CS631 - Advanced Programming in the UNIX Environment
–
File Systems, System Data Files, Time & Date

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HW#2 Notes: Avoid useless comments

```
//Check if the argc number is right or not
if ( argc != 3 ){

//a buffer with proper size
char buf[BUFFSIZE];

// open src file for read only mode
if ((fd_src= open (src,O_RDONLY)) == -1) {

int   bytes_read; /* The bytes of read() read from stream*/
int bytes_write;/* The bytes of write() write from stream *
```

HW#2 Notes

Errors go to `stderr`, please! Use `strerror(3)`/`perror(3)`.

```
fname = (char*)malloc(sizeof(char) * (strlen(argv[2]) + strlen(argv[1]) +2));
if(fname == NULL)
{
  printf("malloc failed\n");
  exit(EXIT_FAILURE);
}
```

HW#2 Notes: Check all return codes!

```
stat(argv[1], &arg_1_stat);
if (    1==S_ISDIR(arg_1_stat.st_mode)   )
```

```
dest = (char*)malloc(strlen(argv[2]) * sizeof(char));
strcpy(dest, argv[2]);
```

```
tmp = malloc(target_len-1 + strlen(basename(source)) +1 );
strncpy(tmp, target, target_len-1);
```

HW#2 Notes: Don't overflow your buffers!

Use of `strcat(3)` etc. considered harmful.

```
if(S_ISDIR(statbuf.st_mode))
        argv[2] = strcat(argv[2], basename(argv[1]));

char str[MAX_INPUT];
strcpy(str, argv[2]);

char target[200];
strcpy(target,argv[2]);
```

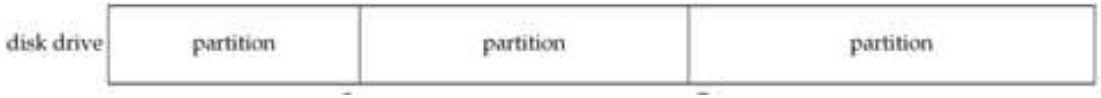
Use `strlcat(3)`/`strlcpy(3)` etc. instead.

File Systems

System Data Files, Time & Date

File Systems

- a disk can be divided into logical *partitions*



File Systems

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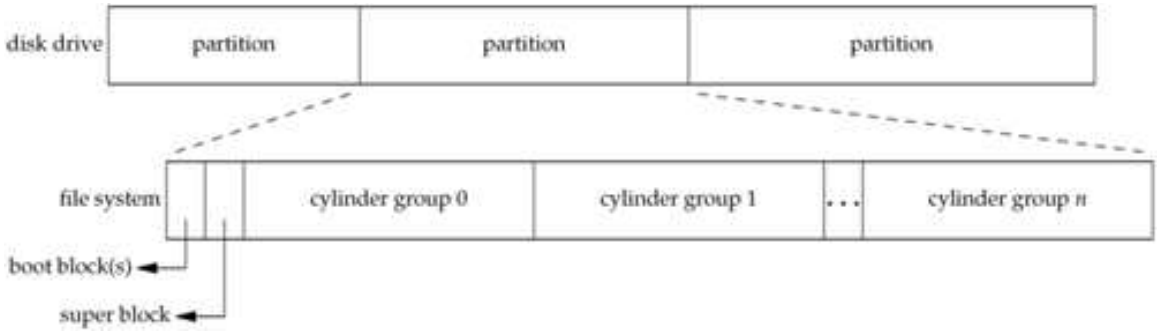

