Topics: Internal Structure of Files, Directories, File Systems

Approach: Work from user view to system view, write pwd

Featured Commands:
mkdir, rmdir, rm, ln, mv, pwd

Main Ideas:
Users see a file system as a tree of directories, files, and info
A file system is a sequence of disk blocks
A file is a struct of info (an inode) and a list of data blocks
A directory is a list of inode numbers and names

Agenda

Intro
  What does it mean to be in a directory? Write pwd.

One tree - multiple disks
  How do several disks appear as a single tree of directories?

errno and perror() and strerror()
  system calls return -1 on error; what's the problem?

User View of File System
  directory tree, files, info, moving around, moving files
  mkdir abuse (don't try this at home)

Face Reality
  A disk is a stack of platters, tracks, sectors, just blocks

The Unix File System
  Three (well, four) parts

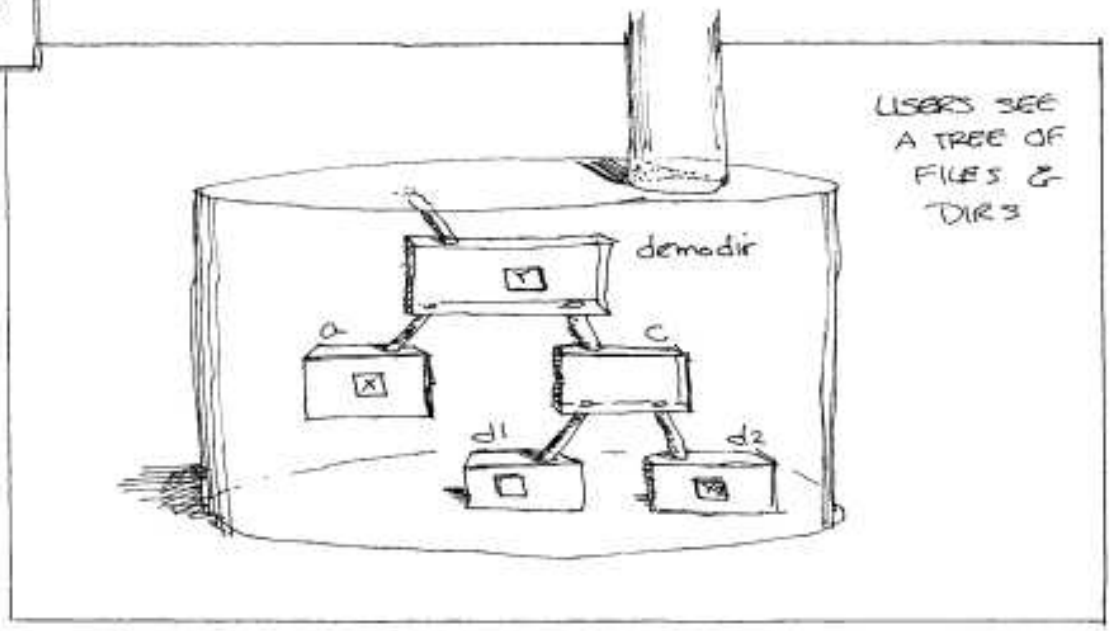
Inodes and Device ID
  Identifying each item in a tree

