Macintosh
Technical Notes

Developer Technical Support

#283: A/UX System Calls From Macintosh Software

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This Technical Note discusses how to make A/UX system calls from applications developed in the Macintosh environment. This is useful to anyone porting an existing Macintosh driver or application to work on A/UX as well.

Changes since August 1990: Added information about how to make use of `fork()` system calls under MultiFinder, as well as how various A/UX system calls behave under the MultiFinder emulation mode.

Introduction

A/UX 2.0 now runs a broad range of Macintosh applications. The A/UX Toolbox allows most code developed for the Macintosh to run unmodified under A/UX. One exception is Macintosh device drivers. Many developers are interested in also making their Macintosh peripherals available to A/UX customers. If the peripheral requires a custom driver that accesses hardware, the driver needs to be modified to run under A/UX.

Split Decision

The A/UX Toolbox runs in “user” space in A/UX. This is a virtual, protected memory space that shares the system resources with all other processes running in “user” space. These processes are not allowed to access hardware directly. Instead, they must make a request to the A/UX kernel through a mechanism called a “system call” to deal with the hardware. The kernel, which runs in “system space,” then returns data, status, etc. back to the caller. The system call is a well-defined interface that gives Unix® systems some degree of application portability.

Since any custom driver code must maintain the Macintosh interface at the Toolbox and application level, and Toolbox code cannot touch the hardware, you must split your driver into two pieces. The high-level Macintosh interface portion stays in user space, and the low-level hardware dependent, Unix-style interface becomes a Unix device driver in the kernel. So how do these two pieces communicate? They have to talk to each other through the Unix system call interface.

The code comprising the kernel portion of your driver must be adapted to do things in a “Unix way,” such as providing the standard routine interface required of all Unix drivers, be multithreaded and reentrant, and not “hog” CPU time by doing “busy waits.” This Note does not cover these issues, but the A/UX Device Drivers Kit (available through APDA) has example code and documentation about the topic. There are also some good books available on writing Unix drivers.

Is This A/UX or What?

If you want your code to work in either environment without change, you first need to determine if you are under A/UX at run time. The best way to do this is with the `_Gestalt` trap using the selector `gestaltAUXVersion` to determine if A/UX is the underlying operating system. Shown below is a function which returns 0 if A/UX is not present, otherwise returns the major A/UX version number (1, 2, etc.). This code relies on `_Gestalt` glue code available in MPW 3.2 and later.

```
/*
*    getAUXVersion.c
*
*    Copyright © 1990 Apple Computer, Inc.
*
*    This file contains routines to test if an application is running
*    on A/UX.  If the Gestalt trap is available, it uses that, otherwise
*    it falls back to HWCfgFlags, which will work on all A/UX systems.
*/
#include <Types.h>
#include <GestaltEqu.h>

#define HWCfgFlags    0xB22    /* Low memory global used to check if A/UX is running */

/*
*    getAUXVersion -- Checks for the presence of A/UX by whatever means is appropriate.
*    Returns the major version number of A/UX (i.e. 0 if A/UX is not present, 1 for
*    any 1.x.x version 2 for any 2.x version, etc.
*
*    This code should work for all past, present and future A/UX systems.
*/
short getAUXVersion ()
{
   long     auxversion;
   short    err;
   short    *flagptr;

   /*
    *    This code assumes the Gestalt glue checks for the presence of the _Gestalt
    *    trap and does something intelligent if the trap is unavailable, i.e.
    *    return unknown selector.
    */
   auxversion = 0;
   err = Gestalt (gestaltAUXVersion, &auxversion);
   /*
    *    If gestaltUnknownErr or gestaltUndefSelectorErr was returned, then either
    *    we weren't running on A/UX, or the _Gestalt trap is unavailable so use
    *    HWCfgFlags instead.
    *    All other errors are ignored (implies A/UX not present).
    */
   if (err == gestaltUnknownErr || err == gestaltUndefSelectorErr) {
       flagptr = (short *) HWCfgFlags;    /* Use HWCfgFlags */
       if (*flagptr & (1 << 9))
           auxversion = 0x100;        /* Do Have A/UX, so assume version 1.x.x */
   }
   /*
    *    Now right shift auxversion by 8 bits to get major version number
    */
   auxversion >>= 8;
   return ((short) auxversion);
}
```

The main system calls used to access kernel driver routines are `open()`, `close()`, `read()`, `write()`, and `ioctl()`. Of use to applications is the routine `creat()` which is included here as well. The A/UX system call mechanism is a `trap #0` with the system call selector code in register `D0`. The arguments are on the stack in the normal C calling convention, last argument pushed first.