File Systems

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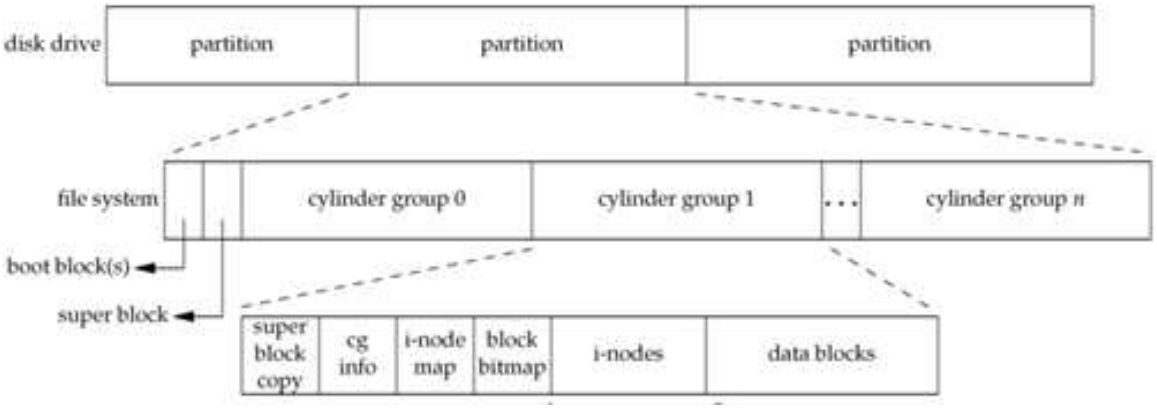

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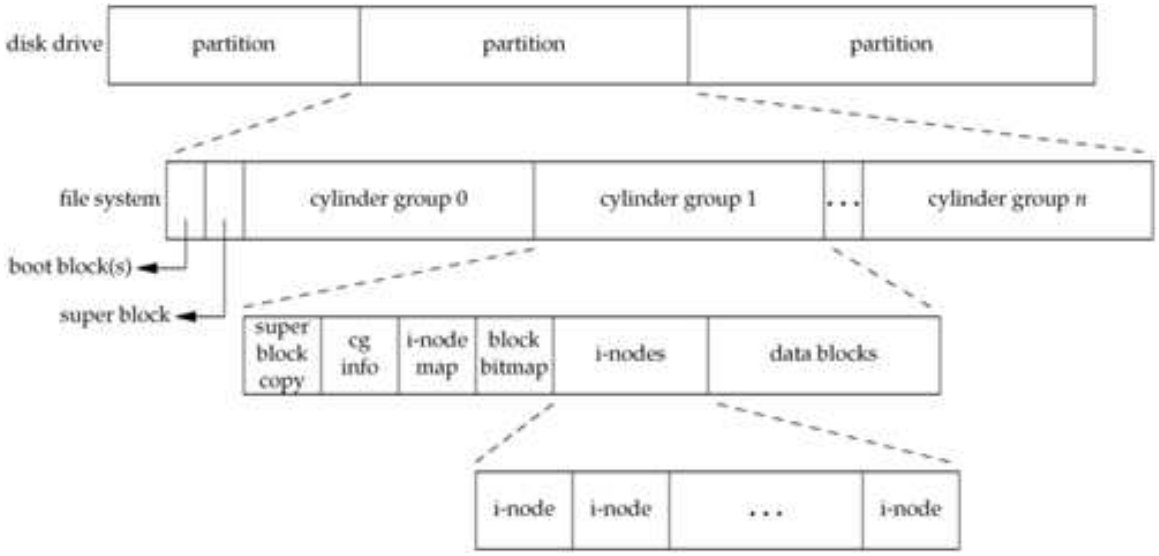

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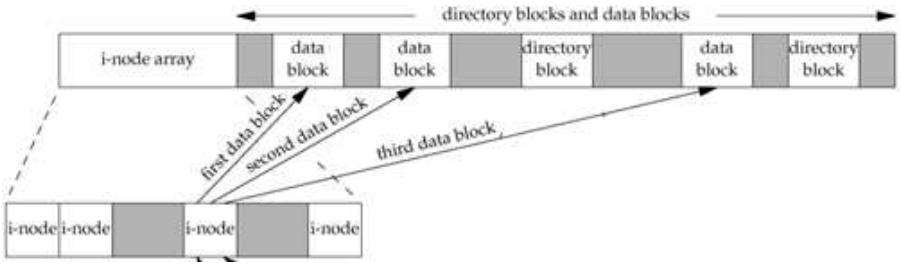

