figure 14-4) can be closed without affecting the way the multiplexer works; these closes will not cause the drivers to be unlinked from the multiplexer. Closing these file descriptors is necessary sometimes when building large multiplexers, so that many devices can be linked together without exceeding the UNIX system limit on the number of simultaneously-open files per process. If these file descriptors (fd1 and fd2 in Figure 14-4) are not closed, the multiplexer will work as expected, but all subsequent read, write, poll, putmsg, and getmsg UNIX operating system service routines issued to fd1 and fd2 will fail.
Building a multiplexer that connects several STREAMS to a single driver, as in Figure 14-5, is similar, except that only one driver is linked below the multiplexer. Additional STREAMS above the multiplexer would be established by issuing repeated open operating system service routines to the multiplexer on "related" minor devices. Again, the way the multiplexer handles these repeated opens is multiplexer-dependent, as is the number of STREAMS that a particular multiplexer will successfully handle.

More complex multiplexing configurations can also be created. It is possible to combine the examples of Figures 14-4 and 14-5 to create a configuration with many STREAMS above and many drivers linked below the multiplexer. STREAMS imposes no restrictions on the number of multiplexing drivers that may be included in a multiplexing configuration or on the number of multiplexers that data can pass through when moving from one end of the stream to the other.
14.7.2 Dismantling a Multiplexer

Multiplexing configurations are taken apart using the ioctl I_UNLINK command. Each of the bottom drivers linked below the multiplexing driver (e.g., Driver1 and Driver2 in Figure 14-4) can be individually disconnected:

```c
ioctl(fd0, I_UNLINK, mux_id);
```

Here, `fd0` is the file descriptor pointing to a stream connected to the multiplexing driver, and `mux_id` is the identifier that was returned by the ioctl L_LINK command when one of the bottom drivers was linked to the multiplexing driver. Each bottom driver can be disconnected individually in this way, or a special `mux_id` value of -1 will disconnect all bottom modules from the multiplexer simultaneously. This unlinking occurs automatically on the "last" close of the top stream through which the lower STREAMS were linked under the multiplexer driver; all these bottom STREAMS are then unlinked.

14.7.3 Multiplexed Data Routing

Processes use the normal UNIX system `read`, `write`, `getmsg`, and `putmsg` operating system service routines to read data from and write data to an upper stream connected to the multiplexer. When these data are routed through a multiplexer, the multiplexer must use its own criteria to route the data moving in both directions. For example, a protocol multiplexer might use protocol address information found in a protocol header to determine over which subnetwork a given packet should be routed. It is the multiplexing driver's responsibility to define its routing criteria.

One option available to the multiplexer is to use the "mux id" value to determine which stream to route data to. The driver has access to this value, and the L_LINK ioctl command returns this value to the user. The driver can therefore specify that the "mux id" value accompany the data routed through it.
STREAMS provides a uniform mechanism for implementing networking services and other I/O in the kernel. The STREAMS interface provides direct access to protocol modules that are implemented in the kernel. A user process accesses STREAMS using the standard operating system service routines described below as well as the new routines PUTMSG(NS_OS), GETMSG(NS_OS), and POLL(NS_OS). A stream is a full-duplex connection between a user process and an open device or pseudo-device. The stream itself exists entirely within the kernel and provides a general character I/O interface for user processes. It optionally includes one or more intermediate processing modules that are interposed between the user-process end of the stream and the device driver (or pseudo-device driver) end of the stream.

STREAMS I/O is based on messages. Messages flow in both directions in a stream. A given module may not understand and process every message in the stream, but every module in the stream handles every message. Each module accepts messages from one of its neighbor modules in the stream, and passes them to the other neighbor. A line discipline module may transform the data. Data flow through the intermediate modules is symmetrical, with all modules handling, and optionally processing, all messages.

The interface between the stream and the rest of the operating system is provided by a set of routines at the stream head (upstream) end of the stream. User-process WRITE(BA_OS), PUTMSG(NS_OS), and IOCTL(BA_OS) calls become messages that are sent down the stream, and the READ(BA.OS) and GETMSG(NS.OS) calls accept data from the stream and pass it to a user process. Data intended for the device at the downstream end of the stream is packaged into messages and sent downstream, while data and signals from the device are composed into messages by the device driver and sent upstream to the stream head.

When a device is opened, the system creates a stream that contains two modules: the stream head module and the stream end (driver) module. Other modules are added to the stream using the IOCTL(BA_OS) routine. New modules are "pushed" onto the stream one at a time in last-in, first-out (LIFO) style, as though the stream was a push-down stack.

There are many message types used by STREAMS modules and these are classified according to queueing priority. Non-priority messages are always placed at the end of the queue following all other messages in the queue. Priority messages are always placed at the head of a queue but after any
other priority messages already in the queue. Priority messages are used to send control and data information outside the normal flow control constraints. A user may access STREAMS messages that contain a data part, control part, or both. The data part is that information which is sent out over the network and the control information is used by the local STREAMS modules. The other types of messages are used between modules and not accessible to users. Messages containing only a data part are accessible via putmsg, getmsg, read, and write routines. Messages containing a control part with or without a data part are accessible via calls to putmsg and getmsg.

Accessing STREAMS Devices

A user process accesses STREAMS devices using the standard routines OPEN(BA_OS), CLOSE(BA_OS), READ(BA_OS), WRITE(BA_OS), and IOCTL(BA_OS) routines as well as the new routines PUTMSG(NS_OS), GETMSG(NS_OS), and POLL(NS_OS). Refer to the detailed component definitions for open, close, read, write, and ioctl for general properties and errors.

Open calls [see OPEN(BA_OS)] have the format

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

When opening a STREAMS file, oflag may be constructed from O_NDELAY or-ed with either O_RDONLY, O_WRONLY, or O_RDWR. These values are defined by <fcntl.h> so the line

```c
#include <fcntl.h>
```

must be included in the user program. Other flag values are not applicable to STREAMS devices and have no effect on them. The value of O_NDELAY affects the operation of STREAMS drivers and certain system calls [see READ(BA_OS), GETMSG(NS_OS), PUTMSG(NS_OS), and WRITE(BA_OS)]. For drivers, the implementation of O_NDELAY is device-specific. Each STREAMS device driver may treat this option differently. Certain flag values can be set following open as described in FCNTL(BA_OS). On success, open returns a file descriptor that corresponds to the opened stream. On failure, open returns -1 and sets errno to one of the following:

[EINTR] A signal was caught during the open.
STREAMS(NS_DEV)

[ENXIO] A module or driver open routine failed.

[ENOSR] Unable to allocate a stream.

[EIO] A hangup or error occurred during the open.

Close [see CLOSE(BA_OS)] is used to close a device and calls have the format

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

If a STREAMS file is closed and the calling process had previously registered to receive a SIGPOLL signal [see SIGNAL(BA_OS) and SIGSET(BA_OS)] for events associated with that file, the calling process will be unregistered for events associated with the file. The last close for a stream causes the stream associated with fildes to be dismantled. If O_NDELAY is not set and there have been no signals posted for the stream, close waits up to 15 seconds (for each module and driver) for any output to drain before dismantling the stream. If the O_NDELAY flag is set or if there are any pending signals, close does not wait for output to drain, and dismantles the stream immediately. Close returns 0 on success. On failure, close returns -1 and sets errno to one of the following values:

[EBADF] Fildes is not a valid open file descriptor.

[EINTR] A signal was caught during the close.

The read routine [see READ(BA_OS)] attempts to read nbyte bytes of data from the file associated with fildes into the buffer pointed to by buf. Read calls have the format

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

Read can operate in three different modes: "byte-stream" mode, "message-nondiscard" mode, and "message-discard" mode. The default read mode is byte-stream mode. This can be changed using the L_SRDOPT ioctl request, and can be tested with the L_GRDOPT ioctl. In byte-stream mode, read will retrieve data from the stream until it has retrieved nbyte bytes, or until there is no more data to be retrieved. Byte-stream mode ignores message boundaries. In message-nondiscard mode, read retrieves data until it has read nbyte bytes, or until it reaches a message boundary. If the read does not retrieve all the data in a message, the remaining data is replaced on the stream, and can be retrieved by the next read (or...
getmsg) call. Message-discard mode also retrieves data until it has retrieved nbyte bytes, or it reaches a message boundary. However, unread data remaining in a message after the read returns is discarded, and is not available for a subsequent read (or getmsg) call.

When attempting to read a file associated with a stream that has no data currently available:

If O_NDELAY is set, the read will return a -1 and set errno to EAGAIN.

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

The read call's handling of zero-byte messages is determined by the current read mode setting. In byte-stream mode, read accepts data until it has read nbyte bytes, or until there is no more data to read, or until a zero-byte message block is encountered. Read then returns the number of bytes read, and places the zero-byte message back on the stream to be retrieved by the next read or getmsg. In the two other modes, a zero-byte message returns a value of 0 and the message is removed from the stream. When a zero-byte message is read as the first message on a stream, a value of 0 is returned regardless of the read mode.

A read from a STREAMS file can only process messages with data and without control information. The read will fail if a message containing control information is encountered at the stream head.

Read returns the number of bytes read when it succeeds. On failure, read returns -1 and sets errno to one of the following:

[EBADF] Fildes is not a valid open file descriptor.
[EFAULT] Buf points outside the allocated address space.
[EBADMSG] Message waiting to be read is not a data message.
[EAGAIN] No message waiting to be read, and O_NDELAY flag set.
[EINVAL] Attempted to read from a stream linked to a multiplexer.
[EINTR] A signal was caught during the read.

Read will also fail if an error message is received at the stream head. In this case, errno is set to the value returned in the error message. If a
hangup occurs on the stream being read, read will continue to operate normally until the stream head read queue is empty. Thereafter, it will return 0.

The write routine [see WRITE(BA_OS)] attempts to write nbyte bytes from the buffer buf to the device associated with the file descriptor fildes. Write calls have the format

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

The operation of write is determined by the values of the minimum and maximum nbyte range ("packet size") accepted by the stream. These values are contained in the topmost stream module. Unless the user pushes the topmost module, these values cannot be set or tested from user level. If nbyte falls within the packet size range, nbyte bytes will be written. If nbyte does not fall within the range and the minimum packet size value is zero, write will break the buffer into maximum packet size segments prior to sending the data downstream (the last segment may contain less than the maximum packet size). If nbyte does not fall within the range and the minimum value is non-zero, write will fail with errno set to ERANGE. Writing a zero-length buffer (nbyte is zero) sends zero bytes with zero returned.

