Topics: Files, System Files, the Manual, Buffering

Approach: Write our own versions of Unix programs

Featured Commands:

who
cp
tail

Main Ideas:

i/o redirection, pipes
standard directories/files
the manual tells all
open, read, write, close
unix time
'expensive' operations
buffered input/output

Applications:

who0 : writing a system utility
  the manual, the header files

who1 : reading and displaying data
  the utmp file
  open(), read()

who2 : displaying dates and times
  localtime(), strftime()

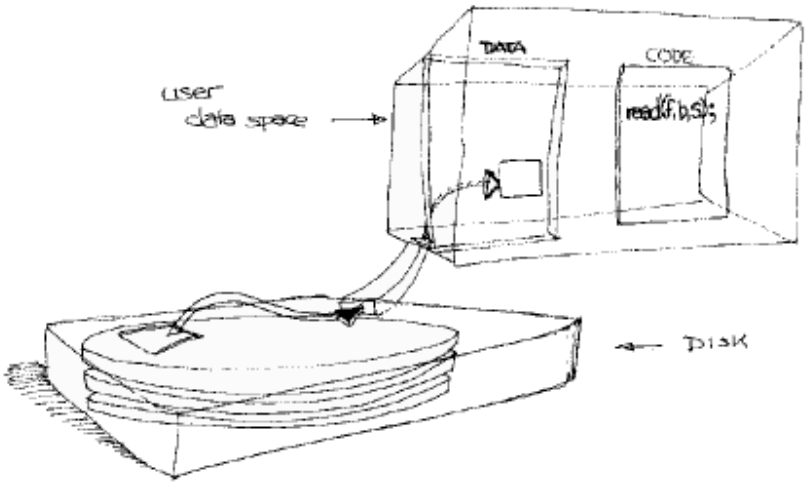
cp : writing data, creating files
  creat(), open()
  write()
  effect of buffer size:
    efficiency, system calls, buffering

who3 : making who more efficient
  more buffering

kernel buffering
  speedier disk access

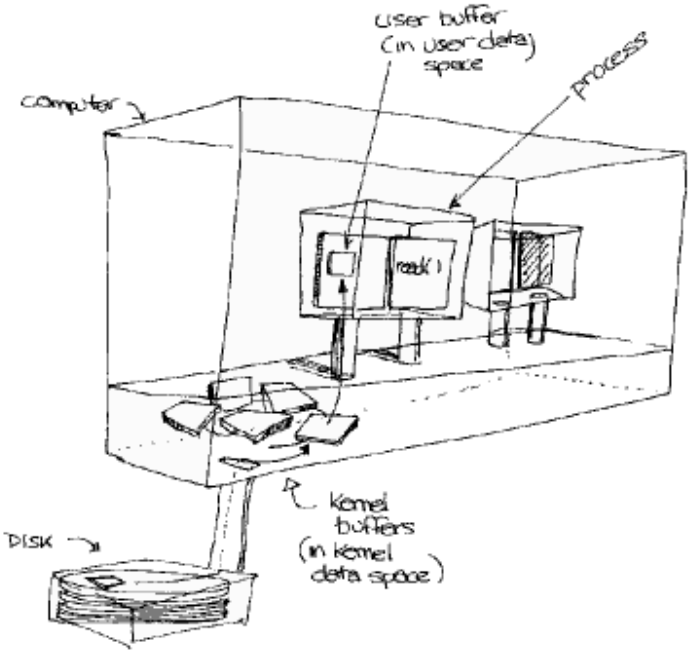
tail
  lseek()
  what it does
  how it does it