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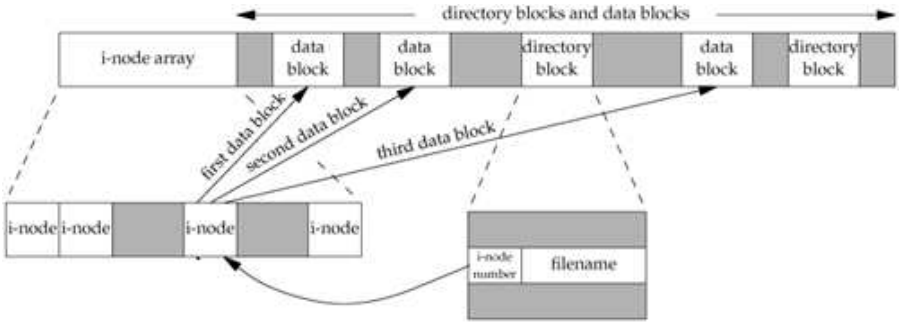

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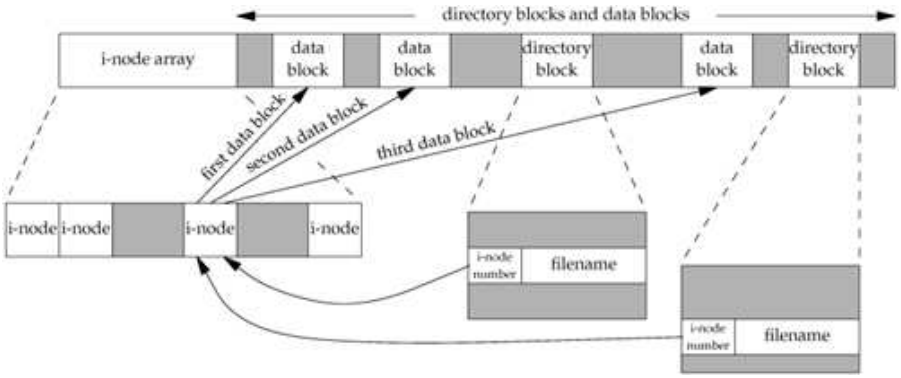
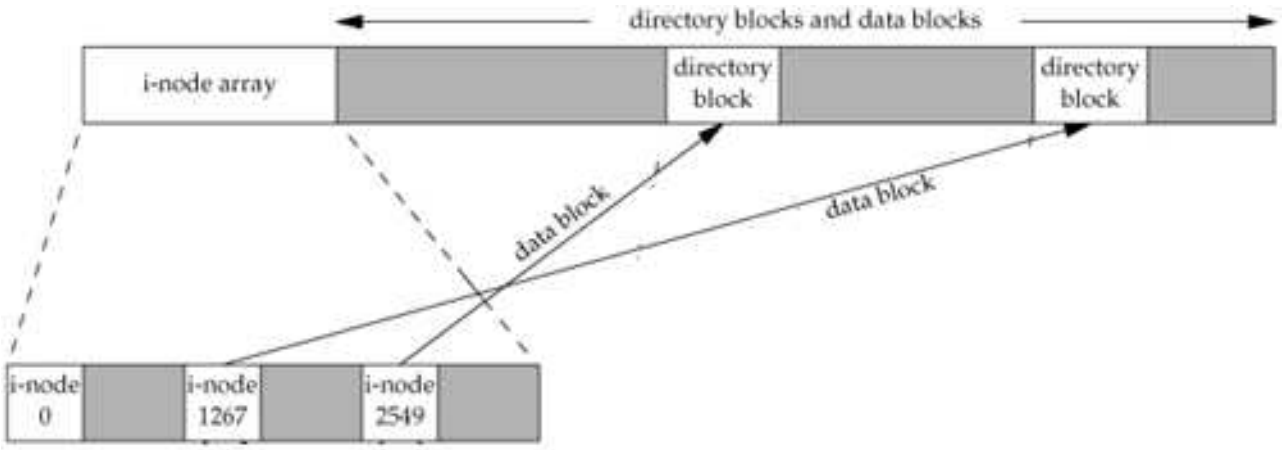
- you can have many such mappings to the same file



