Files and directories

Contents

- File system = file data + **file attribute**
  - File attributes
    - Type, permission, size, time, user/group ID
  - File attributes modification
    - chown, chmod, …
  - Symbolic link
  - Directories

stat( ), fstat( ), lstat( )

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

int stat(const char *pathname, struct stat *buf);
int fstat(int filedes, struct stat *buf);
int lstat(const char *pathname, struct stat *buf);
                                        All three return: 0 if OK, -1 on error
```

- stat
  - Gets information about the named file.
- fstat
  - Gets information about the file that is already open.
- lstat
  - Gets information about the symbolic link itself.
  - If pathname is not a symbolic link, equivalent to *stat*.

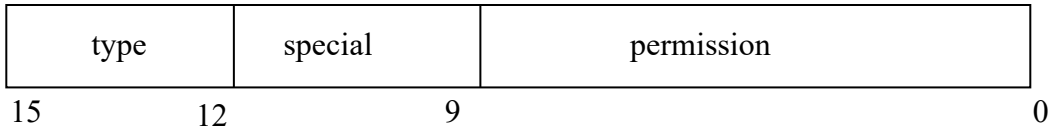
stat( ), fstat( ), lstat( )

- Status structure
  - can differ among implementations

```
struct stat {
      mode_t    st_mode;      /* file type & mode (permissions) */
      ino_t     st_ino;       /* i-node number (serial number) */
      dev_t     st_dev;       /* device number (file system) */
      nlink_t   st_nlink;     /* number of links */
      uid_t     st_uid;       /* user ID of owner */
      gid_t     st_gid;       /* group ID of owner */
      off_t     st_size;      /* size in bytes, for regular files */
      time_t    st_atime;     /* time of last access */
      time_t    st_mtime;     /* time of last modification */
      time_t    st_ctime;     /* time of last file status change */
};
```

st_mode

- Format of ‘st_mode’
  - Composed of three parts:
    file type, special bit, and file permission bit.



st_mode

- file type
  - #define S_IFSOCK 0140000 /* socket */
  - #define S_IFLNK 0120000 /* symbolic link */
  - #define S_IFREG 0100000 /* regular */
  - #define S_IFBLK 0060000 /* block special */
  - #define S_IFDIR 0040000 /* directory */
  - #define S_IFCHR 0020000 /* character special */
  - #define S_IFIFO 0010000 /* FIFO */

st_mode

- special bits
  - #define S_ISUID 0004000 /* set uid on execution */
  - #define S_ISGID 0002000 /* set group id on execution */
  - #define S_ISVTX 0001000 /* save text(sticky bit) */

Usage of the sticky bit

-In early time, used to save an running program to swap area for speed up.

→ Needless because of the virtual memory

-Currently, it was extended for the following functions

- In /tmp and /var/spool/uucppublic,
all files are readable, writable, and executable by all users.
- But, the files must not be deleted/renamed by non-owner.
- Thus, the sticky bit is set in these directories.

st_mode

- permission bits
  - #define S_IRUSR 00400 /* read permission: owner */
  - #define S_IWUSR 00200 /* write permission: owner */
  - #define S_IXUSR 00100 /* execute permission: owner */
  - #define S_IRGRP 00040 /* read permission: group */
  - #define S_IWGRP 00020 /* write permission: group */
  - #define S_IXGRP 00010 /* execute permission: group */
  - #define S_IROTH 00004 /* read permission: other */
  - #define S_IWOTH 00002 /* write permission: other */
  - #define S_IXOTH 00001 /* execute permission: other */

File types

- About file type
  - Regular file
    - Contains data of some form.
    - No distinction to UNIX kernel whether the data is text or binary. (Applications interpret the file contents.)
  - Directory
    - Contains the names of other files and pointers to information on these files.
  - Block special file
    - Provides buffered I/O access in fixed-size units to devices
    - E.g. disk

File types

- About file type(cont.)
  - Character special file
    - Provides unbuffered I/O access in variable-sized units to devices
    - Keyboard, mouse, …
  - FIFO
    - used for communication between processes.
    - Also called *named pipe*
  - Socket
    - used for network communication between processes.
  - Symbolic link
    - Points to another file.

File types

- File type macros
  - Argument of macros is the st_mode from the stat structure.

Macro	Type of file
S_ISREG()	regular file
S_ISDIR()	directory file
S_ISCHR()	character special file
S_ISBLK()	block special file
S_ISFIFO()	pipe or FIFO
S_ISLNK()	symbolic link
S_ISSOCK()	socket

File types

- example

```
#include "apue.h"

int
main(int argc, char *argv[])
{
    int         i;
    struct stat buf;
    char        *ptr;

    for (i = 1; i < argc; i++) {
        printf("%s: ", argv[i]);
        if (lstat(argv[i], &buf) < 0) {
            err_ret("lstat error");
            continue;
        }
```

File types