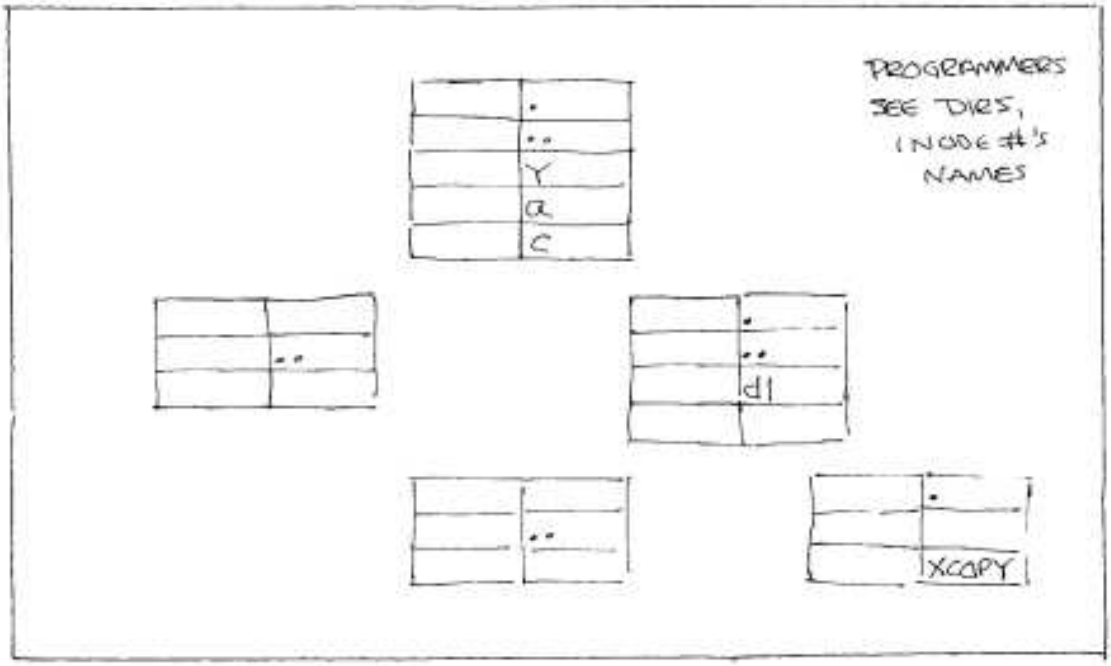
Looking at Operations in terms of a Unix File System
  Creating a file
  Building a Tree
  File operations: rm, ln, mv, mkdir, rmdir

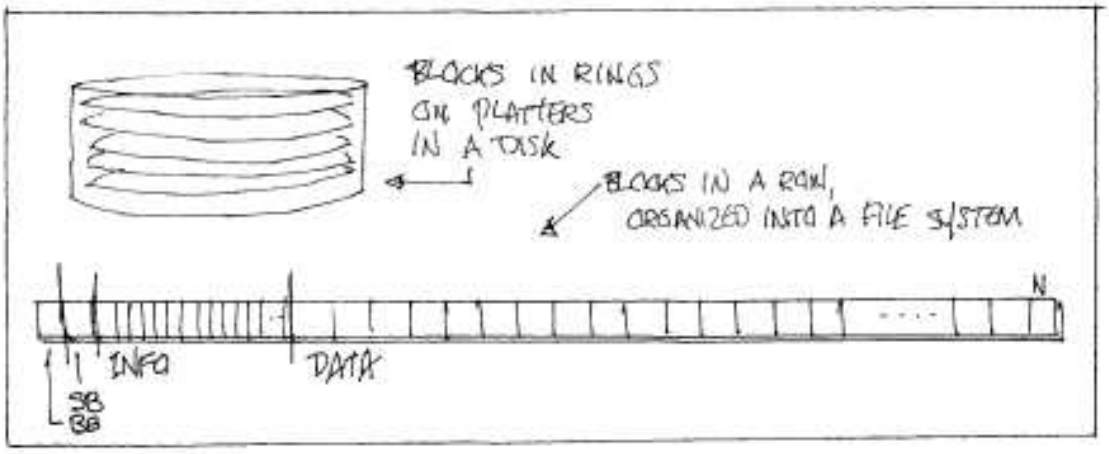
Writing pwd
  inodes and names

[Symbolic Links -- if time
  Definition, Examples, Directories, cross-system]