If O_NDELAY is not set and the stream cannot accept data (the stream write queue is full due to internal flow control conditions), write will block until data can be accepted. If O_NDELAY is set and the stream cannot accept data, write will return -1 and set errno to EAGAIN. If O_NDELAY is set and part of the buffer has been written when a condition in which the stream cannot accept additional data occurs, write will terminate and return the number of bytes written. Upon successful completion, the number of bytes actually written is returned.

On failure, write returns -1 and sets errno to one of the following values:

- **EBADF**  Fildes is not a valid open file descriptor.
- **EFAULT** Buf points outside the allocated address space.
- **ERANGE** Attempt to write to a stream with nbyte outside specified minimum and maximum write range, and the minimum value is non-zero.
[EAGAIN] Attempt to write to a stream that cannot accept data with the O_NDELAY flag set.

[EINVAL] Attempt to read from a stream linked to a multiplexer.

[EINTR] A signal was caught during the write.

[ENXIO] A hangup occurred on the stream being written to.

Write can also fail if an error message has been received at the stream head. In this case, errno is set to the value included in the error message.

Ioctl calls [see IOCTL(BA_OS)] are used to perform control functions with the device associated with the file descriptor fildes. The arguments command and arg are passed to the file designated by fildes and are interpreted by the stream head. Certain combinations of these arguments may be passed to a module or driver in the stream.

fildes is an open file descriptor that refers to a stream. command determines the control function to be performed as described below. arg represents additional information that is needed by this command. The type of arg depends upon the command, but it is generally an integer or a pointer to a command-specific data structure.

Since these STREAMS commands are a subset of ioctl, they are subject to the errors described there. In addition to those errors, the call will fail with errno set to EINVAL, without processing a control function, if the stream referenced by fildes is linked below a multiplexer, or if command is not a valid value for a stream.

Also, as described in ioctl, STREAMS modules and drivers can detect errors. In this case, the module or driver sends an error message to the stream head containing an error value. This causes subsequent system calls to fail with errno set to this value. ioctl calls have the format

```c
int ioctl(fildes, command, arg)
int fildes;
int command;
int arg;
```

The ioctl commands applicable to STREAMS and their arguments are described below. Unless specified, the return value from ioctl is 0 upon success and -1 upon failure with errno set as indicated. Errno will be set to EINVAL for any of the following ioctl calls if the stream is linked below a multiplexer.
STREAMS(NS_DEV)

To use ioctl, the line

```
#include <stropts.h>
```

must be included in the user program.

The following ioctl commands, with error values indicated, are applicable to all STREAMS files:

**I_PUSH**

Pushes the module whose name is pointed to by arg onto the top of the current stream, just below the stream head. It then calls the open routine of the newly-pushed module. On failure, errno is set to one of the following values:

- **[EINVAL]** Invalid module name.
- **[EFAULT]** Arg points outside the allocated address space.
- **[ENXIO]** Open routine of new module failed.
- **[ENXIO]** Hangup received on fildes.

**I_POP**

Removes the module just below the stream head of the stream pointed to by fildes. Arg should be 0 in an I_POP request. On failure, errno is set to one of the following values:

- **[EINVAL]** No module present in the stream.
- **[ENXIO]** Hangup received on fildes.

**I_LOOK**

Retrieves the name of the module just below the stream head of the stream pointed to by fildes, and places it in a character string pointed to by arg. The buffer pointed to by arg should be at least FMNAMESZ+1 bytes long where FMNAMESZ is defined by "#include <sys/conf.h>". On failure, errno is set to one of the following values:

- **[EFAULT]** Arg points outside the allocated address space.
- **[EINVAL]** No module present in stream.
L_FLUSH

This request flushes all input and/or output queues, depending on the value of arg. Legal arg values are:

FLUSHR  Flush read queues.
FLUSHW  Flush write queues.
FLUSHRW Flush read and write queues.

On failure, errno is set to one of the following values:

[EINVAL] Invalid arg value.
[EAGAIN] Unable to allocate buffers for flush message.
[ENXIO] Hangup received on fildes.

L_SETSIG

Informs the stream head that the user wishes the kernel to issue the SIGPOLL signal [see SIGNAL(BA_OS) and SIGSET(BA_OS)] when a particular event has occurred on the stream associated with fildes. L_SETSIG supports an asynchronous processing capability in STREAMS. The value of arg is a bitmask that specifies the events for which the user should be signaled. It is the bitwise-OR of any combination of the following constants:

S_INPUT A non-priority message has arrived on a stream head read queue, and no other messages existed on that queue before this message was placed there. This is set even if the message is of zero length.

S_HIPRI A priority message is present on a stream head read queue. This is set even if the message is of zero length.

S_OUTPUT The write queue just below the stream head is no longer full. This notifies the user that there is room on the queue for sending (or writing) data downstream.

S_MSG A STREAMS signal message that contains the SIGPOLL signal has reached the front of the stream head read queue.

A user process may choose to handle asynchronously only priority messages by setting the arg bitmask to the value S_HIPRI.
Processes that wish to receive SIGPOLL signals must explicitly register to receive them using L_SETSIG. If several processes register to receive this signal for the same event on the same stream, each process will be signaled when the event occurs.

If the value of arg is zero, the calling process will be unregistered and will not receive further SIGPOLL signals. On failure, errno is set to one of the following values:

- **[EINVAL]** Arg value is invalid or arg is zero and process is not registered to receive the SIGPOLL signal.
- **[EAGAIN]** Allocation of a data structure to store the signal request failed.

**L_SETSIG**

Returns the events for which the calling process is currently registered to be sent a SIGPOLL signal. The events are returned as a bitmask pointed to by arg, where the events are those specified in the description of L_SETSIG above. On failure, errno is set to one of the following values:

- **[EINVAL]** Process not registered to receive the SIGPOLL signal.
- **[EFAULT]** Arg points outside the allocated address space.

**L_FIND**

This request compares the names of all modules currently present in the stream to the name pointed to by arg, and returns 1 if the named module is present in the stream. It returns 0 if the named module is not present. On failure, errno is set to one of the following values:

- **[EFAULT]** Arg points outside the allocated address space.
- **[EINVAL]** Arg does not contain a valid module name.
L_PEEK

This request allows a user to retrieve the information in the first message on the stream head read queue without taking the message off the queue. Arg points to a strpeek structure which contains the following members:

```
struct strbuf
struct strbuf
long

ctlbuf;
databuf;
flags;
```

where strbuf is a structure that contains the following members:

```
int maxlen;
int len;
char *buf;
```

The maxlen field in the ctlbuf and databuf strbuf structures [see GETMSG(NS_OS)] must be set to the number of bytes of control information and/or data information, respectively, to retrieve. If the user sets flags to RS_HIPRI, L_PEEK will only look for a priority message on the stream head read queue.

L_PEEK returns 1 if a message was retrieved, and returns 0 if no message was found on the stream head read queue, or if the RS_HIPRI flag was set in flags and a priority message was not present on the stream head read queue. It does not wait for a message to arrive. On return, ctlbuf specifies information in the control buffer, databuf specifies information in the data buffer, and flags contains the value 0 or RS_HIPRI. On failure, errno is set to the following value:

[EFAULT] Arg points or the buffer area specified in ctlbuf or databuf is outside the allocated address space.
STREAMS(NS_DEV)

I_SRDOPT Sets the read mode using the value of the argument arg. Legal arg values are:

RNORM Byte-stream mode, the default.
RMSGD Message-discard mode.
RMSGN Message-nondiscard mode.

Read modes are described in READ(BA_OS). On failure, errno is set to the following value:

[EINVAL] Arg is not one of the above legal values.

I_GRDOPT Returns the current read mode setting in an int pointed to by the argument arg. Read modes are described in READ(BA_OS). On failure, errno is set to the following value:

[EFAULT] Arg points outside the allocated address space.

I_NREAD Counts the number of data bytes in data blocks in the first message on the stream head read queue and places this value in the location pointed to by arg. The return value for the command is the number of messages on the stream head read queue. For example, if zero is returned in arg, but the ioctl return value is greater than zero, this indicates that a zero-length message is next on the queue. On failure, errno is set to the following value:

[EFAULT] Arg points outside the allocated address space.

I_FDINSERT Creates a message from user specified buffer(s), adds information about another stream, and sends the message downstream. The message contains a control part and an optional data part. The data and control parts to be sent are distinguished by placement in separate buffers, as described below.
Arg points to a strfdinsert structure which contains the following members:

```
struct strbuf       ctlbuf;
struct strbuf       databuf;
long                flags;
int                 fildes;
int                 offset;
```

The len field in the ctlbuf strbuf structure [see PUTMSG(NS_OS)] must be set to the size of a pointer plus the number of bytes of control information to be sent with the message. Fd specifies the file descriptor of the other stream and offset, which must be word-aligned, specifies the number of bytes beyond the beginning of the control buffer where L_FDINSERT will store a pointer to the fd stream's driver read queue structure. The len field in the databuf strbuf structure must be set to the number of bytes of data information to be sent with the message or zero if no data part is to be sent.

Flags specifies the type of message to be created. A non-priority message is created if flags is set to 0, and a priority message is created if flags is set to RS_HIPRI. For non-priority messages, L_FDINSERT will block if the stream write queue is full due to internal flow control conditions. For priority messages, L_FDINSERT does not block on this condition. For non-priority messages, L_FDINSERT does not block when the write queue is full and O_NDELAY is set. Instead, it fails and sets errno to EAGAIN.

L_FDINSERT also blocks, unless prevented by lack of internal resources, waiting for the availability of message blocks in the stream, regardless of priority or whether O_NDELAY has been specified. No partial message is sent. On failure, errno is set to one of the following values:

[EAGAIN] A non-priority message was specified, the O_NDELAY flag is set, and the stream write queue is full due to internal flow control conditions.
 Buffers could not be allocated for the message that was to be created.