What read() appears to do



1. A process calls read()
2. The kernel copies a number of bytes from a file into an array in the calling process.

What <u>really</u> happens when you read from the disk



1. Your process places a read() request to the kernel.
2. The kernel checks its pool of buffers to see if the data you want are in a buffer in memory.
3. If not, the kernel arranges to copy the data from the device to a buffer.
4. When the information arrives the kernel copies data from the buffer in kernel memory to the array in the the process.

```
:::::::::::::: who0.c ::::::::::::::
#include        <stdio.h>
#include        <fcntl.h>
#include        <utmp.h>
#include        <stdlib.h>
#include       <unistd.h>
/*
 *      who version 0
 *              main outline but no substance
 */
main()
{
        int     fd;                     /* for file des of utmp */
        struct utmp current_record;     /* hold info from file */
        int     reclen = sizeof(struct utmp);

        fd = open( UTMP_FILE, O_RDONLY );
        if ( fd == -1 )
        {
                perror( "who0" );
                exit(1);
        }

        while ( read ( fd , &current_record , reclen ) == reclen )
                show_info( &current_record );

        close ( fd );
}
:::::::::::::: who1.c ::::::::::::::
#include        <stdio.h>
#include        <sys/types.h>
#include        <utmp.h>
#include        <fcntl.h>
#include        <stdlib.h>
#include        <unistd.h>

/*
 *      who version 1           - read /var/run/utmp and list info therein
 */

#define INFOFILE        UTMP_FILE

void show_info( struct utmp *utbufp );

int main(int ac, char **av)
{
        struct utmp     utbuf;          /* read info into here */
        int             utmpfd;         /* read from this descriptor */

        if ( (utmpfd = open( INFOFILE, O_RDONLY )) == -1 ){
                fprintf(stderr,"%s: cannot open %s\n", *av, INFOFILE);
                exit(1);
        }

        while ( read( utmpfd, &utbuf, sizeof(utbuf) ) == sizeof(utbuf) )
                show_info( &utbuf );
        close( utmpfd );
        return 0;                       /* went ok                      */
}
/*
 *      show info()
 *                      displays the contents of the utmp struct
 *                      in human readable form
 *                      *note* these sizes should not be hardwired
 */
void show_info( struct utmp *utbufp )
{
        // printf("%-8.8s", utbufp->ut_name);           /* the logname  */
        printf("%s", utbufp->ut_name);                  /* the logname  */
        printf(" ");                                    /* a space      */
        printf("%-8.8s", utbufp->ut_line);              /* the tty      */
        printf(" ");                                    /* a space      */
        printf("%10ld", (long) utbufp->ut_time);        /* login time   */
        printf(" ");                                    /* a space      */
        printf("(%.256s)", utbufp->ut_host);            /* the host     */
        printf("\n");                                   /* newline      */
}
```

```
:::::::::::::: who2.c ::::::::::::::
#include        <stdio.h>
#include        <unistd.h>
#include        <sys/types.h>
#include        <utmp.h>
#include        <fcntl.h>
#include        <time.h>
#include        <stdlib.h>
/*
 *      who version 2           - read /var/run/utmp and list info therein
 *                              - surpresses empty records
 *                              - formats time nicely
 */

/* UTMP_FILE is a symbol defined in utmp.h */
/* note: compile with -DTEXTDATE for dates format: Feb  5, 1978         */
/*       otherwise, program defaults to NUMDATE (1978-02-05)            */

#define TEXTDATE
#ifndef DATE_FMT
#ifdef  TEXTDATE
#define DATE_FMT        "%b %e %H:%M"           /* text format  */
#else
#define DATE_FMT        "%Y-%m-%d %H:%M"        /* the default  */
#endif
#endif

int main(int ac, char *av[])
{
        struct utmp     utbuf;          /* read info into here */
        int             utmpfd;         /* read from this descriptor */
        void            show_info(struct utmp *);

        if ( (utmpfd = open( UTMP_FILE, O_RDONLY )) == -1 ){
                fprintf(stderr,"%s: cannot open %s\n", *av, UTMP_FILE);
                exit(1);
        }

        while ( read( utmpfd, &utbuf, sizeof(utbuf) ) == sizeof(utbuf) )
                show_info( &utbuf );
        close( utmpfd );
        return 0;
}
/*
 *      show info()
 *                      displays the contents of the utmp struct
 *                      in human readable form
 *                      * displays nothing if record has no user name
 */
void show_info( struct utmp *utbufp )
{
        void showtime(time_t, char *);

        if ( utbufp->ut_type != USER_PROCESS )
                return;

        printf("%-8s", utbufp->ut_name);               /* the logname  */