Note that different trap calls under A/UX have different procedures concerning the use of registers
and stack frames.In this Tech Note we are not trying to document each possible case, so we limit the examples to show how the registers and stack frame are used| with the `open()`,`close()`, `read()`, `write()`, `fork()` and `ioctl()` A/UX system calls. In the case of other A/UX system calls you have to disassemble code compiled under the A/UX environment in order to find out how the parameters are passed, and how the stack frames are set.

Since MPW does not contain any A/UX libraries and doesn't know about Unix system calls, you need to use some assembly-language glue code around the trap. Following is glue code for the common A/UX routines listed above. You can extend your A/UX system call library by adding additional routines with additional system call selectors. This glue code relies on the similarity between A/UX C calling conventions and MPW C calling conventions, as well as the similarity in the sizes of parameters (`int` variables are four bytes in both systems). When these routines are entered the stack frame is already correctly set up for the `trap #0`; if you are using other languages or development systems, you may need to extend the glue to rearrange parameters on the stack to match A/UX C calling conventions.

The error code from the call is returned in `D0`. In the Unix environment, this error code is normally placed in the `errno` global variable and `D0` is set to -1 before return to the caller. Since global variables are very bad for Macintosh device drivers, this glue code relies on a special A/UX trap called `_AUXDispatch` which can return a pointer to an A/UX `errno` global variable. The C functions `SetAUXErrno()` and `GetAUXErrno()` are used to set and retrieve this value. The `_AUXDispatch` trap is defined in an A/UX include file /usr/include/mac/aux.h and you need this file to compile the C code. For more information about the AUXDispatch trap, consult the *A/UX Toolbox: Macintosh ROM Interface* manual. Lastly, all function names have been preceded by the prefix "AUX" to distinguish them from their MPW C library counterparts (e.g., the A/UX `read()` function is named `AUXRead()` here).

```
;   AUXIO.a -- Glue for A/UX I/O system calls
;
;   Copyright © 1990 Apple Computer, Inc.
;   All rights reserved.
;
```

```
;   This module contains C callable routines to execute A/UX system (trap 0)
;   calls.  The parameters to these routines is exactly as they are described
;   in the A/UX man(2) documentation.  This means all char * parameters are
;   NULL terminated C strings, not Pascal strings.  They all presume that A/UX
;   is in fact running.  Certain death will result otherwise.

           CASE    ON      ; For C
           INCLUDE 'SysEqu.a'
           IMPORT  SetAUXErrno
;
;   Here are all the routines and their C calling conventions:
;   long    AUXCreat (char *path, long mode);
           EXPORT      AUXCreat
;   long    AUXOpen (char *path, long oflag, long mode);
           EXPORT      AUXOpen
;   long    AUXClose (int fildes);
```

```
            EXPORT      AUXClose
;   long     AUXRead (long fildes, char *buf, long nbytes)
            EXPORT      AUXRead
;   long     AUXWrite (long fildes, char *buf, long nbytes)
            EXPORT      AUXWrite
;   long     AUXIoctl (long fildes, long request, long arg)
            EXPORT      AUXIoctl

;   Some local entry points
            ENTRY       auxerr
            ENTRY       auxcommon
            ENTRY       auxexit

AUXCreat     PROC
            move.l      #$8,D0          ; creat function selector
            bra.b       auxcommon       ; Join common code
AUXOpen      PROC        EXPORT
            move.l      #$5,D0          ; open function selector
            bra.b       auxcommon       ; Join common code
AUXClose     PROC        EXPORT
            move.l      #$6,D0          ; close function selector
            bra.b       auxcommon       ; Join common code
AUXRead      PROC        EXPORT
            move.l      #$3,D0          ; read function selector
            bra.b       auxcommon       ; Join common code
AUXWrite     PROC        EXPORT
            move.l      #$4,D0          ; write function selector
            bra.b       auxcommon       ; Join common code
AUXIoctl     PROC        EXPORT
            move.l      #$36,D0         ; ioctl function selector
            bra.b       auxcommon       ; Join common code

;   Trivia of the month.  The flow of the code is a little weird
;   here because of a strange interaction between the assembler
;   and the linker.  Logically, auxcommon should go here, but what
;   happens in that case is the assembler generates a byte branch
;   instruction for the previous instruction, but then the linker
;   cheerfully fills in the byte offset, which if auxcommon were
;   the next instruction would be zero.  At runtime, this causes
;   the bra.b to get interpreted as a bra.w and of course the code
;   flies off into never-never land.  So we stick in some convenient
;   intervening code to ensure the offset is never zero.
auxerr       PROC        ENTRY
            move.l      D0,-(SP)        ; Push error code
            jsr         SetAUXErrno     ; Set errno
            add.w       #$4,SP          ; Remove parameter
            move.l      #$FFFFFFFF,D0   ; Set -1 for return value
            bra.b       auxexit         ; Outta here

auxcommon    PROC        ENTRY
            trap        #$0             ; trap 0
            bcc.b       auxexit         ; CC, no error
            bra.b       auxerr          ; Do common error handling

auxexit      PROC        ENTRY
            rts
            ENDPROC

            END
```