[EFAULT] Arg points, or the buffer area specified in ctibuf or databuf is, outside the allocated address space.

[EINVAL] One of the following: fd in the strfdinsert structure is not a valid, open stream file descriptor; the size of a pointer plus offset is greater than the len field for the buffer specified through ctlptr; offset does not specify a properly-aligned location in the data buffer; an undefined value is stored in flags.

[ENXIO] Hangup received on fildes.

[ERANGE] The len field for the buffer specified through databuf does not fall within the range specified by the maximum and minimum packet sizes of the topmost stream module or the len field for the buffer specified through databuf is larger than the maximum configured size of the data part of a message; or the len field for the buffer specified through ctibuf is larger than the maximum configured size of the control part of a message.

L_STR

Constructs an internal STREAMS ioctl message from the data pointed to by arg, and sends that message downstream.

This mechanism is provided to send user ioctl requests to downstream modules and drivers. It allows information to be sent with the ioctl, and will return to the user any information sent upstream by the downstream recipient. L_STR blocks until the system responds with either a positive or negative acknowledgment message, or until the request "times out" after some period of time. If the request times out, it fails with errno set to ETIME.

At most, one L_STR can be active on a stream. Further L_STR calls will block until the active L_STR completes at the stream head. The default timeout interval for these requests is 15 seconds. The O_NDELAY [see OPEN(BA_OS)] flag has no effect on this call.
To send requests downstream, `arg` must point to a `strioctl` structure which contains the following members:

```c
int ic_cmd;  /* downstream command */
int ic_timeout; /* ACK/NAK timeout */
int ic_len;  /* length of data arg */
char *ic_dp;  /* ptr to data arg */
```

`ic_cmd` is the internal ioctl command intended for a downstream module or driver and `ic_timeout` is the number of seconds (-1 = infinite, 0 = use default, >0 = as specified) an L_STR request will wait for acknowledgment before timing out. `ic_len` is the number of bytes in the data argument, and `ic_dp` is a pointer to the data argument. The `ic_len` field has two uses: on input, it contains the length of the data argument passed in, and on return from the command, it contains the number of bytes being returned to the user (the buffer pointed to by `ic_dp` should be large enough to contain the maximum amount of data that any module or the driver in the stream can return).

The stream head will convert the information pointed to by the `strioctl` structure to an internal ioctl command message and send it downstream. On failure, `errno` is set to one of the following values:

- **[EAGAIN]** Unable to allocate buffers for the ioctl message.
- **[EFAULT]** Arg points or the buffer area specified by `ic_dp` and `ic_len` (separately for data sent and data returned) is, outside the allocated address space.
- **[EINVAL]** `ic_len` is less than 0, or `ic_len` is larger than the maximum configured size of the data part of a message, or `ic_timeout` is less than -1.
- **[ENXIO]** Hangup received on fildes.
- **[ETIME]** A downstream ioctl timed out before acknowledgment was received.

An L_STR can also fail while waiting for an acknowledgement if a message indicating an error or a hangup is received at the stream head. In addition, an error code can be
returned in the positive or negative acknowledgement mes-
sage, in the event the ioctl command sent downstream fails.
For these cases, LSTR will fail with errno set to the value
in the message.

The following two commands are used for connecting and disconnecting
multiplexed STREAMS configurations.

**L_LINK**
Connects two STREAMS, where fildes is the file descriptor
of the stream connected to the multiplexing driver, and arg
is the file descriptor of the stream connected to another
driver. The stream designated by arg gets connected below
the multiplexing driver. L_LINK requires the multiplexing
driver to send an acknowledgement message to the stream
head regarding the linking operation. This call returns a
multiplexer ID number (an identifier used to disconnect the
multiplexer, see L_UNLINK) on success, and a -1 on failure.
On failure, errno is set to one of the following values:

- [ENXIO] Hangup received on fildes.
- [ETIME] Time out before acknowledgement message was received at stream head.
- [EAGAIN] Unable to allocate STREAMS storage to perform the L_LINK.
- [EBADF] Arg is not a valid, open file descriptor.
- [EINVAL] Fildes stream does not support multiplexing.
- [EINVAL] Arg is not a stream or is already linked under a multiplexer.
- [EINVAL] The specified link operation would cause a "cycle" in the resulting configuration; that is,
if a given stream head is linked into a multi-
plexing configuration in more than one place.

An L_LINK can also fail while waiting for the multiplexing
driver to acknowledge the link request, if a message indicat-
ing an error or a hangup is received at the stream head of
fildes. In addition, an error code can be returned in the
positive or negative acknowledgment message. For these
cases, L_LINK will fail with errno set to the value in the
message.
I_UNLINK  Disconnects the two STREAMS specified by fildes and arg. Fildes is the file descriptor of the stream connected to the multiplexing driver. Arg is the multiplexer ID number that was returned by the ioctl I_LINK command when a stream was linked below the multiplexing driver. If arg is -1, then all STREAMS which were linked to fildes are disconnected. As in I_LINK, this command requires the multiplexing driver to acknowledge the unlink. On failure, errno is set to one of the following values:

[ENXIO]  Hangup received on fildes.
[ETIME]  Time out before acknowledgment message was received at stream head.
[EAGAIN]  Unable to allocate buffers for the acknowledgment message.
[EINVAL]  Invalid multiplexer ID number.

An I_UNLINK can also fail while waiting for the multiplexing driver to acknowledge the link request, if a message indicating an error or a hangup is received at the stream head of fildes. In addition, an error code can be returned in the positive or negative acknowledgment message. For these cases, I_UNLINK will fail with errno set to the value in the message.

RETURN VALUE
Unless specified otherwise above, the return value from ioctl is 0 upon success and -1 upon failure with errno set as indicated.

SEE ALSO
CLOSE(BA_OS), FCNTL(BA_OS), IOCTL(BA_OS), OPEN(BA_OS), READ(BA_OS), GETMSG(NS_OS), POLL(NS_OS), PUTMSG(NS_OS), SIGNAL(BA_OS), SIGSET(BA_OS), WRITE(BA_OS).

LEVEL
Level 1.
GETMSG(NS_OS)

NAME
getmsg – receive next message off a stream

SYNOPSIS
#include <stropts.h>

int getmsg(fd, ctlptr, dataptr, flags)
int fd;
struct strbuf *ctlptr;
struct strbuf *dataptr;
int *flags;

DESCRIPTION
Getmsg retrieves the contents of a message located at the stream head read queue from a STREAMS file, and places the contents into user specified buffer(s). The message must contain either a data part, a control part or both. The data and control parts of the message are placed into separate buffers, as described below. The semantics of each part is defined by the STREAMS module that generated the message.

Fd specifies a file descriptor referencing an open stream. Ctlptr and dataptr each point to a strbuf structure which contains the following members:

    int maxlen;    /* maximum buffer length */
    int len;       /* length of data */
    char *buf;     /* ptr to buffer */

where buf points to a buffer in which the data or control information is to be placed, and maxlen indicates the maximum number of bytes this buffer can hold. On return, len contains the number of bytes of data or control information actually received; or is 0 if there is a zero-length control or data part; or is -1 if no data or control information is present in the message. Flags may be set to the values 0 or RS_HIPRI and is used as described below.

Ctlptr is used to hold the control part of the message, and dataptr is used to hold the data part of the message. If ctlptr (or dataptr) is NULL or the maxlen field is -1, the control (or data) part of the message is not processed and is left on the stream head read queue, and len is set to -1. If the maxlen field is set to 0 and there is a zero-length control (or data) part, that zero-length part is removed from the read queue and len is set to 0. If the maxlen field is set to 0 and there are more than zero bytes of control (or data) information, that information is left on the read queue and len is set to 0. If the maxlen field in ctlptr (or dataptr) is less than
the control (or data) part of the message, maxlen bytes are retrieved. In this case, the remainder of the message is left on the stream head read queue and a non-zero return value is provided, as described below under RETURN VALUE. If information is retrieved from a priority message, flags is set to RS_HIPRI on return.

By default, getmsg processes the first priority or non-priority message available on the stream head read queue. However, a user may choose to retrieve only priority messages by setting flags to RS_HIPRI. In this case, getmsg will only process the next message if it is a priority message.

If O_NONDELAY has not been set, getmsg blocks until a message of the type(s) specified by flags (priority or either) is available on the stream head read queue. If O_NONDELAY has been set and a message of the specified type(s) is not present on the read queue, getmsg fails and sets errno to EAGAIN.

If a hangup occurs on the stream from which messages are to be retrieved, getmsg will continue to operate normally, as described above, until the stream head read queue is empty. Thereafter, it will return 0 in the len fields of ctlptr and dataptr.

ERRORS
Getmsg fails if one or more of the following are true:

[EAGAIN] The O_NONDELAY flag is set, and no messages are available.
[EBADF] Fd is not a valid file descriptor open for reading.
[EBADMSG] Queued message to be read is not valid for getmsg.
[EFAULT] Ctlptr, dataptr, or flags points to a location outside the allocated address space.
[EINTR] A signal was caught during the getmsg system call.
[EINVAL] An illegal value was specified in flags, or the stream referenced by fd is linked under a multiplexer.
[ENOSTR] A stream is not associated with fd.

Getmsg can also fail if a STREAMS error message had been received at the stream head before the call to getmsg. The error returned is the value contained in the STREAMS error message.

RETURN VALUE
Upon successful completion, a non-negative value is returned. A value of 0 indicates that a full message was read successfully. A return value of
GETMSG(NS_OS)

MORECTL indicates that more control information is waiting for retrieval. A return value of MOREDATA indicates that more data is waiting for retrieval. A return value of MORECTL MOREDATA indicates that both types of information remain. Subsequent getmsg calls will retrieve the remainder of the message.

SEE ALSO
READ(BA_OS), POLL(NS_OS), PUTMSG(NS_OS), STREAMS(NS_DEV), WRITE(BA_OS)

LEVEL
Level 1.
NAME
poll - STREAMS input/output multiplexing

SYNOPSIS
#include <stropts.h>
#include <poll.h>

int poll(fds, nfds, timeout)
struct pollfd fds[];
unsigned long nfds;
int timeout;

DESCRIPTION
Poll provides users with a mechanism for multiplexing input/output over a set of file descriptors that reference open STREAMS. Poll identifies those STREAMS on which a user can send or receive messages, or on which certain events have occurred. A user can receive messages using READ(BA_OS) and GETMSG(NS_OS) and send messages using WRITE(BA_OS) and PUTMSG(NS_OS).