```
        if (S_ISREG(buf.st_mode))
          ptr = "regular";
        else if (S_ISDIR(buf.st_mode))
          ptr = "directory";
        else if (S_ISCHR(buf.st_mode))
          ptr = "character special";
        else if (S_ISBLK(buf.st_mode))
          ptr = "block special";
        else if (S_ISFIFO(buf.st_mode))
          ptr = "fifo";
        else if (S_ISLNK(buf.st_mode))
          ptr = "symbolic link";
        else if (S_ISSOCK(buf.st_mode))
          ptr = "socket";
        else
          ptr = "** unknown mode **";
        printf("%s\n", ptr);
  }
   exit(0);
}
```

File types

- Running result

```
$ ./a.out /etc/passwd /etc /dev/initctl /dev/log /dev/tty \
   > /dev/scsi/host0/bus0/target0/lun0/cd /dev/cdrom
   /etc/passwd: regular
   /etc: directory
   /dev/initctl: fifo
   /dev/log: socket
   /dev/tty: character special
   /dev/scsi/host0/bus0/target0/lun0/cd: block special
   /dev/cdrom: symbolic link
```

File types

- different file types in a Linux systems

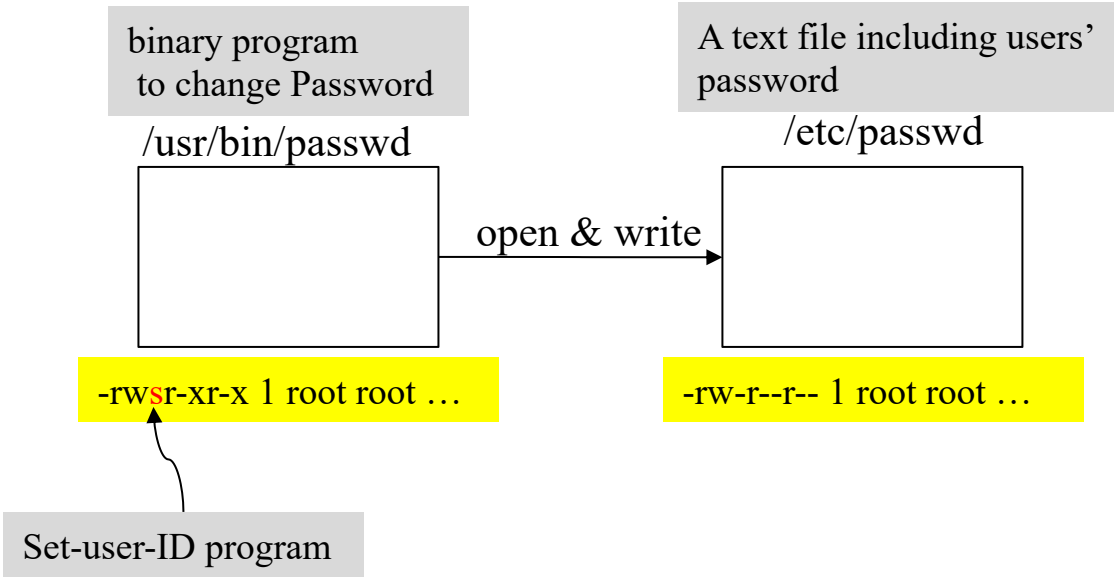
File type	Count	Percentage
regular file	226,856	88.22 %
directory	23,017	8.95
symbolic link	6,442	2.51
character special	447	0.17
block special	312	0.12
socket	69	0.03
FIFO	1	0.00

Set-user-ID and set-group-ID

- Every process has six or more than IDs
- real ID and effective ID
  - real user(group) ID
    - Identifies who we really are.
    - Written in the password file(/etc/passwd,/etc/shadow).
  - effective user(group) ID
    - Determines file access permission.
  - Normally, effective user(group) ID = real user(group) ID.