The second argument to the `AUXIoctl` call needs some special attention. The A/UX header file /usr/include/sys/ioctl.h describes the format of `request`. These four bytes hold several fields describing the data format. Normally, macros defined in the ioctl.h header file take care of packing these fields. Make sure you use the same format when you construct your `request` argument. Just use the example commands in the /usr/include/sys/*ioctl.h files as a reference.

Following are the C functions to properly get and set the A/UX `errno` global variable:

```
/*
*    AUXErrno.c
*
*    Copyright © 1990 Apple Computer, Inc.
*    All rights reserved.
*
*    This file contains routines to properly get and set the standard Unix global
*    errno from within an Macintosh application.  It uses the AUXDispatch trap
*    to get a pointer to the address to be set.
*/
#include <aux.h>

void SetAUXErrno (err)
long err;
{
   long    *errnoptr;

   if (!getAUXVersion ())
       return;                /* No A/UX, do nothing */

   errnoptr = 0;
   AUXDispatch (AUX_GET_ERRNO, (char *) &errnoptr);
   /*
    * If errnoptr is still NIL, AUXDispatch failed so do nothing
    */
   if (errnoptr)
       *errnoptr = err;
   return;
}

long GetAUXErrno ()
{
   long    *errnoptr;

   if (!getAUXVersion ())
       return (0);            /* No A/UX, return noerror */
   errnoptr = 0;
   AUXDispatch (AUX_GET_ERRNO, (char *) &errnoptr);
   /*
    * If errnoptr is still NIL, we're not under A/UX, or AUXDispatch failed
    * so do nothing
    */
   if (errnoptr)
       return (*errnoptr);
   else
       return (0);
}
```

Use of the fork() call under A/UX MultiFinder emulation

The following advice concerns the use of the A/UX `fork()` system call under the MultiFinder emulation mode. Under A/UX the kernel does not separate the data region of the parent process for the child after a `fork()` call. If we do a simple fork we have suddenly two MultiFinder processes running, and they both will share the same resources. The MultiFinder memory space is set up as shared memory, and since the child in UNIX inherits all shared memory segments from the parent across the fork, both the parent process and the child process will be using the same stack. This will lead to chaos if the child pushes something to the stack while the parent removes the data, or vice versa. The child should have a separate stack until we have done an `exec()`, then the child process has it's own memory world.

