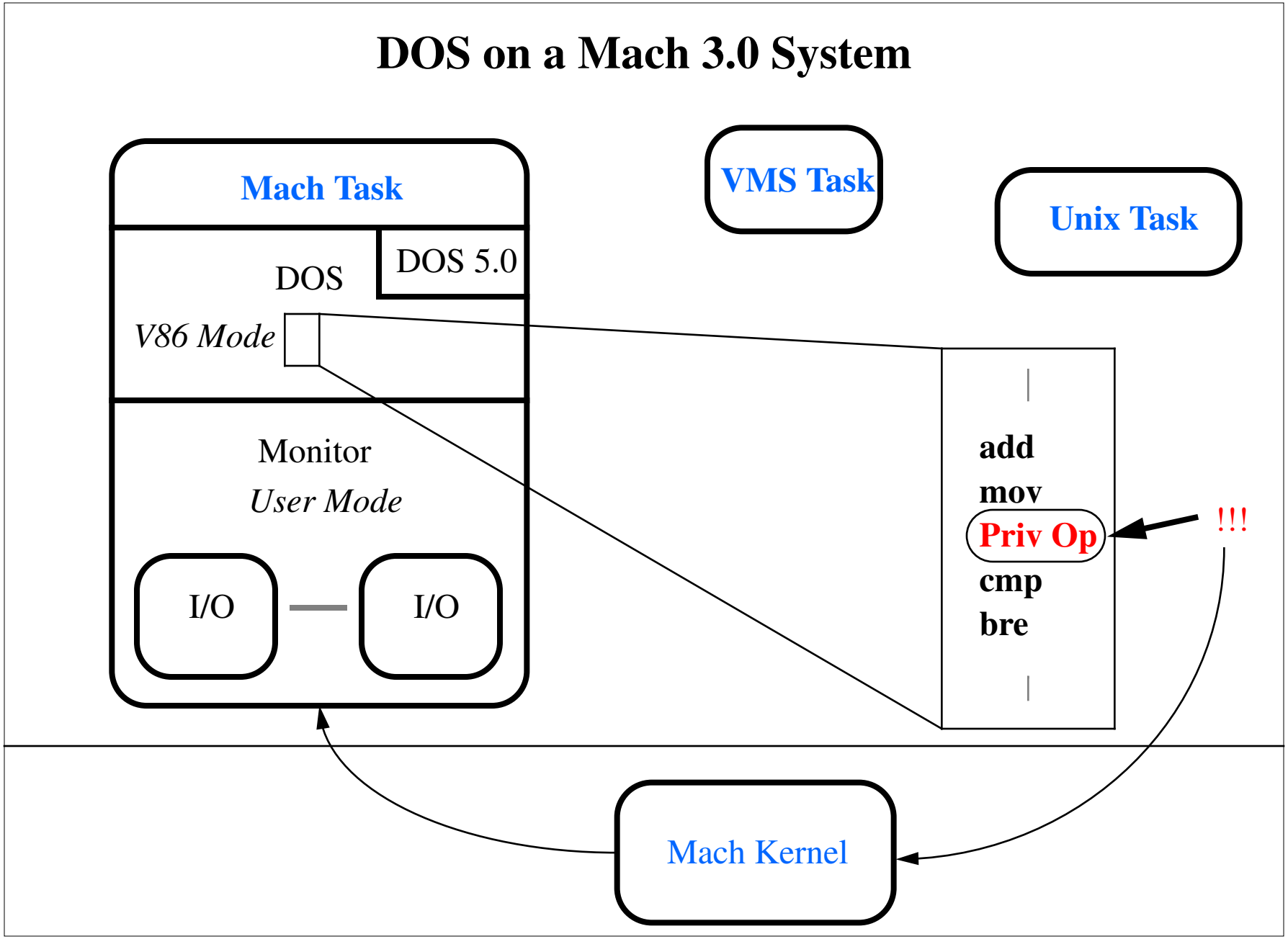
DOS on a Mach 3.0 System



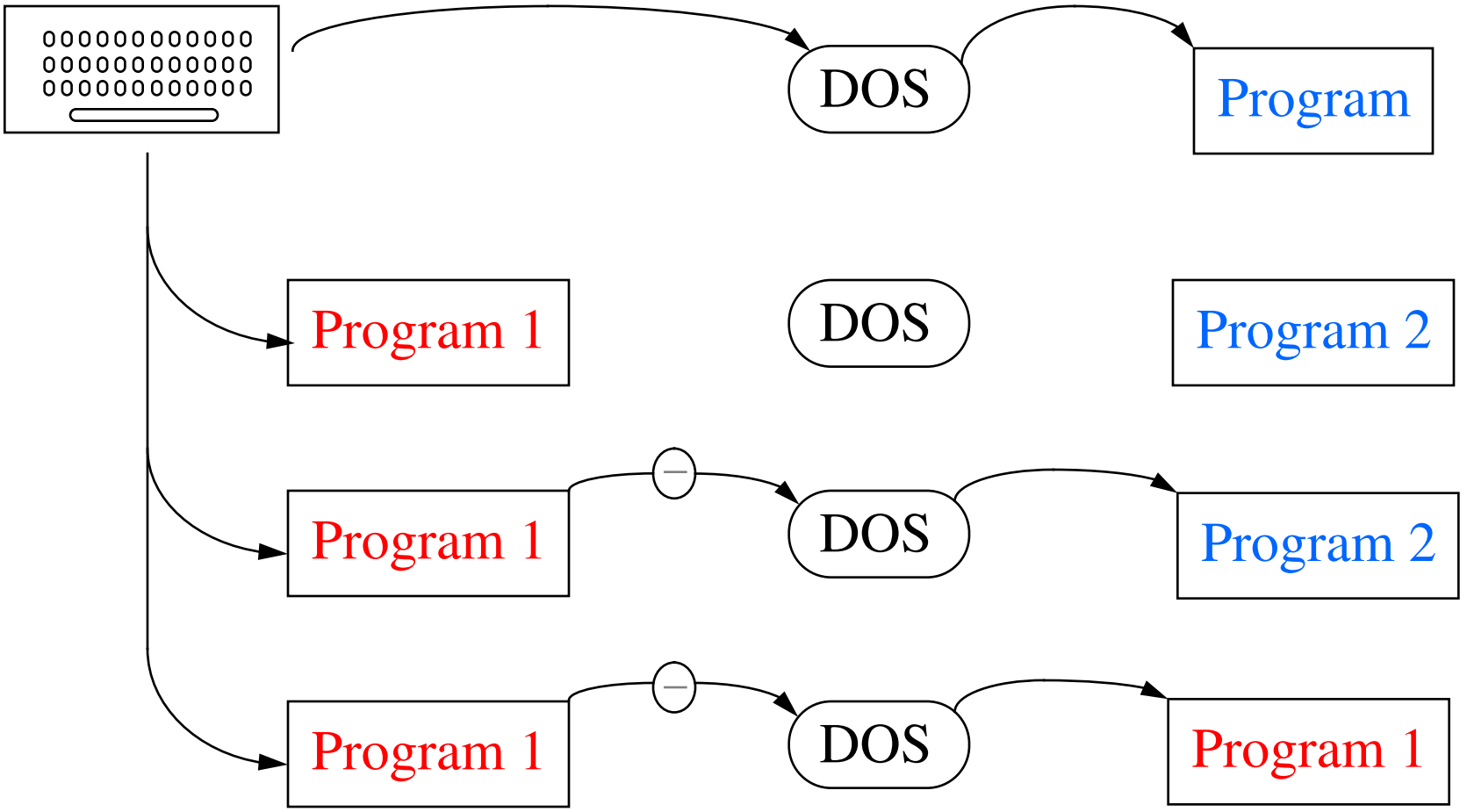
Keyboard Interrupt Generation

* Like Mouse thread, must not be asynch, setup required

* Don’t let kernel do keyboard interrupts, only user level threads

* Keyboard interrupt:
  - Dequeue scan code
  - Store it in User space routine’s data area
  - Save it in keyboard_output_buffer variable
  - forces interrupt to occur