  - But, effective user(group) ID can be different from the real user(group) ID, in the case of programs with the setuid(setgid) bit set.

Set-user-ID and set-group-ID

- In case of changing password by using passwd program
  - Has a root's privilege while passwd program is running
    - Real user ID of passwd program: user
    - Effective user ID of passwd program: root

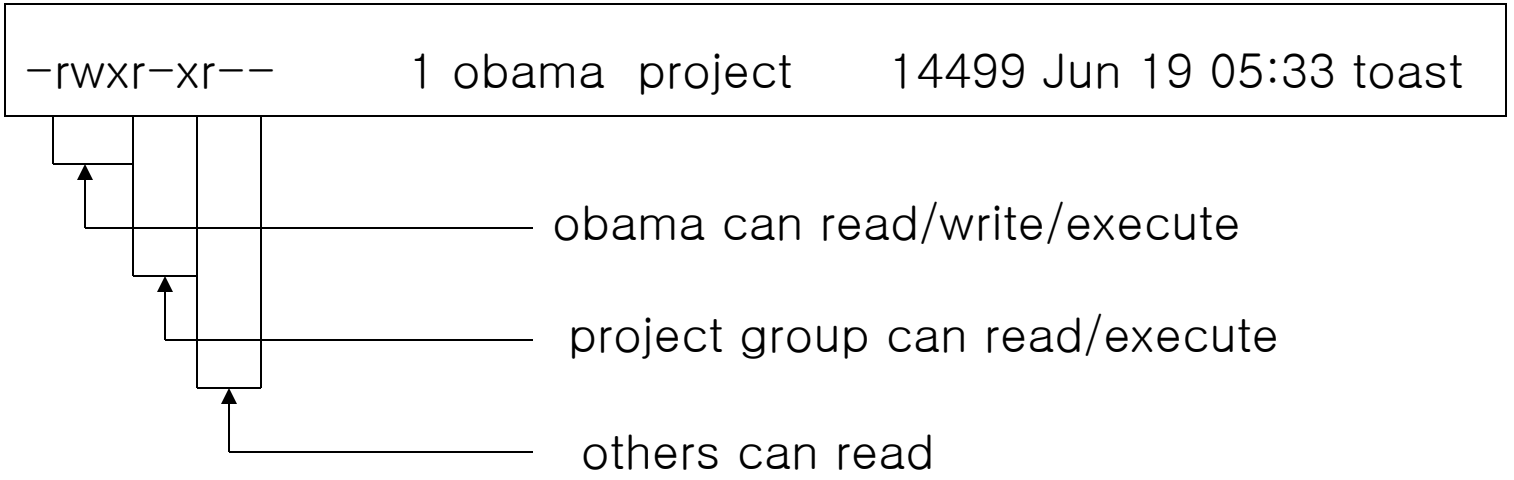


File access permissions

- R/W/X of user, group, others
  - Read
    - file: can read the file data?(able to copy?)
    - Directory: can read the file list?(i.e., able to run ‘ls’?)
  - write
    - File: can modify the file data?
    - Directory: can create or delete the file?
  - execute
    - File: can execute the file?
    - Directory: can move there?(i.e., able to run ‘cd’?)

File access permissions

- File permission example

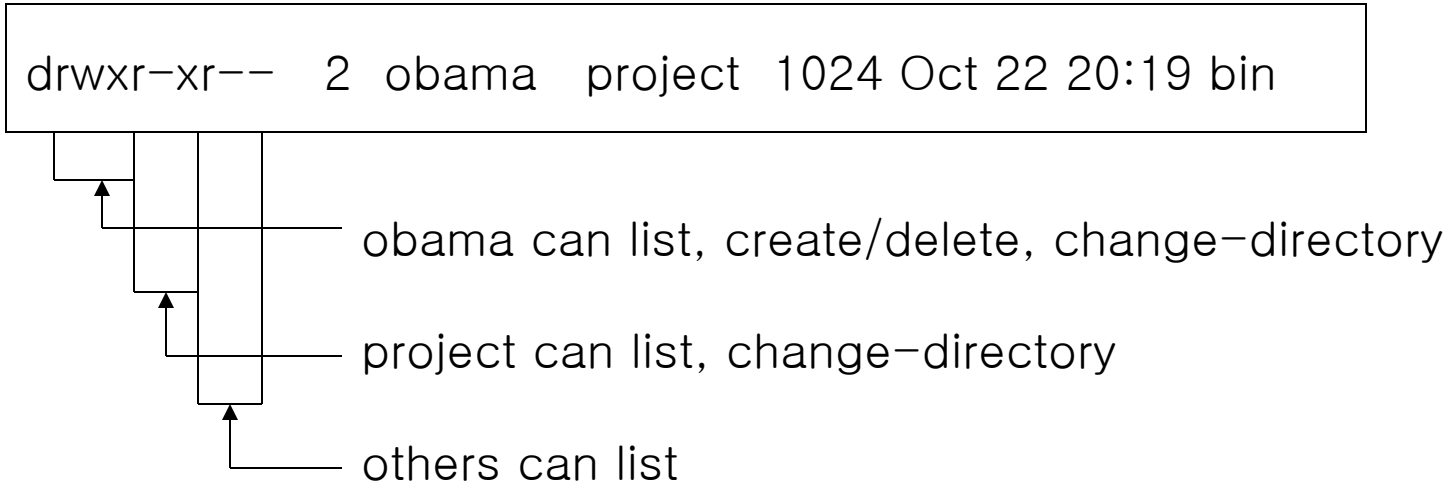


Character	Permission	Octal
R	Read	4
W	Write	2
X	Execute	1

Character	Permission	Value
`---`	None	0
`r--`	readable	4
`rw-`	readable/writable	6
`rwx`	readable/writable/executable	7
`r-x`	readable/executable	5
`--x`	executable	1

File access permissions

- Directory permission example



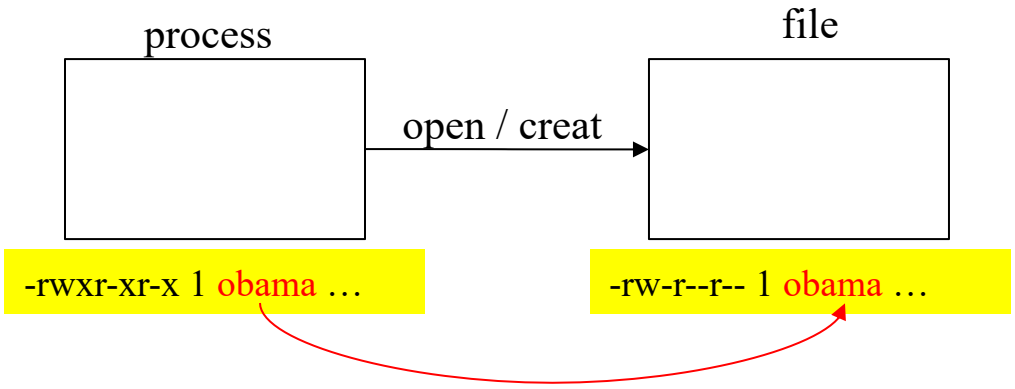
File access permissions

- Frequently used file access permissions

Permission	Value	Description
-rw-------	600	?
-rw-r--r--	644	
-rw-rw-rw-	666	
-rwx------	700	
-rwxr-xr-x	755	
-rwxrwxrwx	777	
-rwx--x--x	711	
drwx------	700	
drwxr-xr-x	755	
drwx--x--x	711	

Ownerships of new files

- When a file is created using open or create
  - Generally, the user ID of a new file is set to the effective user ID of the process.
  - What about group ID? There are two options.



access()