So what we need to do is to set up a separate data area for the child's process stack use. The child process will get its own data area by allocating enough stack space by the parent before the `fork()`, and passing this space to the `fork()` system call using a special `fork()` call, which is explained later.

The `fork()` system call copies the current stack frame of the parent onto the new stack space, resets the stack pointer to point to the new stack in the child, and then issues the trap to jump into the Unix kernel to continue to set up the new process structures. This enables the child to access information from the stack in the same manner as any other process. Details to keep in mind while using this mechanism are :

a) Allocate memory for the stack which is guaranteed not to be freed until after the child process has completed its exec.

b) Pass the address of the high memory end of the allocated memory for the stack to `fork()`, not the low memory address.

c) The address to be passed as the caller-environment argument is computed differently depending on whether the calling routine has a Pascal or a C stack frame. The examples given later show how the calculation is done.

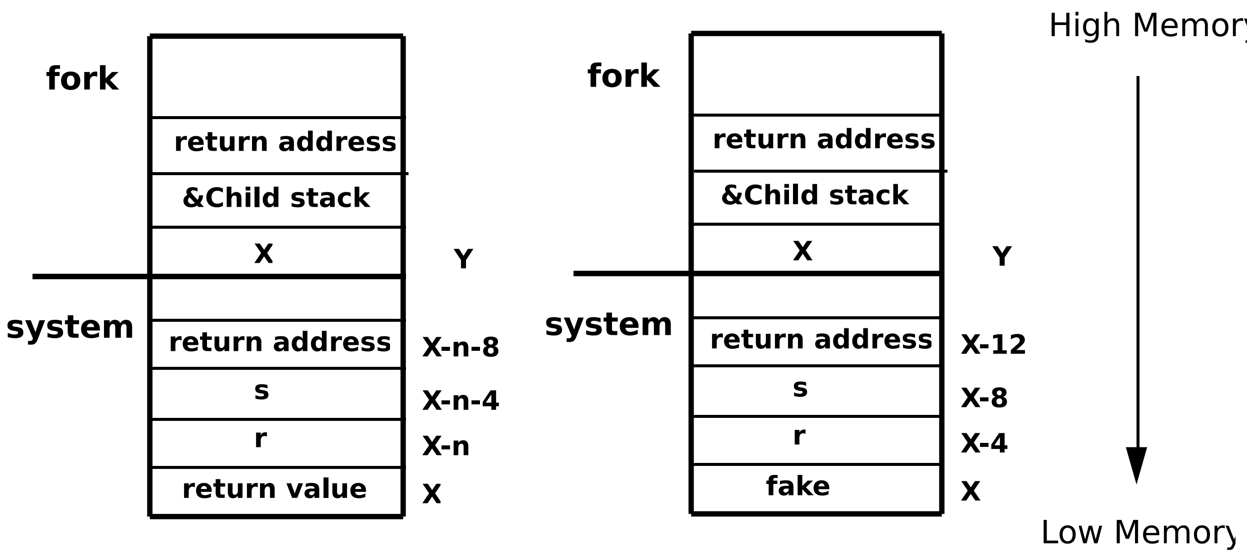
d) The calling routine needs to be very careful about what the child does before `exec()` or `exit()`. Pointers and structures accessed via the stack will point to the parent's copy, since only the local/current frame has been copied.

In particular allocation of large arrays should be done only after ensuring that the space allocated for the child stack is sufficiently large to copy the entire stack frame. This is important because arrays could be allocated on the stack, and there could exist array sizes which cause the current stack frame size to exceed that of the allocated child stack space. This will result in only part of the current stack frame being copied over onto the child. In such cases seemingly normal accesses from the child will end up being in the wrong area and cause strange behavior (the screen is locked up, bus errors are frequent etc.).

Using `malloc()` and `free()` to allocated space for such large buffers on the heap will eliminate this problem. However one needs to be aware that though the space is allocated on the heap, the space is accessed via a pointer which is on the current stack frame. This means that accesses from the child to the space in question will result in accesses to the parent's copy.

e) The parent must clean up of the allocated space for the interim stack for the child after the child has exit:ed.