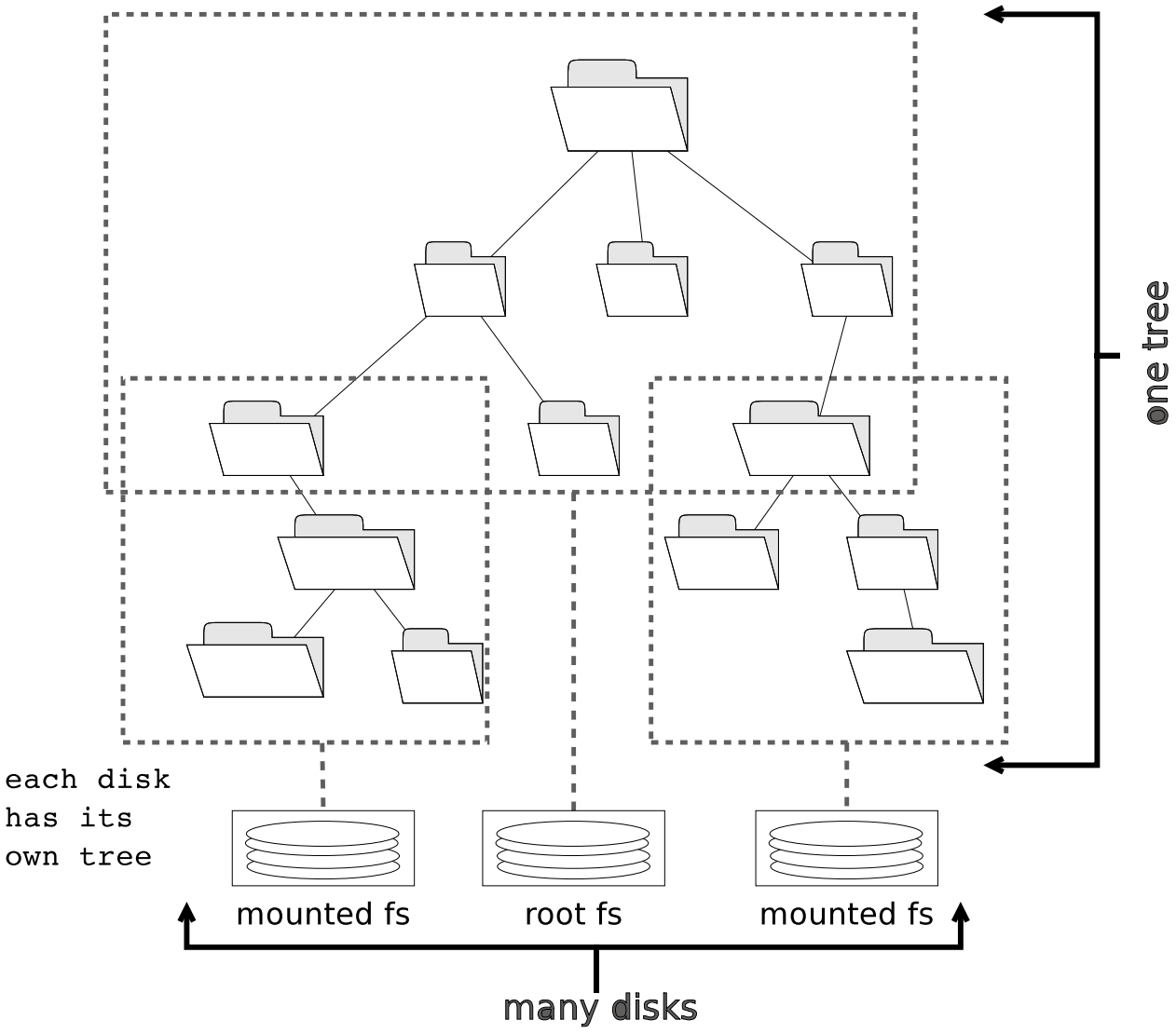
CSCI-E28
CLASS 4







A Unix Directory Tree Can Consist of Several Disks



Notes:

- Each disk can be a regular hard disk, a USB flash drive, a camera memory card, ... any *block device*
- The 'root directory' of each mounted file system obscures the directory on which it is *mounted*
- The disks can be connected directly to the computer or may be connected over a network. An **nfs** disk is attached using a *network file system* connection.

```
:::::::::::::: perror_demo.c ::::::::::::::
#include       <stdio.h>
#include       <errno.h>
#include       <string.h>
#include       <fcntl.h>

/* program   perror_demo.c
 * purpose   show how errno is set by syscalls
 *           and how perror prints the associated message
 *   usage   perror_demo
 *   action  tries to open() a file for a given mode
 *           then, if error, prints errno and message
 */

int main()
{
        char    name[100];                  /* filename            */
        int     mode;                       /* second arg to open  */
        int     rv = 0;                     /* program status reprt */

        printf("Open what file or dir? ");
        fgets(name, 100, stdin);
        name[strlen(name)-1] = '\0';
        printf("   Open %s for 0,1, or 2? ", name);
        scanf("%d", &mode);
        if ( open( name, mode ) == -1 ){
                printf("Oh No!, errno %d just occurred\n", errno);
                perror( name );                      /* print message      */
                rv = 1;
        }
        else
                printf("%s opened ok\n", name );

        return rv;
}
:::::::::::::: dig ::::::::::::::
#!/bin/sh
#
# script   dig
# purpose  show how to dig deep holes in a file system
# method   mkdir s; cd s; repeat  (like on shampoo bottles)
# warning  good way to annoy system managers

        while true
        do
                mkdir s
                cd s
        done

:::::::::::::: rm1.c ::::::::::::::
#include       <stdio.h>
#include       <unistd.h>

/* example of using unlink to 'delete' a file */

int main(int ac, char *av[])
{
        int     rv = 0;
        while(--ac){
                if ( unlink( *++av ) == -1 ){
                        perror(*av);
                        rv = 1;
                }
                else
                        printf("%s is gone\n", *av);
        }
        return rv;
}
```

```
:::::::::::::: rm2.c ::::::::::::::
#include       <stdio.h>
#include       <unistd.h>
/*
 * rm2 - interactive version of rm using unlink(2)
 */

int main()
{
        char    name[100];
        char    confirm[100];
        int     rv = 0;               /* return value from main */

        while ( printf("delete what file? "), fgets(name,100,stdin) ){
                printf("about to unlink %s, ok? ", name );
                fgets(confirm,100,stdin);
                if ( *confirm == 'y' ){
                        if( unlink(name) == -1 ){
                                perror(name);
                                rv = 1;
                        }
                        else
                                printf("%s is gone\n", name);
                }
        }
        return rv;
}

:::::::::::::: mv1.c ::::::::::::::
#include       <stdio.h>
#include       <errno.h>
#include       <stdlib.h>
#include       <unistd.h>

/*
 * program  mv1.c
 * purpose  show how to use link and unlink to rename a file
 * notes    checks errno to make it more adaptable
 * note     This version could be replaced by rename() but it
 *          works differently when the target exists
 */

int main(int ac, char *av[])
{

        if ( link( av[1], av[2]) != -1 )
                unlink( av[1] );

        else if ( errno == EEXIST )           /* name2 already in use */
        {
                if (unlink( av[2] ) == -1 )   /* not any more               */
                {
                        perror(av[2]);
                        exit(1);
                }
                return main(ac,av);           /* and try again      */
        }
        return 0;
}
```

```
:::::::::::::: mv2.c ::::::::::::::
#include       <stdio.h>
#include       <limits.h>
#include       <unistd.h>
#include       <stdlib.h>
#include       <string.h>

/**
 **     mv28 version 1
 **
 **             if last arg is a dir, then move all files into there
 **             if two args and last is a file, then move first to
 **             second.  will clobber second if exists.
 **             Uses isadir .
 **
 **             problems: 1) what if an arg is a dir?
 **                       2) what about paths in source files?
 **/

void mv(char *,char *);