Fds specifies the file descriptors to be examined and the events of interest for each file descriptor. It is a pointer to an array with one element for each open file descriptor of interest. The array's elements are pollfd structures which contain the following members:

    int fd;     /* file descriptor */
    short events; /* requested events */
    short revents; /* returned events */

where fd specifies an open file descriptor and events and revents are bit-masks constructed by or-ing any combination of the following event flags:

POLLIN     A non-priority message is present on the stream head read queue. This flag is set even if the message is of zero length. In revents, this flag is mutually exclusive with POLLPRI.

POLLPRI    A priority message is present in the stream head read queue. This flag is set even if the message is of zero length. In revents, this flag is mutually exclusive with POLLIN.

POLLOUT   The first downstream write queue in the stream is not full. Priority messages can be sent [see PUTMSG(NS_OS)] at any time.
POLLERR  An error message has arrived at the stream head. This flag is only valid in the revents bitmask; it is not used in the events field.

POLLHUP  A hangup has occurred on the stream. This event and POLLOUT are mutually exclusive; a stream can never be writable if a hangup has occurred. However, this event and POLLIN or POLLPRI are not mutually exclusive. This flag is only valid in the revents bitmask; it is not used in the events field.

POLLNVAL  The specified fd value does not belong to an open stream. This flag is only valid in the revents field; it is not used in the events field.

For each element of the array pointed to by fds, poll examines the given file descriptor for the event(s) specified in events. The number of file descriptors to be examined is specified by nfds. If nfds exceeds NOFILES, which is the system limit of open files, poll will fail.

If the value of fd is less than zero, events is ignored and revents is set to zero in that entry on return from poll.

The results of the poll query are stored in the revents field in the pollfd structure. Bits are set in the revents bitmask to indicate which of the requested events are true. If none are true, none of the specified bits is set in revents when the poll call returns. The event flags POLLHUP, POLLErr, and POLLNVAL are always set in revents if the conditions they indicate are true; this occurs even when these flags were not present in events.

If none of the defined events have occurred on any selected file descriptor, poll waits at least timeout msec for an event to occur on any of the selected file descriptors. On a computer where millisecond timing accuracy is not available, timeout is rounded up to the nearest legal value available on that system. If the value of timeout is 0, poll returns immediately. If the value of timeout is -1, poll blocks until a requested event occurs or until the call is interrupted. Poll is not affected by the O_NDELAY flag.

ERRORS
Poll fails if one or more of the following are true:

[EAGAIN] Allocation of internal data structures failed but request should be attempted again.
POLL(NS.OS)

[EFAULT] Some argument points outside the allocated address space.
[EINTR] A signal was caught during the poll system call.
[EINVAL] The argument nfds is less than zero, or nfds is greater than NOFILES.

RETURN VALUE
Upon successful completion, a non-negative value is returned. A positive value indicates the total number of file descriptors that has been selected (i.e., file descriptors for which the revents field is non-zero). A value of 0 indicates that the call timed out and no file descriptors have been selected. Upon failure, a value of -1 is returned and errno is set to indicate the error.

SEE ALSO
READ(BA_OS), GETMSG(NS_OS), PUTMSG(NS_OS), STREAMS(NS_DEV), WRITE(BA_OS).

LEVEL
Level 1.
NAME
putmsg - send a message on a stream

SYNOPSIS
#include <stropts.h>

int putmsg (fd, ctlptr, dataptr, flags)
int fd;
struct strbuf *ctlptr;
struct strbuf *dataptr;
int flags;

DESCRIPTION
Putmsg creates a message from user-specified buffer(s) and sends the message to a STREAMS file. The message may contain either a data part, a control part or both. The data and control parts to be sent are distinguished by placement in separate buffers, as described below. The semantics of each part is defined by the STREAMS module that receives the message.

Fd specifies a file descriptor referencing an open stream. Ctlptr and dataptr each point to a strbuf structure which contains the following members:

int maxlen; /* not used */
int len; /* length of data */
char *buf; /* ptr to buffer */

Ctlptr points to the structure describing the control part, if any, to be included in the message. The buf field in the strbuf structure points to the buffer where the control information resides, and the len field indicates the number of bytes to be sent. The maxlen field is not used in putmsg [see GETMSG(NS_OS)]. In a similar manner, dataptr specifies the data, if any, to be included in the message. Flags may be set to the values 0 or RS_HIPRI and is used as described below.

To send the data part of a message, dataptr must be non-NULL and the len field of dataptr must have a value of 0 or greater. To send the control part of a message, the corresponding values must be set for ctlptr. No data (control) part will be sent if either dataptr (ctlptr) is NULL or the len field of dataptr (ctlptr) is set to -1.

If a control part is specified, and flags is set to RS_HIPRI, a priority message is sent. If flags is set to 0, a non-priority message is sent. If no control part is specified, and flags is set to RS_HIPRI, putmsg fails and sets
errno to EINVAl. If no control part and no data part are specified, and flags is set to 0, no message is sent, and 0 is returned.

For non-priority messages, putmsg will block if the stream write queue is full due to internal flow control conditions. For priority messages, putmsg does not block on this condition. For non-priority messages, putmsg does not block when the write queue is full and O_NDELAY is set. Instead, it fails and sets errno to EAGAIN.

Putmsg also blocks, unless prevented by lack of internal resources, waiting for the availability of message blocks in the stream, regardless of priority or whether O_NDELAY has been specified. No partial message is sent.

ERRORS

Putmsg fails if one or more of the following are true:

[EAGAIN] A non-priority message was specified, the O_NDELAY flag is set, and the stream write queue is full due to internal flow control conditions.

[EAGAIN] Buffers could not be allocated for the message that was to be created.

[EBADF] Fd is not a valid file descriptor open for writing.

[EFAULT] Ctlptr or dataptr points outside the allocated address space.

[EINTR] A signal was caught during the putmsg system call.

[EINVAL] An undefined value was specified in flags, or flags is set to RS_HIPRI and no control part was supplied.

[EINVAL] The stream referenced by fd is linked below a multiplexer.

[ENOSTR] A stream is not associated with fd.

[ENXIO] A hangup condition was generated downstream for the specified stream.

[ERANGE] The size of the data part of the message does not fall within the range specified by the maximum and minimum packet sizes of the topmost stream module. This value is also returned if the control part of the message is larger than the maximum configured size of the control part of a message, or if the data part of a message is larger than the maximum configured size of the data part of a message.
PUTMSG(NS_OS)

A `putmsg` also fails if a STREAMS error message had been processed by the `stream` head before the call to `putmsg`. The error returned is the value contained in the STREAMS error message.

RETURN VALUE
Upon successful completion, a value of 0 is returned. Otherwise, a value of -1 is returned and `errno` is set to indicate the error.

SEE ALSO
READ(BA_OS), GETMSG(NS_OS), POLL(NS_OS), STREAMS(NS_DEV), WRITE(BA_OS).

LEVEL
Level 1.
Chapter 15
Shared Resource Environment

15.1 INTRODUCTION

The SHARED RESOURCE ENVIRONMENT section of the NETWORK SERVICES EXTENSION describes a set of capabilities for sharing and administering resources among interconnected machines, that are collectively called Remote File Sharing. Using Remote File Sharing, files that physically reside on a remote machine can be accessed as if they were on the local machine; the capabilities described here provide the interface for accessing and managing Remote File Sharing. New utilities provide the basic functionality, while additional functionality is added to the BASE, the BASIC UTILITIES EXTENSION, and the ADMINISTERED SYSTEM EXTENSION.

This extension is dependent on the Base System and on the MOUNT(AS_CMD) and UMOUNT(AS_CMD) utilities in the ADMINISTERED SYSTEM EXTENSION.

15.2 DESCRIPTION

UTILITIES

<table>
<thead>
<tr>
<th>adv</th>
<th>idload</th>
<th>rfstart</th>
</tr>
</thead>
<tbody>
<tr>
<td>dname</td>
<td>nsquery</td>
<td>rfstop</td>
</tr>
<tr>
<td>fmount</td>
<td>rfadmin</td>
<td>rmnstat</td>
</tr>
<tr>
<td>fusage</td>
<td>rfpasswd</td>
<td>unadv</td>
</tr>
</tbody>
</table>

ERROR CONDITIONS

- **ECOMM**: Communications error
- **EMULTIHOP**: Multihop not allowed
- **ENOLINK**: The link has been severed
- **EREMOTE**: The object is remote
15.3 DEFINITIONS

Advertise

Make a directory available as a remotely sharable resource.

Client

A host that has mounted sharable resources from another host (the server).

Domain

An administrative structure for managing the names of a set of hosts and the names of their sharable resources.

Domain Name Server

A host that has the responsibility for maintaining the name space for one or more domains. For each domain, one host is designated the primary domain name server, and some number of other hosts are designated secondary domain name servers. The host exercising the domain name server responsibility at any given time is the acting domain name server. A host need not be a member of a domain for which it is a name server.

Host

A computer running the Remote File Sharing facility. A host may be a client, a server, or both. A host may be a member of only one domain.

Implementation-specific Constants

In addition to the values listed under Implementation-specific constants in Volume I: Part II – Base System Definition: Chapter 4 – Definitions, several values are defined here.

\{NS_RECOVER\} Maximum number of minutes before domain name service recovery.

\{RDESC_MAX\} Maximum number of characters in a resource description.
Multihop Access

Multihop access refers to the following structure of "indirect" access to a remote resource. Suppose host A advertises a resource that has mounted within it a resource from host B. If any other host mounts the resource from host A and uses it to access a file on the resource from host B, then that access is termed multihop access.

Server

A host that has one or more advertised resources.

Sharable Resource

A sharable resource is one that is advertised by a server and thus is available to authorized clients.

15.4 ERROR CODES

In addition to the error codes defined as part of the SOFTWARE DEVELOPMENT EXTENSION, new error codes have been added to the header file errno.h.