The following picture illustrates how the stack parameter passing is done with a Pascal stack and a C stack:



Pascal Call Stack **C Call Stack**

n = sizeof(Ret. value)
X is determined thus;
X = &r + sizeof(r) + sizeof(Ret. value)

X is determined thus:
X = &fake

The design issue of returning to the caller from `fork()` (as opposed to providing a `fork()-exec()` combination which does not return from the fork but goes ahead and execs the required program as well) should be favored after looking into the problem carefully. Providing a separate `fork()` has advantages in the form of letting the user set up communication channels between the parent and child before `exec()`, or allowing the user to set up the appropriate environment before exec(). The problems has to do with the possibility of the not-so-wary programmer using the feature improperly and leaving two Macintosh environments running simultaneously, which will lead to chaos very quickly. Thus use of `fork()` from within an application must be done with extreme caution.

Given below is an example of the use of `AUXFork()`, a special `fork()` implementation. This example also shows how to set up the A/UX environment.

```
#define STACKBYTES 2048          /* size in bytes */
#define STACKSIZE STACKBYTES/sizeof(long)
unsigned long *childstack;

pascal long     AUXDispatch(selector,p)
short           selector;
char            *p;
extern          0xABF9;

#define AUX_GET_ENVIRON 11       /* get pointer to environ */
```

```
char **auxenviron;
extern int AUXFork(), AUXExecl(),AUXWait(), AUX_exit();

int system(s,fake)
char   *s;
int    fake;
{
       int    status, pid, w;
       register int (*istat)(), (*qstat)(), (*cstat)();
       int GetAUXErrno();
       long aux_errno;

       childstack = (unsigned long *) (NewPtr (STACKBYTES));

       /* copy the environment */
       AUXDispatch(AUX_GET_ENVIRON,(char *)&auxenviron);

       if((pid = AUXFork(&childstack[STACKSIZE],&fake)) == 0) {
              (void) AUXExecl("/bin/sh", "sh", "-c", s, 0);
              (void) AUX_exit(127);
       }
       else {
              if (pid < 0) {
                     DisposPtr((char *)childstack);    /* Fork failed */
                     return(-1);
              }
              else {
                     w = auxwait(&status);
                     DisposPtr((char *)childstack);
                     return((w == -1)? w: status);
              }
       }
}
```

In the above example, the parent sets up the space for the child stack, gets a pointer to the environment to be passed to `exec()`, and calls `AUXFork()`. A dummy variable 'fake' is passed as a parameter to `system()` to enable `AUXFork()` to copy the current stack frame on to the child stack. After the child exits, the parent cleans up the space allocated to the child stack. `AUXWait()` is used to block the parent until the child exits or terminates. The parent has to wait for the child to exit or terminate for this scheme to work properly within MultiFinder, If the child does not exit or terminate, the Macintosh environment is blocked and may lose a number of events and signals necessary to maintain its state. Thus use of fork makes sense only if we are sure that the child exits or terminates without taking too much time to execute.