```
#include <unistd.h>

int access(const char *pathname, int mode);
                                        Returns: 0 if OK, -1 on error
```

- Check the access permission based on real ID.
- mode

mode	Description
R_OK	test for read permission
W_OK	test for write permission
X_OK	test for execute permission
F_OK	test for existence of file

access()

- example

```
#include "apue.h"
#include <fcntl.h>

int
main(int argc, char *argv[])
{
    if (argc != 2)
        err_quit("usage: a.out <pathname>");
    if (access(argv[1], R_OK) < 0)
        err_ret("access error for %s", argv[1]);
    else
        printf("read access OK\n");
    exit(0);
}
```

access()

- Execution

```
$ whoami
obama
$ ls -l a.out
-rwxrwxr-x 1 obama  project   15945 Nov 30 12:10 a.out
$ ./a.out a.out
read access OK
$ ls -l /etc/shadow
-r--------- 1 root  root      1315 Jul 17 2002 /etc/shadow
$ ./a.out /etc/shadow
access error for /etc/shadow: Permission denied
$
```

umask( )

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

mode_t umask(mode_t cmask);
                                    Returns: previous file mode creation mask
```

- Set the file mode creation mask
- permissions in the umask are turned off from the mode argument to open( )

```
umask(022);
fd = creat("tmp", 0666);
...
➔ permission of "tmp" is -rw-r--r-- (0644)
```

umask( )

- The umask file access permission bits <sys/stat.h>

st_mode mask	Meaning	Mask bit
S_IRUSR	user-read	0400
S_IWUSR	user-write	0200
S_IXUSR	user-execute	0100
S_IRGRP	group-read	0040
S_IWGRP	group-write	0020
S_IXGRP	group-execute	0010
S_IROTH	other-read	0004
S_IWOTH	other-write	0002
S_IXOTH	other-execute	0001

umask( )

- Example

```
#include "apue.h"
#include <fcntl.h>

#define RWRWRW (S_IRUSR|S_IWUSR|S_IRGRP|S_IWGRP|S_IROTH|S_IWOTH)

int
main(void)
{
    umask(0);
    if (creat("foo", RWRWRW) < 0)
        err_sys("creat error for foo");
    umask(S_IRGRP | S_IWGRP | S_IROTH | S_IWOTH);
    if (creat("bar", RWRWRW) < 0)
        err_sys("creat error for bar");
    exit(0);
}
```

666

066

600

umask( )

- Execution

```
$ ./a.out
$ ls -l foo bar
-rw------- 1 sar          0 Dec 7 21:20 bar
-rw-rw-rw- 1 sar          0 Dec 7 21:20 foo
$
```

- 참고) umask utility

```
$ umask                    first print the current file mode creation mask
002
$ umask –S                 print the symbolic form
u=rwx, g=rwx, o=rx
$ umask 027                change the file mode creation mask
$ umask –S
u=rwx, g=rx, o=
```

chmod( ) and fchmod( )