Directories

- directories are special ”files” containing hardlinks



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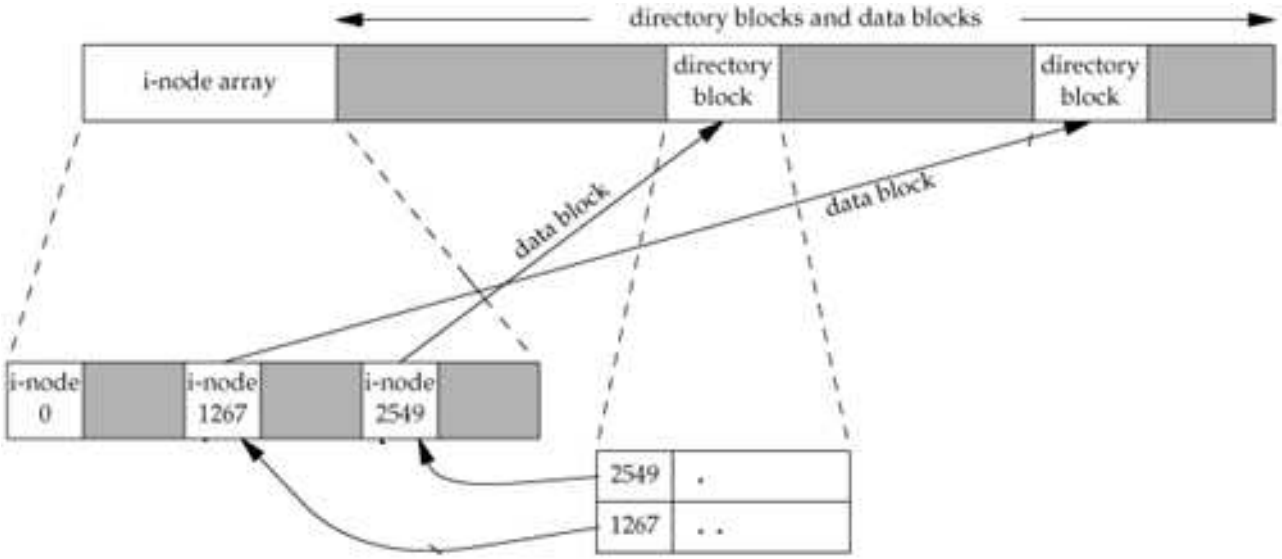
- each directory contains at least two entries:
  - . (*this* directory)
  - . . (the parent directory)



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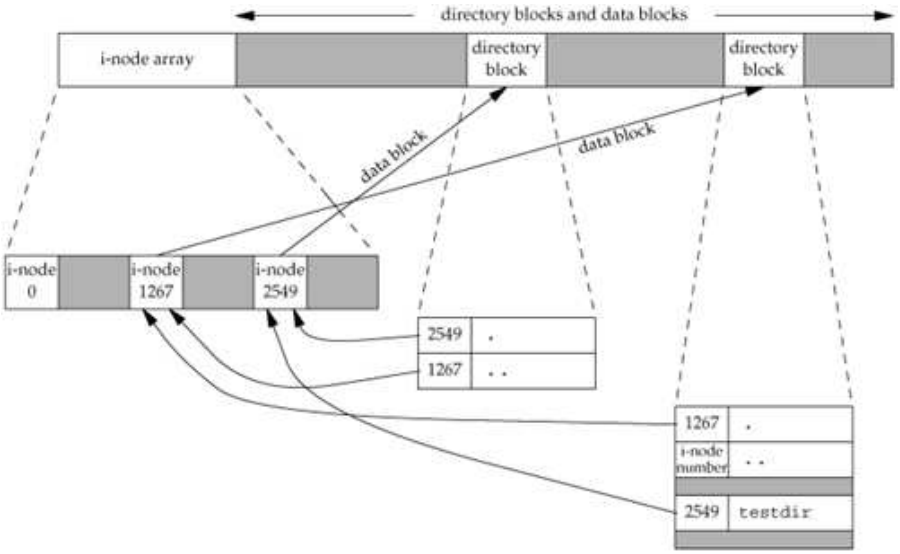
- the link count (`st_nlink`) of a directory is at least 2