The following example shows how to write `AUXFork()`:

```
;   AUXFork.a -- Glue for A/UX fork call
;
;   Copyright © 1990-91 Apple Computer, Inc.
;   All rights reserved.
;
;   This module contains C callable routines to execute A/UX fork
;   calls. This function presumes that A/UX is in fact running.
;   Certain death will result otherwise.
```

```
INCLUDE      'Traps.a'

CASE   OBJECT
```

```
                            EXPORT AUXFork
;   AUXFork routine
;
;
; pid = AUXFork(new_top_sp, caller_env)
;
;      new_top_sp:   This is one past the highest address that is
;                           in the new stack area.
;      caller_env:   This is an address on the current stack that is
;                           one past the highest address in the stack frame
;                           of the calling routine.
;
;      return values -
;       in parent:   pid == -1           failure
;                           pid == child  success
;       in child:    pid == 0
;
;
;      To call auxfork -
;             Allocate memory for the child's stack which is guaranteed not to
;      be freed until after the child process has completed its exec.  Remember
;      to pass the end of that memory region to auxfork, not the beginning.  The
;      address to be passed as the caller_env argument is computed differently
;      depending on whether the calling routine has a pascal or C stack frame.
;             Note that the calling routine needs to be very careful about what
;      the child does before exec or exit.  Only the local frame has been copied
;      and only the frame pointer has been fixed up.  For example, if the calling
;      routine has an array on the stack and uses a pointer to it for efficiency
;      then the child's pointer will point at the parent's copy, not the child's.
;      Also, if the parent must be careful not to delete or change anything the
;      child may be using.  Caveat emptor!
;
;
;      How to compute the caller_env argument -
;
;      Pascal: compute ((char*)&leftmost_argument) + sizeof(leftmost_argument)
;                    + sizeof(function return value, if any) and pass that.
;
;             e.g.   pascal Boolean system(short r, long s, long c)
;             auxfork(&new_stack[LENGTH_OF_STACK], (&r + sizeof(shor) + sizeof(Boolean)))
;
;      C:            add a fake rightmost_argument and pass the address of that.
;




;             e.g.   int system(short r, long s, long c, long fake)
;                           auxfork(&new_stack[LENGTH_OF_STACK], &fake)
;
;
AUXFork                     PROC

       ; make a copy of the stack frame
       move.l 4(a7),a0             ; just past end of new stack
       move.l 8(a7),d1             ; just past end of caller environment
       move.l d1,d0                ; length = end of caller
       sub.l  a7,d0                ; ... - current stack
       sub.l  d0,a0                ; new stack -= length of old
       move.l a0,d0                ; save the stack base for after copy
       move.l a7,a1                ; don't want interrupts to trash stack

@2     move.w (a1)+,(a0)+          ; word aligned (it is a stack!)
       cmp.l  a1,d1                ; done?
       bhi.s  @2                   ; ... nah, keep copying
```

```
      move.l d0,a0               ; ... yep, save new stack pointer

      ; now, do the fork
      move.l 2,D0
      trap   #0
      ; D1 == 0 in parent process,  D1 == 1 in child process.
      ; D0 == child pid in parent,  D0 == parent pid in child.
      bcc.b  @0                  ; did we fork?
      move.l #-1,D0              ; ... nah, failure
@1    rts
@0    tst.b  D1                  ; who am i now?
      beq.b  @1                  ; ... parent, get out of here

      ; ... child, so fudge registers
      move.l a6,d1               ; offset of fp = fp
      sub.l  a7,d1               ; ... - old stack
      move.l a0,a7               ; set up new stack pointer
      move.l a0,a6               ; new frame pointer = sp
      add.l  d1,a6               ; ... + offset of fp

      clr.l  (a6)                ; the fp points to never-never land
      lea    do_exit,a1          ; and a guaranteed exit
      move.l a1,4(a6)            ; becomes the return address

      move.l #0,D0               ; the child returns
      rts

do_exit move.l 1,D0
      trap   #0
      ENDP

      END
```

Issues with using A/UX system calls in the MultiFinder environment

General :

The following comments describe how various A/UX system calls behave under the MultiFinder environment:

Blocking / Sleeping system calls :

Many of the system calls can result in situations which cause the calling process to go to sleep awaiting an event which wakes it up .For instance opening a pipe from process and writing to the pipe will result in the write waiting until another process opens the pipe for reading. Such situations should be avoided when using the system calls from within a Macintosh application.

Depending on the priority at which the sleep occurs, the application can cause the entire Macintosh environment to hang (when the sleep is non interruptible), or the system call returns with error number indicating an interrupted system call. This will happen because the blocked process is sleeping at a priority from which it can be woken up by signals used to implement VBL's or other Macintosh aspects - and which is almost always bound to happen. One way to get around this problem is by using options which prevents the blocking and spin in a loop polling the result from the system call, until we are guaranteed to have a situation wherein the system call will not block. However, polling in this manner should be done only for very short intervals, and when we are sure that the polling will end in success in a short time. If this is not the case, then the application doing the polling will be stuck in the polling loop without giving up the CPU for other applications (which is extremely unfriendly MultiFinder behavior).