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

int chmod(const char *pathname, mode_t mode);
int fchmod(int filedes, mode_t mode);
                                        Both return: 0 if OK, -1 on error
```

- Change the file access permission
  - chmod: for the specified file
  - fchmod: for an open file

- To change the permission bits of a file
  - the effective user ID of the process must be equal to the owner ID of the file, or
  - the process must have super-user permissions.

chmod( ) and fchmod( )

- Mode (in <sys/stat.h>)

mode	Description
S_ISUID	set-user-ID on execution
S_ISGID	set-group-ID on execution
S_ISVTX	saved-text (sticky bit)
S_IRWXU	read, write, and execute by user (owner)
S_IRUSR	read by user (owner)
S_IWUSR	write by user (owner)
S_IXUSR	execute by user (owner)
S_IRWXG	read, write, and execute by group
S_IRGRP	read by group
S_IWGRP	write by group
S_IXGRP	execute by group
S_IRWXO	read, write, and execute by other (world)
S_IROTH	read by other (world)
S_IWOTH	write by other (world)
S_IXOTH	execute by other (world)

chmod( ) and fchmod( )

- Example

```
#include "apue.h"

int main(void)
{
    struct stat      statbuf;

    /* turn on group-execute and turn off group-write */
    if (stat("foo", &statbuf) < 0)
        err_sys("stat error for foo");
    if (chmod("foo", (statbuf.st_mode & ~S_IWGRP) | S_ISGID) < 0)
        err_sys("chmod error for foo");

    /* set absolute mode to "rw-r--r--" */
    if (chmod("bar", S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH) < 0)
        err_sys("chmod error for bar");

    exit(0);
}
```

chmod( ) and fchmod( )

- Execution

```
$ ls -l foo bar
-rw------- 1 sar            0 Dec 7 21:20 bar
-rw-rw-rw- 1 sar            0 Dec 7 21:20 foo
$ ./a.out
$ ls -l foo bar
-rw-r--r-- 1 sar            0 Dec 7 21:20 bar
-rw-r-Srw- 1 sar            0 Dec 7 21:20 foo
$
```

s : set-group-ID bit is set w/ the group-execution bit being set
S : set-group-ID bit is set w.o. the group-execution bit being set

* Sticky bit is represented by ‘t’ or ‘T’ in Other’s execution bit location.

chown( ), fchown( ), and lchown( )

```
#include <unistd.h>

int chown(const char *pathname, uid_t owner, gid_t group);
int fchown(int filedes, uid_t owner, gid_t group);
int lchown(const char *pathname, uid_t owner, gid_t group);
                                        All three return: 0 if OK, -1 on error
```

- Change the user ID and the group ID
  - chown: of the specified file
  - fchown: of an open file
  - lchown: of the symbolic link itself, not the file pointed to by the symbolic link
- In BSD-based system, only superuser may change the owner of a file.
- If the arguments *owner* or *group* is specified as -1, then the corresponding ID is not changed.

File Size

- st_size in stat structure
  - The size of the file in bytes
  - Valid only for regular, directory, and symbolic link files
  - In a symbolic link file, it denotes the length of the pathname of the target file.
- For block sizes,
  - st_blksize : the block size for I/O
  - st_blocks : the actual number of blocks allocated

truncate()

```
#include <unistd.h>

int truncate(const char *pathname, off_t length);
int ftruncate(int filedes, off_t length);
                                        Returns: 0 if OK, -1 on error
```

- Truncate an existing file to *length* bytes
  - Emptying a file is a special case
    - Open a file with O_TRUNC flag
  - May make a hole

link()

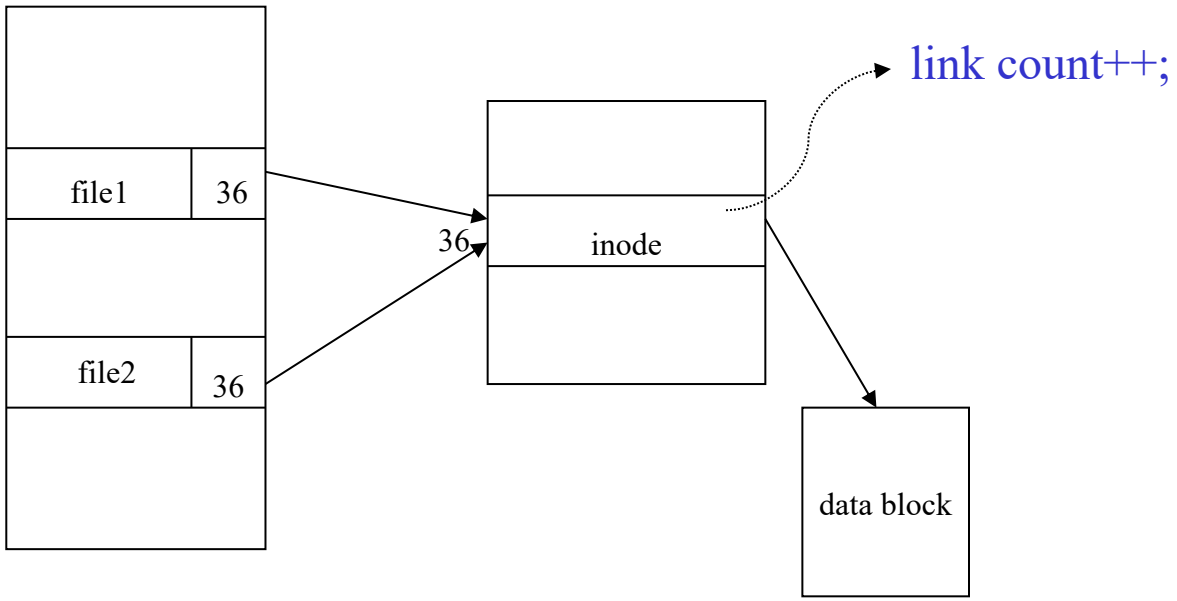
```
#include <unistd.h>