<errno.h>

Defines the following symbolic names for the indicated error return conditions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOMM</td>
<td>Communications error</td>
</tr>
<tr>
<td>EMULTIHOP</td>
<td>Multihop not allowed</td>
</tr>
<tr>
<td>ENOLINK</td>
<td>The link has been severed</td>
</tr>
<tr>
<td>EREMOTE</td>
<td>The object is remote</td>
</tr>
</tbody>
</table>

The ECOMM error condition occurs on any operating system service routine that references a remote resource (through a file descriptor or path name), whenever there is a communications error while trying to send the request for that service routine to the server machine. The EMULTIHOP error condition may occur on any operating system service routine that has a path name as one of its arguments, and indicates that resolution of that path name involves multihop access to a remote resource, when multihop access is not supported by the underlying implementation. Whether multihop access is supported is implementation-specific, but if it is not supported, then the EMULTIHOP error condition must be returned on any attempted multihop access. The ENOLINK error condition occurs on any operating system service routine that references a remote file, when the communications link to the server for that resource has been lost; any file descriptor associated with this remote file should not be used for further I/O.
The EREMOTE error condition occurs on the MOUNT(BA_OS) operating system service routine when the requested mount point resides on a remote resource.

15.5 EFFECTS ON THE BASE SYSTEM

Header Files

Under the Shared Resource Environment, components in the Base System may return a new value for errno, as listed above. In addition, some operating system service routines may return the errno value of EINTR when accessing a remote resource.

The operating system service routines that do not return this value of errno except under the Shared Resource Environment are:

access  creat  mknod
chdir   dup    stat
chmod   exec   unlink
chown   fcntl  ustat
close   link   utime

An application that checks the value of errno must include the header file <errno.h>.

15.6 EFFECTS ON OTHER EXTENSIONS

Some of the utilities in other Extensions are affected by the additional services in the Network Services Extension. The effects are listed below for each utility within each affected Extension.

15.6.1 Effects on the BASIC UTILITIES EXTENSION

Df(BU_CMD)

Df(BU_CMD) is updated to provide free block and free inode information on remote resources mounted locally in addition to local resources. The new syntax is:

df [ -l ] [ -t ] [ file_system : resource ] ...

When used with no arguments, df(BU_CMD) previously reported on all mounted file systems; now df(BU_CMD) will report on both mounted file systems and mounted remote resources. If the -l option is used, df will report only on the local file systems.

If the mounted remote resource is a file system, the free space data are reported for the remote file system. If the mounted remote resource is not a file system, free space data for the parent file system are reported; when df(BU_CMD) reports...
on more than one resource from a specific file system, the second and subsequent entries in the report will be flagged by an asterisk.

Find(BU_CMD)

Find(BU_CMD) is updated to be able to distinguish local and remote files. A new primary is defined, -local, which is true if the file physically resides on the local system.

15.6.2 Effects on the ADMINISTERED SYSTEM EXTENSION

Mount(AS_CMD)

When the Network Services Extension is present, a -d option is available with the MOUNT(AS_CMD) utility. This option is used to locally mount remote resources that have been advertised by a server. The complete syntax is:

```
mount [ [-d ] [ -r ] special directory ]
```

When used with no options, MOUNT(AS_CMD) will report on both local file systems and remote resources that have been mounted.

When the -d option is used, special must be a valid resource name of the form resource or domain.resource. For users and applications processes, the effect of a remote mount is the same as a local mount: an additional file system has been mounted into the local file tree. Once a remote resource has been mounted, all operating system service routines will operate on the remote files as they do on local files, except that it is implementation-specific whether the following operating system service routines will accept a remote file:

```
acct(KE_OS) poll(NS_OS)
getmsg(NS_OS) putmsg(NS_OS)
```

Future Direction

The four operating system service routines listed above will be extended in the future to operate with remote files.

Errors

If the -d option is used and (1) Remote File Sharing is not running on this host, (2) the mount point directory is itself advertised as a resource, (3) the mount point directory is already a mount point, (4) the -r is not specified and the resource was advertised as read-only, (5) the resource is not currently advertised,
(6) the resource is already mounted, or (7) the client is not authorized to access
the resource, an error message will be sent to standard error.

**Umount(AS_CMD)**

When the Network Services Extension is present, an additional option, `-d`, is
available with `UMOUNT(AS_CMD)` for unmounting remote resources mounted
locally. The complete syntax is:

```
umount [ -d ] special
```

If the `-d` option is used, `special` must be a valid resource name of the form
`resource` or `domain.resource`.

**Errors**

Additional error conditions can arise on servers when they attempt to unmount
local resources that are currently advertised or remotely mounted. If (1) the
resource has not been unadvertised or (2) the resource is still currently mounted
on a remote machine, an error message will be sent to standard error.

**Fuser(AS_CMD)**

There are no changes to the syntax for `FUSER(AS_CMD)`, but remote resources
mounted locally can now be specified on the command line by giving the resource
name as an argument. Although a local file can still be used as an argument, the
command will issue a warning if a remote file is specified.

**Sar(AS_CMD)**

When the Network Services Extension is present, the options `-S` and `-D` are
available with `SAR(AS_CMD)`. If neither of these options are specified on the
command line, the output of `SAR(AS_CMD)` will not change. The complete syntax
is:

```
sar [ -ubdycwqvmpr ADS ] [ -o file ] t [ n ]
sar [ -ubdycwqvmpr ADS ] [ -s time ] [ -e time ] [ -i sec ] [ -f file ]
```

The `-D` option is used in combination with either the `-u` or `-c` option. If the
-D is used and neither `-u` nor `-c` is specified, `-u` is assumed.
The command `sar -u` reports time spent in user mode, in system mode, idle with some process waiting for block I/O, and otherwise idle. If the `-D` option is also specified, system time is reported for time servicing remote requests and all other system time. The command `sar -c` reports activity data on system calls. If the `-D` option is also specified, the data are reported for three categories: system calls resulting in outgoing remote activity, system calls resulting from incoming remote activity, and strictly local system calls.

The `-S` option is used to obtain reports on server processes and request queue status. Every request from a remote host to access your resources is conveyed by a request message that is handled by a `server process`. When there are too many messages for the servers to handle, the messages are placed on a request queue. Messages leave the queue and are processed when servers are available. The data reported by the `-S` option are the following: average number of server processes on the system (serv/lo-hi), % of time request messages are on the request queue (request %busy), average number of request messages waiting for service when the request queue is occupied (request avg lgth), % of time there are idle servers (server %avail), and average number of idle servers when idle ones exist (server avg avail).

The new `-S` and `-D` options described for SAR(AS_CMD) are also available for sa2; the interfaces to sa1 and sadc are unchanged. The complete syntax for sa2 is:

```
/usr/lib/sa/sa2 [ -ubdycwaqvmprAD8 ] [ -s time ] [ -e time ] [ -i sec ]
```

### 15.7 CONFORMING SYSTEM CHARACTERISTICS

This section delineates characteristics that all systems must possess in order to conform to the Shared Resource Environment. From an application perspective, these are characteristics of the overall Shared Resource Environment, and do not reside in any one component. Thus, all conforming systems will have the following characteristics, in addition to the individual component interfaces presented in the SHARED RESOURCE ENVIRONMENT section of the NETWORK SERVICES EXTENSION, in order to ensure portability of source code from single-machine environments to a network of machines sharing resources.

Network Services Extension Definition
15.7.1 Network Compatibility

There are implementation-specific criteria for what underlying network(s) can be used to support the Remote File Sharing capabilities described in the SHARED RESOURCE ENVIRONMENT section of the NETWORK SERVICES EXTENSION, but if two machines can each use a given network to support Remote File Sharing with some other machines, then they will be able to jointly engage Remote File Sharing with each other (using that network).

15.7.2 Operation Across Heterogeneous Processors

Some application-level operations may depend on characteristics of the underlying processor. For example, when an application writes a floating-point number into a file, it is typically stored in a format specific to that processor, which may differ in size or byte-ordering from the representation of the same number on a different processor. Similar considerations apply to the representation of more elaborate structured data items, which may also differ across processors in their alignment characteristics. Because the identification and interpretation of such complex data items is solely under the control of the application process, and is not known to the operating system, the operating system cannot automatically perform the translations required for the proper interpretation of those data items when they are shared among processors of different types.

However, for any set of machines that are able to engage in Remote File Sharing with one another, applications on those machines will be able to share named pipes (FIFO's) and any files that are regarded purely as a sequence of bytes (such as ASCII files) without concern for the underlying processor characteristics. Furthermore, by agreeing on a standard external data representation format, applications may manipulate arbitrarily complex data items as a pure sequence of bytes, and thus share those data items across dissimilar processors.

15.7.3 Reliability Against a Single Point of Failure

If a machine that conforms to the SHARED RESOURCE ENVIRONMENT section of the NETWORK SERVICES EXTENSION turns off its Remote File Sharing facility, it must not cause domain name service to be halted completely; service may be interrupted, however, for up to \{NS_RECOVER\} minutes. Within this time interval, domain name service must be resumed, even if the departing machine has not resumed Remote File Sharing. During the outage interval, new MOUNT(AS_CMD) requests do not have to be honored, but previously mounted resources must continue to work as before, unless they physically reside on the machine that stopped its Remote File Sharing facility. Information maintained by the domain name service (such as the list of currently advertised resources) must be retained across the outage.
15.8 FILE SHARING

The Remote File Sharing facility of the Shared Resource Environment provides access to files from a remote machine as though they were on the machine you are logged into. Remote files are named using the same conventions as for local files, and all operations on remote files work the same as they do on local files.

This section presents an overview of the functionality and administrative features of Remote File Sharing. It is included as background for understanding this part of the Network Services Extension of the System V Interface Definition.

Every machine participating in Remote File Sharing is able to make selected parts of its file tree available for sharing, by advertising them. Correspondingly, each machine is able to augment its own file tree with the advertised files from other machines. This augmentation is performed by means of a remote mount, which is a direct extension of the standard mount operation. This section describes the advertise, unadvertise, and remote mount concepts.