Caution About Blocking On Read Calls

Be aware that reads from drivers may block the calling application until some data arrives. Since the complete MultiFinder environment exists as a single process under A/UX, you do not want a pending read to block for an extended period of time. This problem is not unique to A/UX—the same thing also happens under the Macintosh OS. In a serial driver, for example, the application should check to see if any characters have been received and are waiting to be read before issuing the read call. The `read()` should then request only that many characters. This is implemented differently under A/UX than under the Macintosh OS. The available character count is determined by doing an `ioctl()` system call to the device in question. The terminal `ioctl()` commands to do this are listed in the A/UX manuals under *"termio"* in section 7. The `FIONREAD ioctl()` command returns the number of characters waiting to be read from the A/UX serial driver. This can cause problems when using the IOP-based serial driver on the Macintosh IIfx; for more information on this topic, refer to Technical Note #284, IOP-Based Serial Differences Under A/UX.

sbrk and brk:

There is no consistent way for an application to use `sbrk()` and `brk()` properly and ensure that other applications within the MultiFinder partition are aware of the new `sbrk()` and `brk()` limits and behave appropriately. Thus it doesn't make sense to use these A/UX system calls. `sbrk()` and `brk()` are mostly used to get additional data space, and this can already be achieved by using either `NewPtr()/NewHandle()` or `malloc()`.

setuid / setgid / setreuid / setregid / nice/ setgroups / setcompat / setsid / setpgid / plock/ ulimit/ phys:

These A/UX system calls have the same problem as above - i.e. we don't want to modify any process related A/UX structures/information which in turn affects all the applications running under the MultiFinder partition.

sethostid / sethostname / setdomainname / sysacct / reboot / powerdown / nfs_getfh / adjtime:

It is not recommended to affect system wide structures/data with user processes (allowed only for super user).

signal / ssig / sigvec / sigblock / sigsetmask / sigpause / sigstack / sigpending / sigcleanup :

Synchronization with signals and related calls have the same problem as earlier stated, but with additional complexities. While not providing signals would eliminate the problem of maintaining signals on a per-application basis within MultiFinder, a subset of the signals functionality has to be provided to enable applications to deal properly with certain system calls. Otherwise these calls may result in the signals being raised to indicate errors or other status information. (e.g the `SIGPIPE` signal is raised if a process sends data on a broken stream set up via the socket system call.). Signals necessary to resolve the situations mentioned earlier should be supported, but all other signals should return without accomplishing anything.

Most of the signal functionality can be accessed via the special `AUXDispatch` trap.

Pause/ alarm/ kill/ setitimer:

If only a subset of the functionality of signals is going to be provided it does not make much sense to make use of these calls.

Use of pipes :

Blocking on reading an empty pipe and blocking on writing more than `PIPE_MAX` bytes of data should not cause the Mac environment to hang (`PIPE_MAX` is defined in A/UX to 8192). These situations can be avoided in the following ways:

a) Ensure that all writes greater than `PIPE_MAX` bytes are broken up into smaller chunks (this may involve a bit of book-keeping and access to additional buffer space.).

b) Use the `fcntl()` A/UX system call to set that appropriate file descriptors returned by `pipe()` to use the `O_NDELAY` flags (or the `_NONBLOCK` semantics provided by POSIX). This guarantees that both the above cases of blocking are avoided. However, both `read()` and `write()` returns with a count of 0 which is indistinguishable from an end-of-file indication. This, along with judicious use of the polling strategy to avoid blocking mentioned above, can be used to prevent a lot of potential blocking situations.

In general use of named pipes is much simpler in a Macintosh application. This because named pipes gives the programmer the possibility to use standard Macintosh File I/O for inter-application communication. Use of regular pipes to set up communications between a parent process and related child/grandchild processes has to be done with great care. The pipe descriptors have to be set up appropriately for communication, before doing the `exec()`, but after the `fork()`. Improper usage may result in two separate MultiFinder processes running - which results in very quick deterioration of the system environment.