int link(const char *existingpath, const char *newpath);
                                        Returns: 0 if OK, -1 on error
```

- Create a link(hard link) to an existing file
  - creates a new directory entry, *newpath*, that references the existing file *existingpath*.
  - If *newpath* exists, an error is returned.

link()

- link("file1", "file2");



- It is impossible to tell which name was the original.
- Hard links, as created by link, cannot span file systems.

unlink()

```
#include <unistd.h>

int unlink(const char *pathname);
                                        Returns: 0 if OK, -1 on error
```

- Removes the directory entry and decrements the link count of the file referenced by pathname.
  - If other process has opened the file, its contents will not be deleted.
  - When the link count reaches 0, file content is deleted.
- Useful to ensure that a temporary file won't be left in case the process crashes (see the following example.)

```
#include "apue.h"
#include <fcntl.h>

int
main(void)
{
    if (open("tempfile", O_RDWR) < 0)
        err_sys("open error");
    if (unlink("tempfile") < 0)
        err_sys("unlink error");
    printf("file unlinked\n");
    sleep(15);
    printf("done\n");
    exit(0);
}
```

Figure 4.16 Open a file and then `unlink` it

Symbolic links

- hard link points directly to the inode of the file.
  - The link and the file should reside in the same file system.
  - Only the superuser can create a hard link to a directory.
- symbolic link is an indirect pointer to a file.
  - There are no file system limitations on a symbolic link.
  - Anyone can create a symbolic link to a directory
- See Figure 4.17 for treatment of symbolic links by various functions

Function	Does not follow symbolic link	Follows symbolic link
access		•
chdir		•
chmod		•
chown		•
creat		•
exec		•
lchown	•	
link		•
lstat	•	
open		•
opendir		•
pathconf		•
readlink	•	
remove	•	
rename	•	
stat		•
truncate		•
unlink	•	

Figure 4.17 Treatment of symbolic links by various functions

symlink()

```
#include <unistd.h>

int symlink(const char *actualpath, const char *sympath);
                                                    Returns: 0 if OK, -1 on error
```

- Create a new directory entry, *sympath* that points to *actualpath*.
  - Not require that *actualpath* exist when the symbolic link is created.
  - *Actualpath* and *sympath* need not reside in the same file system.

symlink()

- Dangling link
  - may point to an non-existing file

Example 1

```
$ ln -s /no/such/file myfile        create a symbolic link
$ ls myfile
myfile                              ls says it's there
$ cat myfile                        so we try to look at it
cat: myfile: No such file or directory
$ ls -l myfile                      try -l option
lrwxrwxrwx 1 sar       13 Jan 22 00:26 myfile -> /no/such/file
$
```

Example 2

```
$ ln -s testfile newfile
$ ls -l newfile
lrwxrwxrwx   1 yhshin   users         8 Aug 27 20:02 newfile -> testfile
$ rm testfile
$ cat newfile
cat: newfile: No such file or directory
$
```

readlink()

```
#include <unistd.h>

ssize_t readlink(const char *pathname, char *buf, size_t bufsize);
                                        Returns: number of bytes read if OK, -1 on error
```

- read value of a symbolic link
  - places the contents of the symbolic link path in the buffer *buf*, which has size *bufsiz*.
- Return value
  - the count of characters placed in the buffer if it succeeds
  - -1 if an error occurs

remove()

```
#include <stdio.h>

int remove(const char *pathname);
                                        Returns: 0 if OK, -1 on error
```

- Unlink a file or a directory
  - For a file, identical to unlink.
  - For a directory, identical to rmdir.

rename()