Classes of Keyboard Programs



Keyboard Thread

* Reads scan codes from /dev/kbd

* If well-behaved program running, decode scan code and insert into SPRAM

* If ill-behaved program, queue scan code and queue keyboard interrupt

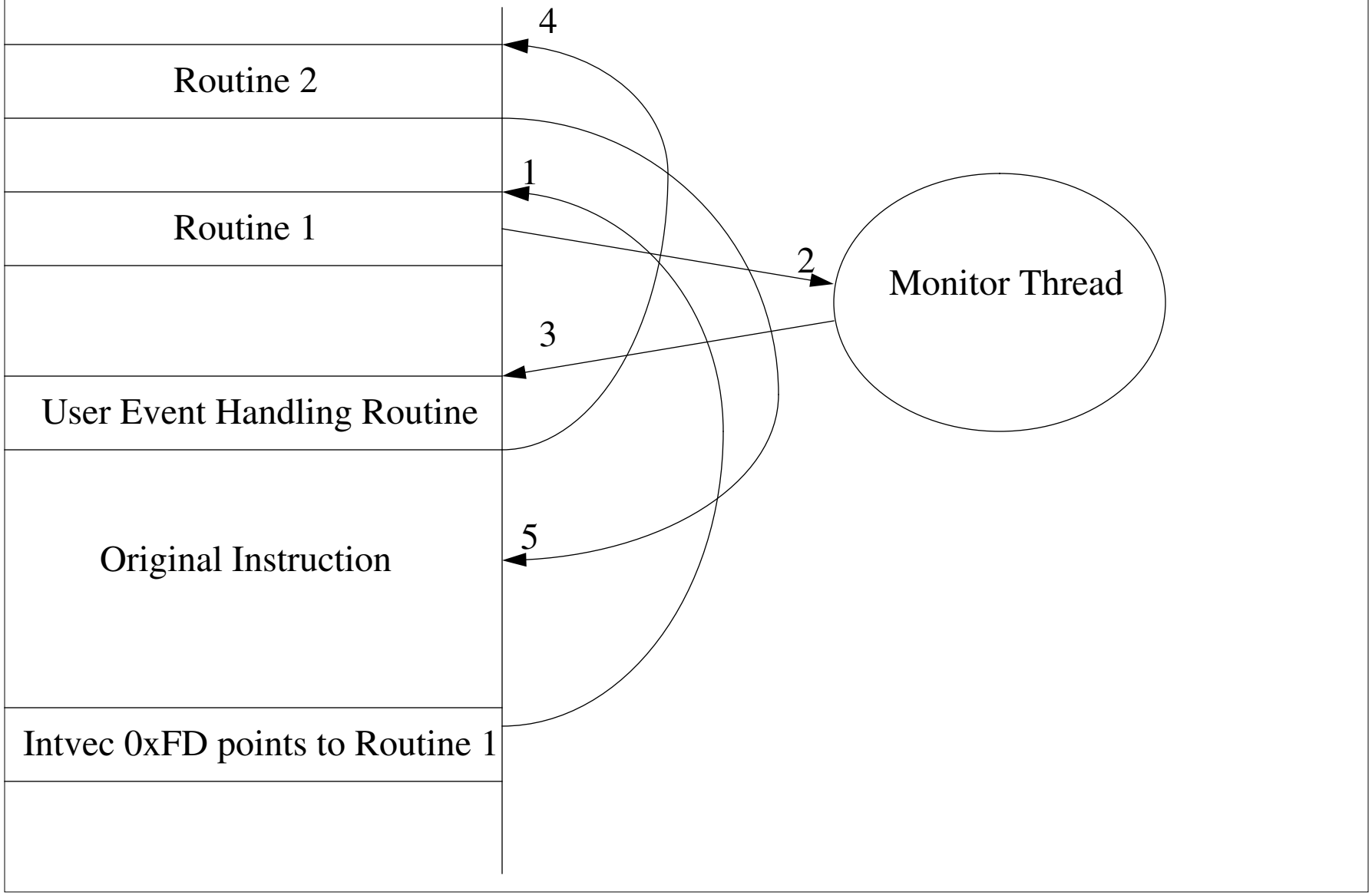
* Supports all three types of keyboard programs:
  - The Hog, takes all
  - The Chain, take what it wants and passes it on
  - The Split, takes what it want, and what everyone else doesn't