        printf(" ");                                   /* a space      */
        printf("%-12.12s", utbufp->ut_line);           /* the tty      */
        printf(" ");                                   /* a space      */
        showtime( utbufp->ut_time , DATE_FMT);         /* display time */
        if ( utbufp->ut_host[0] != '\0' )
                printf(" (%.256s)", utbufp->ut_host);  /* the host     */
        printf("\n");                                  /* newline      */
}

#define MAXDATELEN      100

void showtime( time_t timeval , char *fmt )
/*
 * displays time in a format fit for human consumption.
 * Uses localtime to convert the timeval into a struct of elements
 * (see localtime(3)) and uses strftime to format the data
 */
{
        char    result[MAXDATELEN];

        struct tm *tp = localtime(&timeval);           /* convert time */
        strftime(result, MAXDATELEN, fmt, tp);         /* format it    */
        fputs(result, stdout);
}
```

```
:::::::::::::: Makefile ::::::::::::::
#
# makefile for lecture 2
#

CC     = cc
CFLAGS = -Wall -Wextra -g

who1: who1.c
        $(CC) $(CFLAGS) -o who1 who1.c

who2: who2.c
        $(CC) $(CFLAGS) -o who2 who2.c

who3: who3.o utmplib.o
        $(CC) $(CFLAGS) -o who3 who3.o utmplib.o

llcopy: llcopy.c
        $(CC) $(CFLAGS) llcopy.c -o llcopy

utmplib.o: utmplib.c
        $(CC) $(CFLAGS) -c utmplib.c

who3.o: who3.c
        $(CC) $(CFLAGS) -c who3.c

clean:
        rm -f who1 who2 who3 llcopy utmplib.o
#
# tests if llcopy works like cp
#
copytest: llcopy
        last -20 > data
        llcopy data data.copy
        if diff data data.copy ; then echo success ; else echo error ; fi
```

```
:::::::::::::: llcopy.c ::::::::::::::
#include        <stdio.h>
#include        <unistd.h>
#include        <fcntl.h>
#include        <stdlib.h>

/**
 **     low level copy
 **                     uses read and write with tunable buffer size
 **
 **     usage: llcopy src dest
 **/

#define BUFFERSIZE      4096
#define COPYMODE        0644

void fatal( char *, char *);

int main( int ac, char *av[] )
{
        int     in_fd, out_fd, n_chars;
        char    buf[BUFFERSIZE];
                                                /*
                                                 *      check args
                                                 */
        if ( ac != 3 ){
                fprintf( stderr, "usage: %s source destination\n", *av);
                exit(1);
        }
                                                /*
                                                 *      open files
                                                 */
        if ( ( in_fd=open(av[1], O_RDONLY) ) == -1 )
                fatal("Cannot open ", av[1]);

        if ( ( out_fd=creat( av[2], COPYMODE ) ) == -1 )
                fatal( "Cannot creat", av[2]);
                                                /*
                                                 *      copy files
                                                 */
        while ( (n_chars = read( in_fd , buf, BUFFERSIZE )) > 0 )
                if ( write( out_fd, buf, n_chars ) != n_chars )
                        fatal("Write error to ", av[2]);
                                                /*
                                                 *      close them up
                                                 */
        if ( n_chars == -1 ){
                perror(av[1]);
                fatal("error reading input","");
        }
        if ( close(in_fd) == -1 )
                fatal("Error closing input file:", av[1]);
        if ( close(out_fd) == -1 )
                fatal("Error closing output file:", av[2]);
        return 0;
}

void
fatal(char *s1, char *s2)
{
        fprintf(stderr,"Error: %s%s\n", s1, s2);
        exit(1);
}
```

```
:::::::::::::: who3.c ::::::::::::::
#include        <stdio.h>
#include        <unistd.h>
#include        <sys/types.h>
#include        <utmp.h>
#include        <fcntl.h>
#include        <time.h>
#include        <stdlib.h>
#include        "utmplib.h"     /* include interface def for utmplib.c  */

/*
 *      who version 3.0         - read /var/run/utmp and list info therein
 *                              - surpresses empty records
 *                              - formats time nicely
 *                              - buffers input (using utmplib)
 */

#define TEXTDATE
#ifndef DATE_FMT
#ifdef  TEXTDATE
#define DATE_FMT        "%b %e %H:%M"           /* text format  */
#else
#define DATE_FMT        "%Y-%m-%d %H:%M"        /* the default  */
#endif
#endif

void            show_info( struct utmp * );

int main(int ac, char **av)
{
        struct utmp     *utbufp;        /* holds pointer to next rec    */

        if ( utmp_open( UTMP_FILE ) == -1 ){
                fprintf(stderr,"%s: cannot open %s\n", *av, UTMP_FILE);
                exit(1);