15.8.1 Advertise

The right to allow file sharing belongs to the administrator of the machine where the file resides. To allow sharing, an administrator advertises a directory using the adv command. Once advertised, the directory and all files in the subtree below it, including named pipes and special devices, are available for sharing by any authorized machine. (How a machine becomes "authorized" is discussed later.)

15.8.2 Unadvertise

The administrator can unadvertise a directory at any time after it has been advertised by using the unadv command. Unadvertising a directory has no effect on existing mounts of the directory, but future mount requests will fail.
15.8.3 Remote Mount

The Shared Resource Environment extends the MOUNT(AS_CMD) operation to include a remote mount. After a machine has advertised a resource, another machine may remotely mount that resource in its own file tree.

Figure 15-1: A System V File System

Figure 15-1 shows part of a typical file tree. To advertise the subtree under /fs1, you type

```
adv DATA /fs1
```

This makes the /fs1 subtree available for sharing, and specifies that other machines will use the name DATA to refer to it when they mount it. The name DATA can be almost any name that would work as a file name as long as it does not contain a period ("."). The period has a special meaning that will be discussed later.

Another machine gains access to the advertised subtree by mounting the remote subtree on a local directory. An administrator mounts the remote /fs1 subtree advertised above on the local /fs1 directory by typing

```
mount -d DATA /fs1
```

The -d option tells the mount command that the resource being mounted is remote.
The machine that owns a file is called the *server machine*, while the machine that uses the file is called the *client machine*.

![Diagram of Remote Mount](image)

**Figure 15-2: Remote Mount**

Figure 15-2 shows the two machines' file systems after the remote mount. The dotted line connecting the directories means that when a user on the client refers to the subtree under `/fs1`, the file referenced is the one on the server subtree under `/fs1`. For example, a user on the client machine who uses the file name `/fs1/src/uts` refers to the file by that name on the server machine.

There is no need for the structures of client and server file trees to match in any way, or for advertised subtrees to be mounted at the same level on the client as they occupy on the server. If the client had done the remote mount onto its `/usr` directory, then its references to files under `/usr` would be to the server subtree under `/fs1`.

A client cannot get to parts of the server file tree that are not under the advertised directory. For example, if a user on a client machine uses "cd .." to move up from the top directory in a remotely mounted subtree, the user always ends up back in the client file tree.
15.9 ADMINISTRATIVE FEATURES

This section describes the resource naming and security features of Remote File Sharing.

15.9.1 Resource Naming

Resource naming is modeled after the proposed ARPA domain naming convention[1], which has a hierarchically structured name space. A domain in this usage is a name space that may encompass a group of machines and a set of resources advertised by that group of machines.

Resource names are made up of two components separated by a period (.). For example, isl.payroll might represent a resource called payroll in domain isl, and isl.acctp might represent the machine acctp within that same domain. Whether a name specifies a resource or a machine is determined by context; there is no syntactic distinction. If a name is unqualified (i.e., contains no periods), the associated domain may (in some cases) be inferred from the context.

A domain's name space is maintained by a domain name server, which insures uniqueness of names within the domain and provides a central place for storing information about the machines and advertised resources in the domain. The ADV(NS_CMD), UNADV(NS_CMD), MOUNT(AS_CMD), UMOUNT(AS_CMD), and NSQUERY(NS_CMD) commands use the domain name server as a data base for information about advertised resources, such as their names and the servers that own them. The Network Services Extension of the System V Interface Definition defines the interface to this name service through new administrative utilities.

As described above, each resource is assigned a symbolic name when it is advertised, and the resource is subsequently identified (say, within a MOUNT(AS_CMD) command issued on a client) using just the domain name and that symbolic name. Because of this symbolic naming of resources, administrators of other machines need not know the actual position of the resource within the server's file tree, nor even what server within the domain is offering the resource. This location independence simplifies references to resources, and allows for the transparent migration of resources among the machines within a domain (for example, for balancing the load among a set of server machines).

15.9.2 Future Directions

In the future, the domain name space will be extended to include subdomains. By allowing a domain to include subdomains, a tree-structured naming hierarchy can be built, to ease administration of large numbers of resources.
15.9.3 Security Features

There are three features that provide a more secure environment for sharing files: client authentication, client authorization, and user and group id mapping. Most administrators want to be sure that access to files is provided only to those clients that are known and, to at least some degree, trusted. In addition, they normally want to have control over the user and group ids that remote users have on their machines.

Client Authentication
This feature associates a password with a client machine so that the identity of the prospective client can be checked before a mount request is serviced. Entry and update of passwords is discussed in the sections on the RFADMIN(NS_CMD), RFSTART(NS_CMD), and RFPASSWD(NS_CMD) commands.

Client Authorization
The Remote File Sharing facility provides a way for an administrator to selectively advertise directories through the ADV(NS_CMD) command. For example, if you want to advertise /usr/private, but only want to authorize machines mach1 and mach2 to mount that directory, you would issue the command:

```
adv PRIVATE /usr/private mach1 mach2
```

Without a list of machines, the ADV(NS_CMD) command puts no restriction on availability.

An administrator may also choose to advertise a directory read-only by using the -r option. Here, a remote mount will only succeed if the mount command also includes the -r option.

User and Group Id Mapping
Whenever a user accesses a remote file, that user's permissions must be checked as part of the normal processing of the request (for example, an "open to write" is only valid if the user making the request has write permissions on the file). When accessing a file across two machines, there is no guarantee that the user and group ids on the local machine have the same meaning on the other machine.

Some systems handle this problem by requiring the same numeric ids across machines and expecting the administrators to make sure that the /etc/passwd and /etc/group files are identical across all machines (at least the entries for all users that access remote files). This approach is very straightforward from the perspective of administrative simplicity, but it is not always feasible, especially in large or already established environments.
Remote File Sharing provides a range of id mapping options through the IDLOAD(NS_CMD) command. Id mapping is done by a server machine on all incoming requests, as well as in reporting file ownership ids in response to a request from a client machine (for example, STAT(BA_OS) and FSTAT(BA_OS). A client machine maps ids in order to determine the effective user or group id to use in executing a program that is stored on a server and is "set user id" or "set group id".

On each machine, mapping can be set globally, for all remote machines, or on a per-machine basis. All mapping is based on one of two default cases:

id This case maps all incoming ids to id, which means that remote users will have the permissions associated with id in accessing a server’s files. This mapping is the default if no other mapping is specified.

transparent This is a null mapping; remote user and group ids are used locally without change.

These base mappings are augmented by two additional capabilities:

exclude This capability excludes selected ids from the default mapping by mapping them to an otherwise-unused id. This capability could be used together with the transparent mapping capability to handle a network where the /etc/passwd and /etc/group files were identical, but the administrators did not want to allow certain permissions (for example, root) from remote machines.

map This capability provides arbitrary mapping between remote and local ids that have different names or different numeric values. It could be used with the transparent mapping to handle exceptions to "nearly" identical /etc/passwd files.

15.9.4 References

NAME

adv - advertise a directory for remote access

SYNOPSIS

adv [ -r ] [ -d description ] resource pathname [ client ... ]
adv -m resource -d description [ client ... ]
adv -m resource [ -d description ] client ...
adv

DESCRIPTION

The adv command is used to make a resource from one computer available for use on other computers. The machine that advertises the resource is called the server, while computers that mount and use the resource are clients. A resource is composed of a directory and everything under that directory (including subdirectories); the directory must be within a file system that is mounted locally.

There are three ways adv is used: (1) to advertise the directory pathname under the name resource so it is available to each client; (2) to modify client and description fields for currently advertised resources; or (3) to print a list of all locally-advertised resources.

The following options are available:

-r
Restricts access to the resource to a read-only basis. The default is read-write access. If the resource is on a read-only file system, it must be advertised read-only, while resources with local read-write access may be advertised either read-only or read-write.

-d description
Provides brief textual information about the advertised resource. The description is a single argument surrounded by double quotes (") and has a maximum length of {RDESC_MAX} characters; a description longer than {RDESC_MAX} characters will be truncated and result in a warning message.

resource
This is the symbolic name used by the server and all authorized clients to identify the resource. The resource name can be up to a maximum of {NAME_MAX} characters long and must be different from every other resource name in the domain; a resource name
ADV(NS_CMD)

longer than \{NAME\_MAX\} characters will be truncated and result in a warning message. All characters must be printable ASCII characters but must not include periods (.), slashes (/), or white space.

**pathname**

This is the absolute path name of the advertised resource on the local host. The *pathname* cannot be the mount point of a remote resource and it can only be advertised under one resource name.

**client**

This specifies client machines that are authorized to remotely mount the resource. If no *client* is named, all machines that can connect to the server are authorized to access the resource. *client* is of the form *nodename*, *domain.nodename*, *domain.*, or an alias that represents a list of client names. A domain name must be followed by a period (.) to distinguish it from a host name. The aliases are defined in */etc/host.alias*; the syntax of this file matches the alias capability in `MAILX(AU_CMD)`.

**-m resource**

This option modifies information for a resource that has already been advertised. The resource is identified by a *resource* name. Only the *client* list and the *description* field can be modified with this option.

When used with no options, *adv* displays all local resources that have been advertised; this includes the resource name, the path name, the description, the read-write status, and the list of authorized clients. The resource field has a fixed length of \{NAME\_MAX\} characters; all others are of variable length. Fields are separated by two spaces and double quotes (") surround the description.

This command may be used without options by any user; otherwise, it is restricted to the super-user.

The host must be running Remote File Sharing before *adv* can be used to advertise or modify a resource entry.
ERRORS

If there is at least one syntactically valid entry in the client list, and the command is otherwise valid, a warning will be issued for each invalid entry and the command will return a zero exit status.

If (1) the resource name is not unique within the server's set of advertised resources and the -m option is not used, (2) the resource name is not unique within the host's domain, (3) resource is not a directory, (4) the resource is not on a file system mounted locally, (5) there is at least one client specified but none are syntactically valid, (6) the -m option is used but neither a description nor a client list is provided, or (7) the resource name contains a period (.) or a slash (/), an error message will be sent to standard error.

FILES
/etc/host.alias

USAGE
Administrator, End-User.