```
#include <stdio.h>

int rename(const char *oldname, const char *newname);
                                        Returns: 0 if OK, -1 on error
```

- Rename
  - renames a file or a directory.
  - oldname and newname should be in the same file system.

File times

- The three time values associated with each file (see Figure 4.20)

Field	Description	Example	ls(1) option
st_atime	last-access time of file data	read	-u
st_mtime	last-modification time of file data	write	default
st_ctime	last-change time of i-node status	chmod, chown	-c

  - st_mtime: time the file contents were last modified.
  - st_ctime: time the inode of the file was last modified.

Function	Referenced file or directory			Parent directory of referenced file or directory			Section	Note
	a	m	c	a	m	c		
chmod, fchmod			•				4.9	
chown, fchown			•				4.11	
creat	•	•	•		•	•	3.4	O_CREAT new file
creat		•	•				3.4	O_TRUNC existing file
exec	•						8.10	
lchown			•				4.11	
link			•		•	•	4.15	parent of second argument
mkdir	•	•	•		•	•	4.21	
mkfifo	•	•	•		•	•	15.5	
open	•	•	•		•	•	3.3	O_CREAT new file
open		•	•				3.3	O_TRUNC existing file
pipe	•	•	•				15.2	
read	•						3.7	
remove			•		•	•	4.15	remove file = unlink
remove					•	•	4.15	remove directory = rmdir
rename			•		•	•	4.16	for both arguments
rmdir					•	•	4.21	
truncate, ftruncate		•	•				4.13	
unlink			•		•	•	4.15	
utimes, utimensat, futimens	•	•	•				4.20	
write		•	•				3.8	

Figure 4.20 Effect of various functions on the access, modification, and changed-status times

utime()

```
#include <utime.h>

int utime(const char *pathname, const struct utimbuf *times);
                                                    Returns: 0 if OK, -1 on error
```

- Change the access time and modified time
  - utimbuf structure

```
struct utimbuf {
    time_t actime;    /* access time */
    time_t modtime;   /* modification time */
  }
```

  - If times is NULL, the access and modification times of the file are set to the current time.
  - st_ctime is automatically updated when the utime is called.

utime()

- example

```
#include "apue.h"
#include <fcntl.h>
#include <utime.h>

int
main(int argc, char *argv[])
{
    int             i, fd;
    struct stat     statbuf;
    struct utimbuf  timebuf;

    for (i = 1; i < argc; i++) {
        if (stat(argv[i], &statbuf) < 0) { /* fetch current times */
            err_ret("%s: stat error", argv[i]);
            continue;
        }
```

utime()

- example(cont.)

```
        if ((fd = open(argv[i], O_RDWR | O_TRUNC)) < 0) { /* truncate */
            err_ret("%s: open error", argv[i]);
            continue;
        }
        close(fd);
        timebuf.actime  =  statbuf.st_atime;
        timebuf.modtime =  statbuf.st_mtime;
        if (utime(argv[i], &timebuf) < 0) {     /* reset times */
            err_ret("%s: utime error", argv[i]);
            continue;
        }
    }
    exit(0);
}
```

utime()

- Execution

```
$ ls -l changemod times          look at sizes and last-modification times
-rwxrwxr-x 1 sar   15019   Nov  18  18:53  changemod
-rwxrwxr-x 1 sar   16172   Nov  19  20:05  times
$ ls -lu changemod times         look at last-access times
-rwxrwxr-x 1 sar   15019   Nov  18  18:53  changemod
-rwxrwxr-x 1 sar   16172   Nov  19  20:05  times
$ date                           print today's date
Thu Jan 22 06:55:17 EST 2004
$ ./a.out changemod times        run the program in the previous page
$ ls -l changemod times          and check the results
-rwxrwxr-x 1 sar       0  Nov  18  18:53  changemod
-rwxrwxr-x 1 sar       0  Nov  19  20:05  times
$ ls -lu changemod times         check the last-access times also
-rwxrwxr-x 1 sar       0  Nov  18  18:53  changemod
-rwxrwxr-x 1 sar       0  Nov  19  20:05  times
$ ls -lc changemod times         and the changed-status times
-rwxrwxr-x 1 sar       0  Jan  22  06:55  changemod
-rwxrwxr-x 1 sar       0  Jan  22  06:55  times
$
```

mkdir()

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

int mkdir(const char *pathname, mode_t mode);
                                        Returns: 0 if OK, -1 on error
```

- Create a new empty directory.
  - The entries for dot and dot-dot are automatically created.

rmdir()

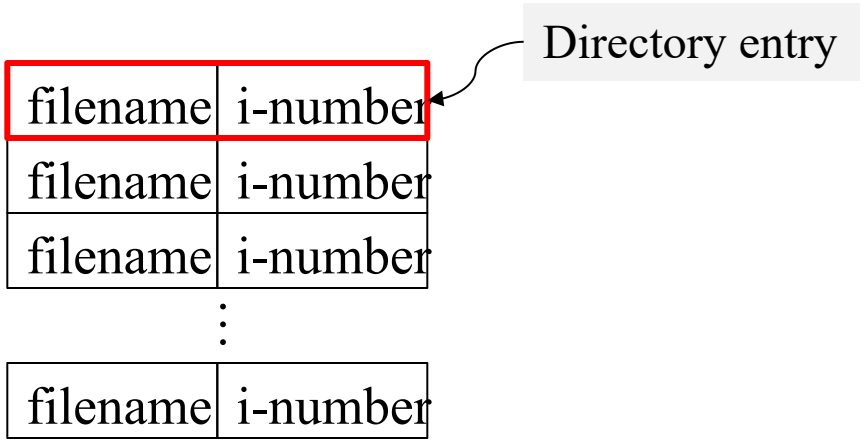
```
#include <unistd.h>

int rmdir(const char *pathname);
                                        Returns: 0 if OK, -1 on error
```

- Delete an empty directory.
  - An empty directory is one that contains entries only for dot and dot-dot.