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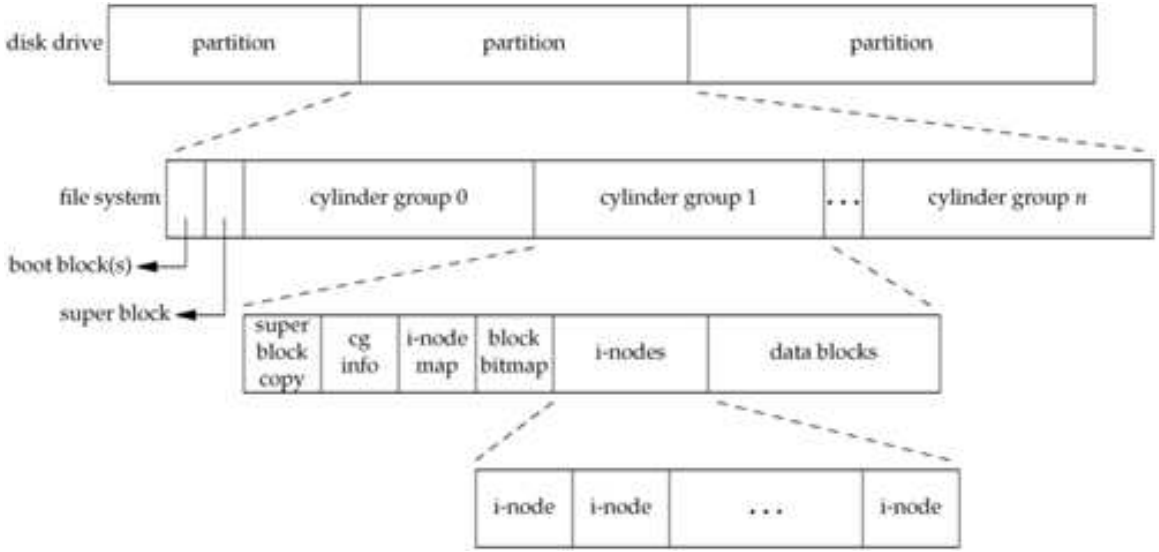

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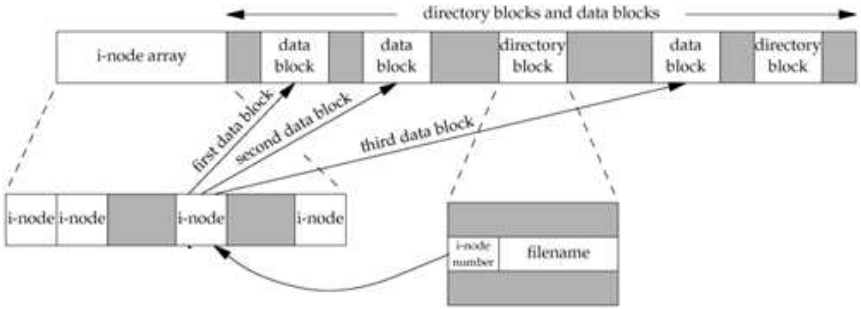

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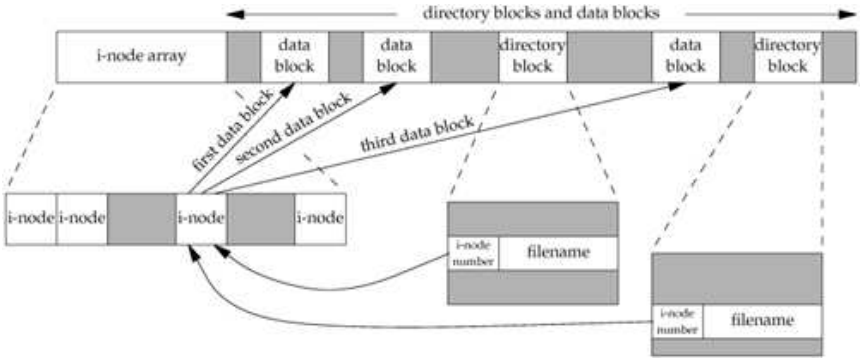