SEE ALSO
MOUNT(NS_CMD), RFSTART(NS_CMD), UNADV(NS_CMD)

LEVEL
Level 1
NAME
dname - print or set the domain name of the host

SYNOPSIS
dname [ -D domain ] [ -d ]

DESCRIPTION
Without options, or when used with the -d option, dname prints the name of the domain. When used with the -D option, dname changes the domain name of the host to domain.

The domain name must be from 1 to {NAME_MAX} characters, consisting of any combination of letters (upper and lower case), digits, hyphens (-), and underscores (_). If domain is not a valid domain name, the previous name is retained.

The domain name cannot be changed while Remote File Sharing is running.

Any user can execute this command without options or with the -d option, but only the super-user can use the -D option to set the domain name.

ERRORS
When dname is used without options and (1) the domain name is not set or (2) the domain name cannot be accessed, an error message will be sent to standard error.

When the -D option is used and (1) the user is not the super-user, (2) Remote File Sharing is running, or (3) the new domain name is not syntactically valid, an error message will be sent to standard error.

USAGE
Administrator, End-User.

SEE ALSO
NSQUERY(NS_CMD), RFSTART(NS_CMD)

LEVEL
Level 1
NAME
fumount – forced unmount of an advertised resource

SYNOPSIS
fumount [ -w sec ] resource

DESCRIPTION
The fumount command unadvertises the specified resource, triggers a remote warning to clients that have the resource mounted, and disables remote access to the resource. The -w sec causes a delay of sec seconds prior to the execution of the disconnect.

When fumount sends its warning to remote clients, as well as when it actually disables remote access to a resource, it triggers the execution of an administrative shell script on the remote system(s). This shell script can be modified by the administrator of each machine, in order to customize the actions taken in response to such fumount operations. The location and default actions of this shell script are implementation-dependent.

The fumount command issues a warning message if the resource is remotely mounted but is not advertised.

This command is restricted to the super-user.

ERRORS
If resource (1) does not physically reside on the local machine, (2) is an invalid resource name, (3) is not currently advertised and is not remotely mounted, or if (4) the command is not run with super-user privileges, an error message will be sent to standard error.

USAGE
Administrator.

SEE ALSO
ADV(NS_CMD), MOUNT(AS_CMD), UMount(AS_CMD), UNADV(NS_CMD)

LEVEL
Level 1.
NAME
fusage - disk access profiler

SYNOPSIS
fusage [ mount_point | advertised_resource | blk_special_dev ] ...

DESCRIPTION
When used with no options, fusage reports block i/o transfers, in kilobytes, to and from all locally mounted file systems and advertised resources on a per client basis. The count data are cumulative since the time of the mount. When used with an option, fusage reports on the named file system, advertised resource, or block special device.

The report includes one section for each file system and advertised resource and has one entry for each machine that has the directory mounted, ordered by decreasing usage. Sections are ordered by device name; advertised resources that are not complete file systems will immediately follow the sections for the file systems they are in.

USAGE
Administrator, End-User.

SEE ALSO
ADV(NS_CMD), MOUNT(AS_CMD)

LEVEL
Level 1.
NAME
idload - user and group ID mapping

SYNOPSIS
idload [ -n ] [ -g g_rules ] [ -u u_rules ] [ directory ]

DESCRIPTION
The idload command is used to build translation tables for user and group ids. These tables are used to translate between the user and group id of a user on a client machine and the ids on a server machine. When a server is responding to a request from a user on a client, the server uses its tables to decide what permissions to give the client user. A server also uses its tables in reporting file ownership ids for its own files, translating them into the corresponding ids for the client. A client uses its tables only when executing a set-uid or set-gid program that is stored on a server; it uses its translation tables to decide what effective user or group id to give the program when it executes on the client.

The idload command produces the user and group translation tables according to the rules set down in the u_rules and g_rules files. If the rules files are empty, or if idload has never been run, remote user and group ids are mapped to the value {UID_MAX}+1. [An id of {UID_MAX}+1 is just like a regular user or group id, except that no local user can be assigned this id.]

Ids are always mapped within the system by their numeric value, but the rules files given to idload can use both names and numeric ids to describe the mapping. If any local users or groups are specified by name in the rules files, idload uses the local /etc/passwd and /etc/group files to translate those names into numeric ids. If any remote users or groups are specified by name, instead of by numeric id, idload must be able to access copies of the /etc/passwd and /etc/group files from the corresponding remote hosts. idload looks for the remote password and group files under the names directory/domain/host/passwd and directory/domain/host/group, respectively, where directory is taken from the command line, and domain and host specify the desired host (domain.host). If directory is not specified, the default value of /usr/nserve/auth.info is used.

The following options can be used with idload:

-n No change will be made to the translation tables currently in effect. Instead, idload will interpret the input files, and will print a description of the results on standard output.
The \texttt{u\_rules} file contains the rules for user id translation. ("If the -u option is omitted, the default rules file \texttt{/usr/nserve/authinfo/uid.rules} is used.")

The \texttt{g\_rules} file contains the rules for group id translation. ("If the -g option is omitted, the default rules file \texttt{/usr/nserve/authinfo/gid.rules} is used.")

This command is restricted to the super-user.

A host need not be running Remote File Sharing in order to run \texttt{idload}; the new mapping will take effect when the host next starts Remote File Sharing. If the host is running Remote File Sharing when \texttt{idload} is run successfully, the new mapping takes effect immediately.

**RULES FILES**

The \texttt{u\_rules} and \texttt{g\_rules} files are built according to the same syntax rules. The following text describes the mapping of user ids and user names in a \texttt{u\_rules} file; the method for mapping group ids in a \texttt{g\_rules} file is directly parallel. Note that the group id mapping is completely independent of the user id mapping.

The rules file has two types of sections, both optional: \texttt{global} and \texttt{host}. There can be only one \texttt{global} section, but there can be as many \texttt{host} sections as needed.

The \texttt{global} section describes the default conditions for translation of user ids from any machines that are not explicitly referenced in a \texttt{host} section. If the \texttt{global} section is missing, the default action is to map all remote user ids from unspecified hosts to the value \{\texttt{UID\_MAX}\}+1.

A \texttt{host} section is used for each host or group of hosts that is to be mapped differently from the global definitions. The first line of a \texttt{host} section names the host(s) that are described by that section. If multiple hosts are described in a single \texttt{host} section, and any users (or groups) are specified by name, \texttt{idload} will read the \texttt{passwd} (or \texttt{group}) file only for the first host named and will use that information for all hosts in the section. A host can only be described once within any one rules file.

The overall format of a rules file is described below. Each of the instructions listed within the \texttt{global} and \texttt{host} sections is optional, but, if used, must appear in the order shown. Following this overall format is an explanation of each of the individual instruction types.
global
default local | transparent
exclude remote_id--remote_id | remote_id ...
map remote_id:local | remote_id ...

# comment text
host domain.host ...
default local | transparent
exclude remote_id--remote_id | remote_id | remote_name ...
map remote:local | remote ...
map all

Any line beginning with a `#' is regarded as a comment, and is otherwise ignored by idload.

The line

default local | transparent

defines the mode of mapping for remote users that are not specifically mapped in other instructions. local can be replaced by a local user name or id to map all remote users into a particular local name or id number. The default value cannot be root; thus, local can be neither 0 nor root. transparent means that each remote user id will have the same numeric value locally unless it appears in the exclude or map instruction. If the default line is omitted, all remote ids that are not explicitly mapped with the map instruction are mapped to the value {UID_MAX}+1.

The line

exclude remote_id--remote_id | remote_id | remote_name ...

defines remote numeric id(s) and remote names that should be excluded from the default mapping, and that will instead be mapped to the value of {UID_MAX}+1. Each item in the list to be excluded can be a range of numeric ids, a single numeric id, or a single name (although a remote_name cannot be used in a global section). This instruction may be repeated as many times as needed.
The lines

map remote:local \ remote ... 

map all

define the local user ids and names that remote user ids and names will be mapped into. The first form of the map instruction is used to map individual ids; this instruction may be repeated as many times as needed. In this instruction, remote may be either the login name or the numeric id of a remote user; similarly, local may be either the login name or numeric id of a local user. (However, remote names cannot be used in a global section.) An id pair remote:local says to map the id for that remote user into the id for the local user. If remote and local are identical within a pair, the :local part may be omitted. In the second form of the map instruction, the literal entry all says to map each of the user names in the remote system's passwd file (or group file, for group names) into the id for the same name on the local host. (map all cannot appear in a global section.)

ERRORS

On successful completion, idload will modify the user and group mapping currently in effect and will return a zero exit status. If idload fails for either type of mapping (user or group), it will return a non-zero exit status without modifying the current mapping of that type.

If any id is mapped more than once within a single host or global section, a warning will be issued, all mappings for that id but the first will be ignored, and idload will continue processing.

If (1) a rules file cannot be found or opened, (2) there are syntax errors in the rules file(s), (3) there are semantic errors in the rules file(s), (4) remote user or group names are used, but the requisite host information could not be found, or (5) the command is not run with super-user privileges, an error message will be sent to standard error.

FILES

/etc/passwd
/etc/group
/usr/nserve/auth.info/domain/host/passwd
/usr/nserve/auth.info/domain/host/group
/usr/nserve/auth.info/uid.rules
/usr/nserve/auth.info/gid.rules
 USAGE

Administrator.

If remote users and groups are mapped by name, the requisite passwd and group files can be gathered on just one host (such as the primary domain name server), advertised as a resource, and then accessed from other hosts by being remotely mounted under directory.

 EXAMPLE

The following is an example of a u.rules file.

    global
    default transparent
    exclude 0-100

    host music.sonata
    exclude fred mary
    map all

This sample file is composed of a global section and one host section, for the host sonata in domain music. For all hosts other than music.sonata, the user ids will be mapped transparently, that is, to the identical numerical value on the local host. Excluded from this transparent mapping are ids between 0 and 100, which will instead be mapped to {UID_MAX}+1.

For host music.sonata, each user id will be mapped to the one with the same login name on the local host, with the exception of remote users fred and mary, which will be mapped to {UID_MAX}+1. Those remote user ids that have no matching login name in the local /etc/passwd file will also be mapped to {UID_MAX}+1.