        }
        while ( ( utbufp = utmp_next() ) != NULL ) /* get ptr to next rec */
                show_info( utbufp );
        utmp_close( );
        return 0;
}
/*
 *      show info()
 *                      displays the contents of the utmp struct
 *                      in human readable form
 *                      * displays nothing if record has no user name
 */
void show_info( struct utmp *utbufp )
{
        void    showtime( time_t , char *);

        if ( utbufp->ut_type != USER_PROCESS )
                return;

        printf("%-8s", utbufp->ut_name);               /* the logname  */
        printf(" ");                                   /* a space      */
        printf("%-12.12s", utbufp->ut_line);           /* the tty      */
        printf(" ");                                   /* a space      */
        showtime( utbufp->ut_time, DATE_FMT );         /* display time */
        if ( utbufp->ut_host[0] != '\0' )
                printf(" (%s)", utbufp->ut_host);      /* the host     */
        printf("\n");                                  /* newline      */
}

#define MAXDATELEN      100

void showtime( time_t timeval , char *fmt )
/*
 * displays time in a format fit for human consumption.
 * Uses localtime to convert the timeval into a struct of elements
 * (see localtime(3)) and uses strftime to format the data
 */
{
        char    result[MAXDATELEN];

        struct tm *tp = localtime(&timeval);           /* convert time */
        strftime(result, MAXDATELEN, fmt, tp);         /* format it    */
        fputs(result, stdout);
}
```

```
:::::::::::::: utmplib.h ::::::::::::::
#ifndef UTMPLIB_H
#define UTMPLIB_H
/* utmplib.h  - header file with decls of functions in utmplib.c */

#include <utmp.h>

int          utmp_open(char *);
struct utmp *utmp_next();
int          utmp_close();
#endif

:::::::::::::: utmplib.c ::::::::::::::
/* utmplib.c  - functions to buffer reads from utmp file
 *
 *      functions are
 *              int utmp_open( filename )      - open file
 *                      returns -1 on error
 *              struct utmp *utmp_next( )      - return pointer to next struct
 *                      returns NULL on eof or read error
 *              int utmp_close()               - close file
 *
 *      reads NRECS per read and then doles them out from the buffer
 *      hist: 2012-02-14 slightly modified error handling (thanks mk)
 *      note: this version is extended from the handout version: this tracks cache hits
 */
#include        <stdio.h>
#include        <fcntl.h>
#include        <sys/types.h>
#include        <utmp.h>
#include       <unistd.h>

#define NRECS   32
#define UTSIZE  (sizeof(struct utmp))

static  struct utmp utmpbuf[NRECS];   /* storage            */
static  int     num_recs;             /* num stored         */
static  int     cur_rec;                 /* next to go      */
static  int     fd_utmp = -1;            /* read from       */

static  int  utmp_reload();

/*
 * utmp_open -- connect to specified file
 *  args: name of a utmp file
 *  rets: -1 if error, fd for file otherwise
 */
int utmp_open( char *filename )
{
        fd_utmp = open( filename, O_RDONLY );           /* open it      */
        cur_rec = num_recs = 0;                         /* no recs yet  */
        return fd_utmp;                                 /* report       */
}

/*
 * utmp_next -- return address of next record in file
 *  args: none
 *  rets: address of record in buffer
 *  note: this location will be reused on next buffer reload
 */
struct utmp *utmp_next()
{
        struct utmp *recp;

        if ( fd_utmp == -1 )                            /* error ?      */
                return NULL;
        if ( cur_rec==num_recs && utmp_reload() <= 0 )  /* any more ?   */
                return NULL;

       recp = &(utmpbuf[cur_rec]);   /* get address of next record   */
        cur_rec++;
        return recp;
}
```

```
static int utmp_reload()
/*
 *      read next bunch of records into buffer
 *      rets: 0=>EOF, -1=>error, else number of records read
 */
{
        int     amt_read;

       amt_read = read(fd_utmp, utmpbuf, NRECS*UTSIZE);   /* read data     */
       if ( amt_read < 0 )                  /* mark errors as EOF   */
              return -1;

        num_recs = amt_read/UTSIZE;          /* how many did we get?       */
        cur_rec  = 0;                        /* reset pointer       */
        return num_recs;                     /* report results      */
}

/*
 * utmp_close -- disconnenect
 *  args: none
 *  rets: ret value from close(2)  -- see man 2 close
 */
int utmp_close()
{
       int rv = 0;
        if ( fd_utmp != -1 ){                   /* don't close if not   */
                rv = close( fd_utmp );          /* open                 */
               fd_utmp = -1;                /* record as closed    */
       }
       return rv;
}
```