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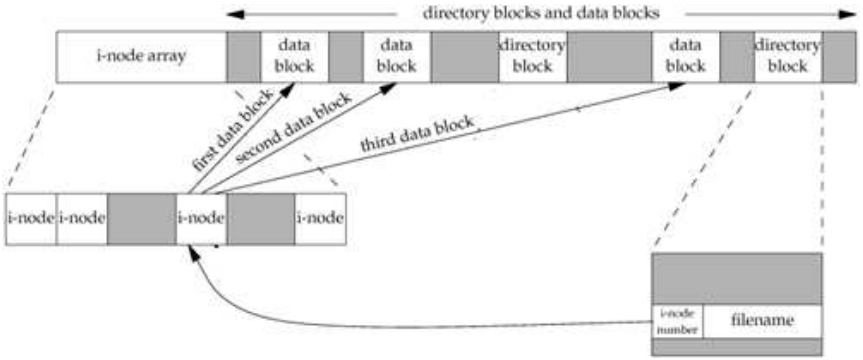

link(2)

```
#include <unistd.h>

int link(const char *name1, const char *name2);
```

Returns: 0 if OK, -1 on error

- Creates a link to an existing file (hard link).
- POSIX.1 allows links to cross filesystems, most implementations (SVR4, BSD) don't.
- only uid(0) can create links to directories (loops in filesystem are bad)

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```
#include <unistd.h>

int unlink(const char *path);
```

Returns: 0 if OK, -1 on error

- removes directory entry and decrements link count of file
- if file link count == 0, free data blocks associated with file (...unless processes have the file open)

link(2) and unlink(2)

```
$ cc -Wall wait-unlink.c
$ ./a.out
$ df .
```

rename(2)

```
#include <stdio.h>

int rename(const char *from, const char *to);
```

Returns: 0 if OK, -1 on error

If *oldname* refers to a file:

- if *newname* exists and it is not a directory, it's removed and *oldname* is renamed *newname*

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If *oldname* refers to a directory:

- if *newname* exists and is an empty directory (contains only . and ..), it is removed; *oldname* is renamed *newname*

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Symbolic Links

```
#include <unistd.h>

int symlink(const char *name1, const char *name2);
```

Returns: 0 if OK, -1 on error

- file whose ”data” is a path to another file
- anyone can create symlinks to directories or files
- certain functions dereference the link, others operate on the link

How do we get the contents of a symlink? `open(2)` and `read(2)`?

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```
#include <unistd.h>

int readlink(const char *path, char *buf, size_t bufsize);
```

Returns: number of bytes placed into buffer if OK, -1 on error

This function combines the actions of `open`, `read`, and `close`.
Note: *buf* is **not** NUL terminated.

File Times

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

int utimes(const char *path, const struct timeval times[2]);
int lutimes(const char *path, const struct timeval times[2]);
int futimes(int fd, const struct timeval times[2]);
```

Returns: 0 if OK, -1 on error

If *times* is NULL, access time and modification time are set to the current time (must be owner of file or have write permission). If *times* is non-NULL, then times are set according to the `timeval struct` array. For this, you must be the owner of the file (write permission not enough).

Note that `st_ctime` is set to the current time in both cases.

For the effect of various functions on the access, modification and changes-status times see Stevens, p. 117.

Note: some systems implement `lutimes(3)` (library call) via `utimes(2)` syscalls.

mkdir(2) and rmdir(2)

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

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

Returns: 0 if OK, -1 on error

Creates a new, empty (except for . and .. entries) directory. Access permissions specified by *mode* and restricted by the umask(2) of the calling process.

```
#include <unistd.h>

int rmdir(const char *path);
```

Returns: 0 if OK, -1 on error

If the link count is 0 (after this call), and no other process has the directory open, directory is removed. Directory must be empty (only . and .. remaining)

Reading Directories

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

DIR *opendir(const char *filename);
                                    Returns: pointer if OK, NULL on error

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

void rewinddir(DIR *dp);
int closedir(DIR *dp);
                                                Returns: 0 if OK, -1 on error
```

- read by anyone with read permission on the directory
- format of directory is implementation dependent (always use readdir and friends)

`opendir`, `readdir` and `closedir` should be familiar from our small `ls` clone. `rewinddir` resets an open directory to the beginning so readdir will again return the first entry.