 SEE ALSO

MOUNT(NS_CMD)

 LEVEL

Level 1.
NSQUERY(NS_CMD)

NAME
nsquery - query name server information

SYNOPSIS
nsquery [ -h ] [ name ]

DESCRIPTION
The nsquery command provides information about resources available from both the local domain and from other domains. When used with no options, nsquery identifies all resources that have been advertised in the local domain. The -h option causes header information to be omitted from the display. A report on selected resources can be obtained by specifying a name, where name is one of the following:

nodename  The report will include only those resources available from the host nodename.

domain.  The report will include only those resources available from domain.

domain.nodename  The report will include only those resources available from the host domain.nodename.

When name does not include a period (.), it will be interpreted as a nodename within the local domain. If the name ends with a period (.), it will be interpreted as a domain name.

The information contained in the report on each resource includes its advertised name (resource), its read/write permissions, the server (domain.nodename) that advertised the resource, and a brief textual description of the resource.

FUTURE DIRECTION
In the future, the nsquery command will be changed so that if the resource was advertised with a restricted client list that does not include this host, the read/write permissions are listed as inaccessible.

ERRORS
If no entries are found when nsquery is executed, a zero exit status is returned.

If (1) the domain name server cannot be contacted, or (2) name is not known to the domain name server, an error message will be sent to standard error.
NSQUERY(NS_CMD)

USAGE
Administrator, End-User.

SEE ALSO
ADV(NS_CMD), UNADV(NS_CMD)

LEVEL
Level 1
RFADMIN(NS_CMD)

NAME
rfadmin - domain administration

SYNOPSIS
rfadmin
rfadmin -a hostname
rfadmin -r hostname
rfadmin -p

DESCRIPTION
The rfadmin command is used to add and remove hosts and their associated authentication information from the domain membership list(s) maintained on a primary domain name server. It is also used to transfer domain name server responsibilities from one host to another. Used with no options, rfadmin prints the name of the current domain name server for the local domain, in the form domain.nodename.

The rfadmin command can only be used to modify the domain membership lists on the primary domain name server (--a and --r options). Any host acting as the domain name server can use the --p option to pass the domain name server responsibility to another machine. Finally, any host running Remote File Sharing can use rfadmin with no options to print the name of the current domain name server. In all cases, the user must have root permissions to use the command.

--a hostname Used to add a host to a domain that is served by this domain name server. hostname must be of the form domain.nodename. It creates an entry for hostname in the domain/passwd file and prompts for an initial authentication password; the password prompting process conforms to that of PASSWD(AU_CMD). The domain/passwd file has a format similar to /etc/passwd; it consists of name and encrypted password fields separated by a colon (:

--r hostname Used to remove a host from its domain by removing it from the domain/passwd file. Hostname must be of the form domain.nodename.

--p Used to pass the domain name server responsibilities to another host. The host that will assume the domain name server responsibility is the first one available from a previously-specified list; the list contains the primary name server as the first choice,
and some number of other hosts that function as secondary name servers. The means by which a domain administrator specifies this list is implementation-specific.

ERRORS
When used with the -a option, if (1) hostname is not unique in the domain or (2) the password prompting process fails, an error message will be sent to standard error.

When used with the -r option, if (1) hostname does not exist in the domain or (2) hostname is defined as a domain name server, an error message will be sent to standard error.

If there are no alternative domain name servers defined for domain when the -p option is used, an error message will be sent to standard error.

If the command is run without super-user privileges, an error message will be sent to standard error.

FILES
/usr/nserv/auth.info/domain/passwd

USAGE
Administrator.

SEE ALSO
PASSWD(AU_CMD), RFPASSWD(NS_CMD), RFSTART(NS_CMD)

LEVEL
Level 1.
RFPASSWD(NS_CMD)

NAME
rfpasswd – change host authentication password

SYNOPSIS
rfpasswd

DESCRIPTION
rfpasswd updates the authentication password for a host; processing of the
new password follows the same criteria as PASSWD(AU_CMD). The updated
password is registered at the domain name server (in
/usr/nserve/auth.info/domain/passwd) and replaces the password stored
at the local host.

This command is restricted to the super-user.

ERRORS
If (1) Remote File Sharing is not currently active on this host, (2) the old
password entered from this command does not match the existing password
for this host, (3) the two new passwords entered from this command do not
match, (4) the new password does not satisfy the security criteria in
PASSWD(AU_CMD), (5) the domain name server does not know about this
host, or (6) the command is not run with super-user privileges, an error
message will be sent to standard error.

FILES
/usr/nserve/domain/passwd

USAGE
Administrator.

SEE ALSO
PASSWD(AU_CMD), RFSTART(NS_CMD)

LEVEL
Level 1.
NAME

rfstart - start Remote File Sharing

SYNOPSIS

rfstart [ -v ] [ -p host_addr ]

DESCRIPTION

The rfstart command starts Remote File Sharing on a host and defines an authentication level for incoming mount requests. rfstart supports two levels of host authentication. When executed, rfstart always sends a password for this host to the domain name server to authenticate this host's identity. A second level of verification is controlled by an administrator via the -v option.

-v Specifies that every client that requests to mount a resource from this host must be verified against the domain/passwd file; any host for which there is no entry in domain/passwd, or that does not provide the correct password, will not be allowed to mount resources from this host. If -v is not specified, hosts named in domain/passwd will still be verified, but mount requests from other hosts will be granted without verification. (In the above, domain is the domain of the client machine.)

-p host_addr Specifies the network address of the domain name server; the syntax for host_addr is implementation specific. How the system determines the domain name server when the -p option is not used is implementation specific (but see below).

If the host password has not been set, rfstart will prompt for a password; the password prompting process conforms to that of LOGIN(AU_CMD). The password entered must match that previously entered on the domain name server for this host with RFADMIN(NS_CMD). If the password entered matches that on the domain name server, it will be set as the local host password. If it does not match, the password will remain unset on the local host, so that rfstart will again prompt for the password on its next invocation.
RFSTART(NS_CMD)

When rfstart is executed successfully on a host other than the domain name server, the host will receive from the domain name server the host names and addresses of the primary and secondary name servers for the local domain. The location and format of this information is implementation-dependent, but it will be used by subsequent invocations of rfstart in the absence of the -$p$ option.

This command is restricted to the super-user.

ERRORS

If (1) Remote File Sharing is already running, (2) there is no communications network, (3) the domain name for this host has not been set, (4) the domain name server cannot be found, (5) the domain name server does not recognize this host, (6) the command is run without super-user privileges, an error message will be sent to standard error.

If rfstart is used without the -$p$ option and the local host has no other listing of name servers for its domain, an error message will be sent to standard error.

FILES

/usr/nserve/auth.info/domain/passwd

USAGE

Administrator.

After the first use, rfstart will probably be used in the system startup scripts. It is expected that rfstart will be used with other initialization routines each time a machine is booted so that remote resources are mounted along with local resources, and are thus always available to users.

SEE ALSO

DNAME(NS_CMD), RFADMIN(NS_CMD), RFPASSWD(NS_CMD), RFSTOP(NS_CMD)

LEVEL

Level 1.
NAME
    rfstop – stop Remote File Sharing

SYNOPSIS
    rfstop

DESCRIPTION
    The rfstop command stops the Remote File Sharing facility on a host until another RFSTART(NS_CMD) is executed.

Executing rfstop on a machine will in no way disrupt the sharing of resources among other machines engaged in Remote File Sharing. Executing rfstop on a machine that is not the domain name server will not halt or interrupt domain name service to other hosts in the domain. When executed on the acting domain name server, the domain name server responsibility is moved to another name server as though RFADMIN(NS_CMD) had been executed with the -p option. Executing rfstop on the domain name server does not halt domain name service to other hosts in the domain if at least one host has been previously configured as a secondary name server for the domain, and one of those hosts is currently accessible through Remote File Sharing.

This command is restricted to the super-user.

ERRORS
    If (1) there are resources currently advertised by this host, (2) resources from this machine are still remotely mounted by other hosts, (3) there are still remotely mounted resources in the local file system tree, (4) RFSTART(NS_CMD) has not previously been executed, or (5) the command is not run with super-user privileges, an error message will be sent to standard error.

USAGE
    Administrator.

SEE ALSO
    ADV(NS_CMD), FUMOUNT(NS_CMD), MOUNT(AS_CMD), RFADMIN(NS_CMD), RFSTART(NS_CMD), RMNTSTAT(NS_CMD), UNADV(NS_CMD)

LEVEL
    Level 1.
RMNTSTAT(NS_CMD)

NAME
rmntstat - display mounted resource information

SYNOPSIS
rmntstat [ -h ] [ resource ]

DESCRIPTION
When used with no options, rmntstat displays a list of all local resources that are remotely mounted, the local path name, and the corresponding clients. rmntstat returns the remote mount data regardless of whether a resource is currently advertised; this ensures that resources that have been unadvertised but are still remotely mounted are included in the report. When a resource is specified, rmntstat displays the remote mount information only for that resource. The -h option causes header information to be omitted from the display.

ERRORS
If no resources are remotely mounted, rmntstat will return a zero exit status.

If resource (1) does not physically reside on the local machine or (2) is an invalid resource name, an error message will be sent to standard error.

USAGE
Administrator, End-User.

SEE ALSO
FUMOUNT(NS_CMD), MOUNT(AS_CMD)

LEVEL
Level 1.
NAME
unadv - unadvertise a resource

SYNOPSIS
unadv resource

DESCRIPTION
The unadv command unadvertises resource, which is the advertised symbolic name of a local directory, by removing it from the advertised information on the domain name server. Unadvertising a resource prevents subsequent remote mounts of that resource. It does not affect continued access through existing remote or local mounts.

An administrator at a server can unadvertise only those resources that physically reside on the local machine. A domain administrator, however, can unadvertise any resource in the domain by running the command from the acting domain name server and specifying the resource name as domain.resource.

This command is restricted to the super-user.

ERRORS
If resource is not found in the advertised information, an error message will be sent to standard error.

USAGE
Administrator.

If a host crashes while it has resources advertised, the domain name server may continue to list those resources as being available even though they are not available. It is only to correct this situation that a domain administrator should unadvertise another host's resources.

SEE ALSO
ADV(NS_CMD), FUMOUNT(NS_CMD), NSQUERY(NS_CMD)

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