Reading directories

- Write permission bits for a directory
  - Means that we can create/remove files in the directory.
  - Does not mean that we can write to the directory itself.
  - ➔ We need some APIs that can deal with directory itself.



A typical directory format
(Details of directory formats are system dependent.)

Reading directories

```
#include <dirent.h>

DIR *opendir(const char *pathname);
                                        Returns: pointer if OK, NULL on error
int closedir(DIR *dp);
                                        Returns: 0 if OK, -1 on error
```

- Open a directory/close an open directory
  - DIR: represents a directory stream
    - Defined in <dirent.h>.
    - Similar to FILE type in the standard I/O library.

Reading directories

```
#include <dirent.h>

struct dirent *readdir(DIR *dp);
                    Returns: pointer if OK, NULL at end of directory or error
```

- Read directory entry into a dirent structure.

```
struct dirent {
      ino_t d_ino;                    /* i-node number */
      char  d_name[NAME_MAX + 1];     /* null-terminated filename */
    }
```

  - On the first call, the first directory entry is read into dirent.
  - On completion, the directory pointer is moved onto the next entry in the directory.
  - If the end of the directory is reached, NULL is returned.

Reading directories

```
#include <dirent.h>

void rewinddir(DIR *dp);
```

- If you want to reread from the beginning of directory, use rewinddir.
  - Following the rewinddir call the next readdir will return the first entry of the directory.

Reading directories

- example

```
#include <stdio.h>
#include <dirent.h>

main (int argc, char ** argv)
{
        char pathname[128];

        if (argc == 1) {
                strcpy(pathname, ".");
        }
        else if (argc > 2) {
                printf("Too many parameter…\n");
                exit(1);
        }
        else {
                strcpy(pathname, argv[1]);
        }
        if (my_double_ls(pathname) ==-1 ) printf("Could not open the directory\n");
}
```

Reading directories

- example (cont.)

```
int my_double_ls (const char *name) {
        struct dirent *d;
        DIR *dp;

        if ((dp = opendir(name)) == NULL)
                return (-1);
        while (d = readdir(dp)) {
                if (d->d_ino !=0)
                printf ("%s\n", d->d_name);
        }

        rewinddir(dp);
        while (d = readdir(dp)) {
                if (d->d_ino != 0)
                printf ("%s\n", d->d_name);
        }
        closedir(dp);
        return (0);
}
```

Reading directories

- Execution

```
$ ls temp_dir/
abc  bookmark  fred
$ ./a.out temp_dir/
fred
abc
bookmark
..
.
fred
abc
bookmark
..
.
$
```

chdir() and fchdir()

```
#include <unistd.h>

int chdir(const char *pathname);
int fchdir(int filedes);
                                        Both return: 0 if OK, -1 on error
```

- Change the current working directory.
  - Specify the new current working directory either as a pathname or file descriptor.

chdir() and fchdir()

- Example

```
#include "apue.h"

int main(void)
{
        if (chdir("/tmp") < 0)
                err_sys("chdir failed");
        printf("chdir to /tmp succeeded\n");
        exit(0);
}
```

  - $ gcc –o mycd chdir.c

chdir() and fchdir()

- Execution

```
$ pwd
/usr/lib
$ mycd
chdir to /tmp succeeded
$ pwd
/usr/lib
$
```

  - Current working directory of shell didn't change after mycd.
  - Each program is run in a separate process
    - ➔ current working directory of shell is unaffected by *chdir* in mycd.
  - Note that "cd" is a built-in shell command!

getcwd()

```
#include <unistd.h>

char *getcwd(char *buf, size_t size);
                                        Returns: buf if OK, NULL on error
```

- Obtain the current working directory.
  - Copies an absolute pathname of the current working directory to the array pointed to by *buf* of length, *size*.
  - *size* must be large enough to accommodate
    - the absolute pathname + a terminating null byte.

getcwd()

- example

```
#include <stdio.h>
#include <unistd.h>
#define SIZE 200
void my_pwd (void);

int main()
{
	my_pwd();
}

void my_pwd (void) {
	char dirname[SIZE];

	if ( getcwd(dirname, SIZE) == NULL)
		perror("getcwd error");
	else
		printf("%s\n", dirname);
}
```

getcwd()

- Execution

```
$ ./a.out
/home/obama/test
$
```