For directory traversal, consider `fts(3)` (not available on all UNIX versions).

Moving around directories

```
#include <unistd.h>

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

Returns: *buf* if OK, `NULL` on error

Get the kernel's idea of our process's current working directory.

```
#include <unistd.h>

int chdir(const char *path);
int fchdir(int fd);
```

Returns: 0 if OK, -1 on error

Allows a process to change its current working directory. Note that `chdir` and `fchdir` affect only the current process.

```
$ cc -Wall cd.c
$ ./a.out /tmp
```

Password File

Called a *user database* by POSIX and usually found in `/etc/passwd`, the password file contains the following fields:

Description	`struct passwd` member	POSIX.1
username	`char *pw_name`	x
encrypted passwd	`char *pw_passwd`	
numerical user id	`uid_t pw_uid`	x
numerical group id	`gid_t pw_gid`	x
comment field	`char *pw_gecos`	
initial working directory	`char *pw_dir`	x
initial shell	`char *pw_shell`	x

Encrypted password field is a one-way hash of the users password.
Some fields can be empty:

- password empty implies **no password**
- shell empty implies `/bin/sh`

Password File

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

struct passwd *getpwuid(uid_t uid);
struct passwd *getpwnam(const char *name);
```

Returns: pointer if OK, NULL on error

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

struct passwd *getpwent(void);
```

Returns: pointer if OK, NULL on error

```
void setpwent(void);
void endpwent(void);
```

- `getpwent` returns next password entry in file each time it's called, no order
- `setpwent` rewinds to "beginning" of entries
- `endpwent` closes the file(s)

See also: `getspnam(3)/getspent(3)` (where available)

Group File

Called a *group database* by POSIX and usually found in `/etc/group`, the group file contains the following fields:

Description	`struct group` member	POSIX.1
groupname	`char *gr_name`	x
encrypted passwd	`char *gr_passwd`	
numerical group id	`uid_t gr_uid`	x
array of pointers to user names	`char **gr_mem`	x

The `gr_mem` array is terminated by a NULL pointer.

Group File

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

struct group *getgrgid(gid_t gid);
struct group *getgrnam(const char *name);
```

Returns: pointer if OK, NULL on error

These allow us to look up an entry given a user's group name or numerical GID. What if we need to go through the group file entry by entry? Nothing in POSIX.1, but SVR4 and BSD give us:

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

struct group *getgrent(void);
```

Returns: pointer if OK, NULL on error

```
void setgrent(void);
void endgrent(void);
```

- `getgrent` returns next group entry in file each time it's called, no order
- `setgrent` rewinds to "beginning" of entries
- `endgrent` closes the file(s)

Supplementary Groups and other data files

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

int getgroups(int gidsetsize, gid_t *grouplist);
```

Returns: returns number of suppl. groups if OK, -1 on error

Note: if `gidsetsize == 0`, getgroups(2) returns number of groups without modifying `grouplist`.

Other system databases

Similar routines as for password/group for accessing system data files:

Description	Data file	Header	Structure	Additional lookup functions
hosts	`/etc/hosts`	`<netbdb.h>`	`hostent`	`gethostbyname`
				`gethostbyaddr`
networks	`/etc/networks`	`<netbdb.h>`	`netent`	`genetbyname`
				`getnetbyaddr`
protocols	`/etc/protocols`	`<netbdb.h>`	`protoent`	`getprotobyname`
				`getprotobynumber`
services	`/etc/services`	`<netbdb.h>`	`servent`	`getservbyname`
				`getservbyport`

System Identification

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

int uname(struct utsname *name);
                Returns:  nonnegative value if OK, -1 on error
```

- Pass a pointer to a `utsname struct`. This struct contains fields like opsys name, version, release, architecture, etc.
- This function used by the `uname(1)` command (try uname -a)
- Not that the size of the fields in the `utsname struct` may not be large enough to id a host on a network

To get just a hostname that will identify you on a TCP/IP network, use the Berkeley-dervied:

```
#include <unistd.h>

int gethostname(char *name, int namelen);
                                Returns:  0 if OK, -1 on error
```

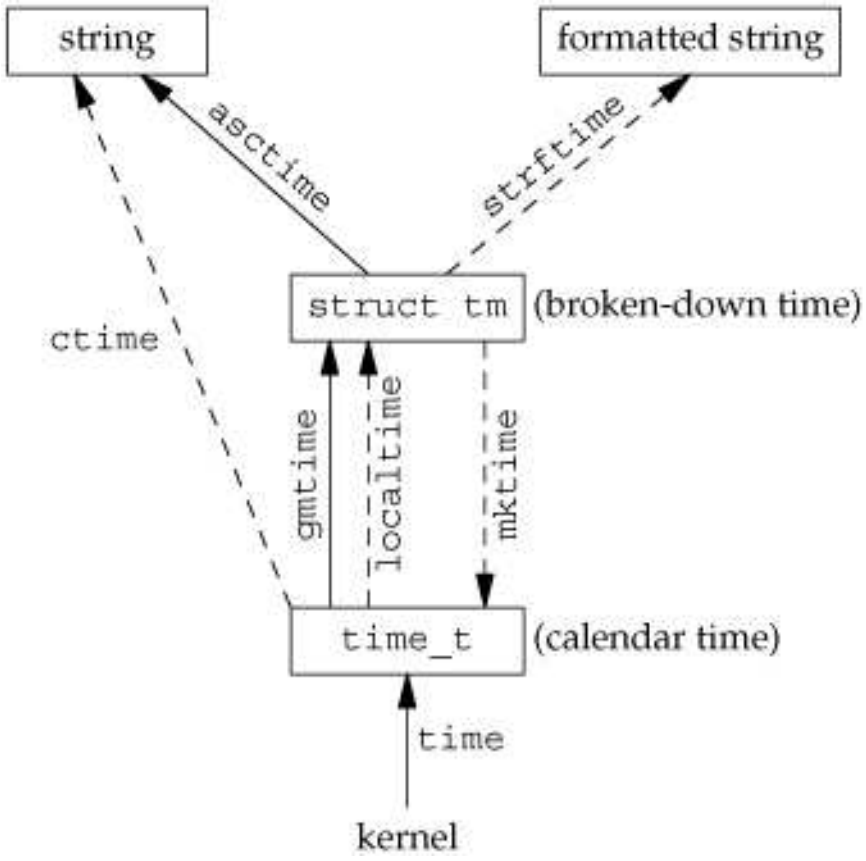
Time and Date

```
#include <time.h>

time_t time(time_t *tloc);
                        Returns:  value of time if OK, -1 on error
```

- Time is kept in UTC
- Time conversions (timezone, daylight savings time) handled ”automatically”
- Time and date kept in a single quantity (`time_t`)

Time and Date



Time and Date

We can break this `time_t` value into its components with either of the following:

```
#include <time.h>

struct tm *gmtime(const time_t *calptr);
struct tm *localtime(const time_t *calptr);
                        Returns:  pointer to broken down time
```

`localtime(3)` takes into account daylight savings time and the *TZ* environment variable.

```
#include <time.h>

time_t mktime(struct tm *tmptr);
                        Returns:  calendar time if OK, -1 on error
```

The `mktime(3)` function operates in the reverse direction.

Time and Date

To output human readable results, use:

```
#include <time.h>

char *asctime(const struct tm *tmptr);
char *ctime(const struct tm *tmptr);
                        Returns:  pointer to NULL terminated string
```

Lastly, there is a `printf(3)` like function for times:

```
#include <time.h>

size_t strftime(char *buf, size_t maxsize, const char *restricted format, const struct tm *timeptr);
                                    Returns:  number of characters stored in array if room, else 0
```

Homework

Reading:

- Stevens, Chapter 4 and 6
- Falsehoods Programmers believe about time: `http://is.gd/yFSYR0`

Other:

- work on your midterm project!