The requirement of cleaning up the interim child stack used during a `fork()` imposes the restriction of the parent (MultiFinder) having to wait for the child to exit. This means that all communication involving pipes between related processes must not block, and moreover must complete relatively quickly.

Messages:

Message operations should ensure that they do not cause the calling process to block. In the case that they result in blocking, the operations invariably fail and return an error number specifying an interrupted system call. The caveats mentioned about blocking hold true in situations where messages could block.

Semaphores:

Semaphores on AT&T SysV based Unix systems are fairly complicated. With the addition of further restrictions imposed by the limitations of MultiFinder running under A/UX, semaphore usage from within a Macintosh application should be attempted with utmost care. By the very nature of the operation of semaphores, sleeping/blocking situations are bound to arise. Usage of the

IPC_NOWAIT flag prevents sleeping/blocking. Thus it's possible to implement a conditional semaphore, whereby the MultiFinder process does not sleep on behalf of the application using semaphores (when it cannot do the required atomic action).

As with its usage from a regular Unix process, care should be taken to avoid situations leading to a deadlock or situations where deadlocks could happen. For instance this is true in the case where one process locks a semaphore and then exits without resetting the semaphore. Other processes will find the semaphore locked even though the process which had done the locking is no longer around. To avoid such problems the SEM_UNDO flag should be used with semaphore operations. Here again the application developer needs to be aware of the problems associated with blocking which is mentioned above.

Use of lockf:

The lockf() system call can be used if it is done judiciously. Using lockf() with the mode set to F_TLOCK is recommended; this will return with an error if a lock already exists for the region of interest to be locked.

Flock :

A request to lock (flock() system call) an object that is already locked will cause the caller to block until the lock is acquired, unless LOCK_NB (nonblocking lock) is used which results in nonblocking semantics to be applied.

Networking :

a) accept() : This call will result in the caller blocking until a connection is present if no pending connections are present on the queue, and the socket in question is not marked as non-blocking, This situation needs to be avoided.

b) recv()/recvfrom()/recvmsg() : These calls would result in the call blocking until a message arrives if no messages are available at the socket, unless the socket is marked nonblocking.

c) select() : Timeout should not be 0 - this would result in blocking indefinitely.

d) send()/sendto()/sendmsg() : These calls will block if no message is available at the socket to hold the message to be transmitted, unless the socket has been placed in the nonblocking mode.

e) socket(): Use of setsockopt() to set options on the socket connection should be done carefully. Situations which could result in the indefinite blocking should be avoided (for eg. setting `SO_LINGER` when the socket is opened in the reliable delivery mode would result in blocking when the socket is closed, until the socket decides that it is unable to deliver the information).

nfssvc / async_daemon:

These system calls cannot be called directly from the Macintosh world because these calls never return. To use these calls we need to first `fork()` a new process and then `exec()` a program containing this call as the child process. Additional mechanism in the form of a nonblocking wait for the parent (perhaps `wait3()`) needs to also be ensured.

ioctl :

The `ioctl()` A/UX system call is provided to enable programs running on Unix to access all the peculiarities of specific devices in cases where the standard I/O library lacks the necessary capabilities. Applications or programs which need to do this require device specific knowledge relevant to A/UX. The recommended way to use `ioctl()` is to write a pure Unix program, a toolbox (hybrid) program, or a small glue code snippet inside the Macintosh binary application using the `ioctl()` system call to accomplish A/UX specific functionality.

Conclusion

The routines presented here show basic techniques for accessing A/UX system services. By properly using these and other system calls, you can extend your Macintosh device drivers and applications beyond the limits of the Macintosh OS without having to ship a special version of your application for A/UX.

Further Reference:

- *A/UX Device Drivers Kit,* APDA
- *A/UX Programmer's Reference,* Section 2.
- *Writing A Unix Device Driver,* Egan & Teixeira, Wiley.
- *The Design of the UNIX Operating System*, Bach, Prentice-Hall
- Technical Note #284, IOP-Based Serial Differences Under A/UX