void mv_to_newdir(int, char **, char *);
int  isadir(char *);

int main( int ac, char *av[] )
{
        if ( ac < 3 ){
                fprintf( stderr, "too few args\n");
                exit(1);
        }

        /*
         *      if last arg is a dir, then move args to there
         */
        if ( isadir( av[ac-1] ) )
                mv_to_newdir(ac-1,av,av[ac-1]);

        /*
         *      last arg is not a dir, so must be two args only
         */
        else if ( ac != 3 ){
                fprintf( stderr, "too many args\n");
                exit(1);
        }
        else mv(av[1], av[2]);
        return 0;
}

void mv_to_newdir( int ac, char *av[], char *newdir )
/*
 *      move av[1], av[2], ... av[ac-1] into newdir
 */
{
        char    newpath[PATH_MAX];
        int     pos ;

        for( pos = 1 ; pos<ac; pos++ ){
                if ( strlen(newdir)+strlen(av[pos])+2 <= PATH_MAX )
                {
                        sprintf( newpath , "%s/%s", newdir, av[pos]);
                        mv( av[pos] , newpath );
                }
        }
}

void mv( char *oldname, char *newname )
{
        if ( link(oldname, newname) == -1 || unlink(oldname) == -1 ){
                fprintf(stderr,"error mv'ing %s to %s\n", oldname, newname);
                exit(1);
        }
}
```

```
:::::::::::::: pwd28.c ::::::::::::::
#include       <stdio.h>
#include       <sys/types.h>
#include       <sys/stat.h>
#include       <dirent.h>
#include       <unistd.h>
#include       <stdlib.h>
#include       <string.h>

/**
 **     a simplified version of pwd
 **
 **     Starts in current directory and recursively
 **        climbs up to root of filesystem, prints top part
 **        then prints current part
 **     Uses readdir() to get info about each thing
 **/

void    get_info(char*, dev_t *, ino_t *);
void    printpathto(dev_t, ino_t);
void    inum_to_name(dev_t , ino_t , char *);

int main()
{
        ino_t   myinode ;
        dev_t   mydev   ;

        get_info(".", &mydev, &myinode);
        printpathto( mydev, myinode );              /* print path to here  */
        putchar('\n');                        /* then add newline    */
        return 0;
}

void printpathto( dev_t this_dev, ino_t this_inode )
/*
 *      prints path leading down to an object with this dev,inode
 */
{
        ino_t   myinode , par_inode;
        dev_t   mydev,    par_dev;
        char    its_name[BUFSIZ];

        chdir( ".." );                                /* up one dir  */

        inum_to_name(this_dev,this_inode,its_name ); /* get its name        */

        get_info(".",&mydev,&myinode);                        /* print head  */
        get_info("..",&par_dev,&par_inode);
        if ( myinode != par_inode || mydev != par_dev )
                printpathto( mydev, myinode );                /* recursively */
        printf("/%s", its_name );                     /* now print   */
                                                      /* name of this        */
}

/*
 * gets inode and dev for the specified path, uses lstat
 */
void get_info(char *path, dev_t *dp, ino_t *inp)
{
        struct stat info;

        if ( lstat(path, &info) == -1 ){
                perror(path);
                exit(2);
        }
        *inp = info.st_ino;
        *dp  = info.st_dev;
}
```

```
void inum_to_name(dev_t dev_to_find, ino_t inode_to_find , char *namebuf)
/*
 *      looks through current directory for a file with this inode
 *      number and copies its name into namebuf
 */
{
        DIR             *dir_ptr;               /* the directory */
        struct dirent   *direntp;               /* each entry   */
        ino_t           cur_inum;
        dev_t           cur_dev;

        dir_ptr = opendir( "." );
        if ( dir_ptr == NULL ){
                fprintf(stderr, "cannot open a directory\n");
                exit(1);
        }
        /*
         * search directory for a file with specified inum and device
         */
        while ( ( direntp = readdir( dir_ptr ) ) != NULL ){
                get_info(direntp->d_name, &cur_dev, &cur_inum);
                if ( cur_inum == inode_to_find && cur_dev == dev_to_find )
                {
                        strcpy( namebuf, direntp->d_name );
                        closedir( dir_ptr );
                        return ;
                }
        }
        fprintf(stderr, "error looking for inum %d\n", (int) inode_to_find);
        exit(1);
}
```