* Uses a user space routine like the mouse routines at the end of the chain.

DOS and the Keyboard

* How DOS programs aquire keyboard data:
  - Call keyboard BIOS routines with INT 0x16
  - Directly access the BIOS keyboard data structures in the SPRAM
  - Redirect hardware keyboard interrupts into the own ISR
  - Combinations of the above

Picture of Mouse Interrupt



How We Do User Event Handling

* Supply 2 small assembly routines in the DOS address space

* Use fake Int number when queuing the interrupt (Int 0xFD)

* At boot time, point intvec 0xFD to point to our first helper routine

* When first routine is called by kernel or I/O thread, it does a real INT 0xFD

* Monitor thread catches the INT 0xFD and knows it's a Mouse Interrupt

* Monitor thread sets up stack to return to second routine and loads regs

* V86 thread resumed at User Event Handler, returns with FAR RET

* Second routine restores registers and IRETS back to original instruction

User Supplied Mouse Event Handlers

* Mouse BIOS allows DOS applications to specify an event handling routine

* When event occurs:
  - Mouse driver loads machine state with mouse info
  - Driver calls the user routine with a FAR CALL
  - User routine does its work
  - User routine returns to driver with a FAR RET
  - Driver exits with IRET

* Why this is difficult for Mach DOS:
  - Our interrupt mechanism only calls routines with pointers in Interrupt Vector Table
  - We must store state and load registers before call to user routine
  - FAR CALL is used to call routine, we only have INT mechanism
  - FAR RET can't return to driver, since no driver in memory

Mouse Thread

* Emulate a DOS Mouse Device driver
  - Keep track of Mouse status
  - Update mouse pointer in VGA memory
  - Provide interrupts for user supplied event handlers

* Emulate a serial line (COM) Mouse
  - Logitech Serial Mouse emulation for Windows 3.0

DOS and Mouse Usage

* How DOS programs use the Mouse:
  - At boot time, load mouse device driver
  - Utilize driver's BIOS syscall interface 0x33
  - DOS programs either:

    1. Poll the mouse driver for mouse status
    2. Provide a user address as a pseudo interrupt routine for mouse events
    3. Supplant the Mouse driver with a user supplied ISR

How Are External Interrupts Delivered?

* In General, I/O Threads queue interrupt when input recieved.
    - Structure `interrupt_table` contains a `count` for each interrupt type:
        - keyboard interrupt
        - mouse interrupt
        - 2 timer interrupts
        - break interrupt
        - COM interrupt

* Interrupts are Delivered by:
    - Periodic checks by User threads after queueing
    - Kernel checks after each successful hw exception emulation

Timer Thread

* Generates two types of Timer Interrupts:
  - Hardware Timer IRQ, Intvec 0x9
  - Timer Tick, Intvec 0x1c

* Updates SPRAM system time

* Timeout on Mach Port (timeoutval is user defined)

* Compensation for slow clock

What Kind of DOS Program is Running?

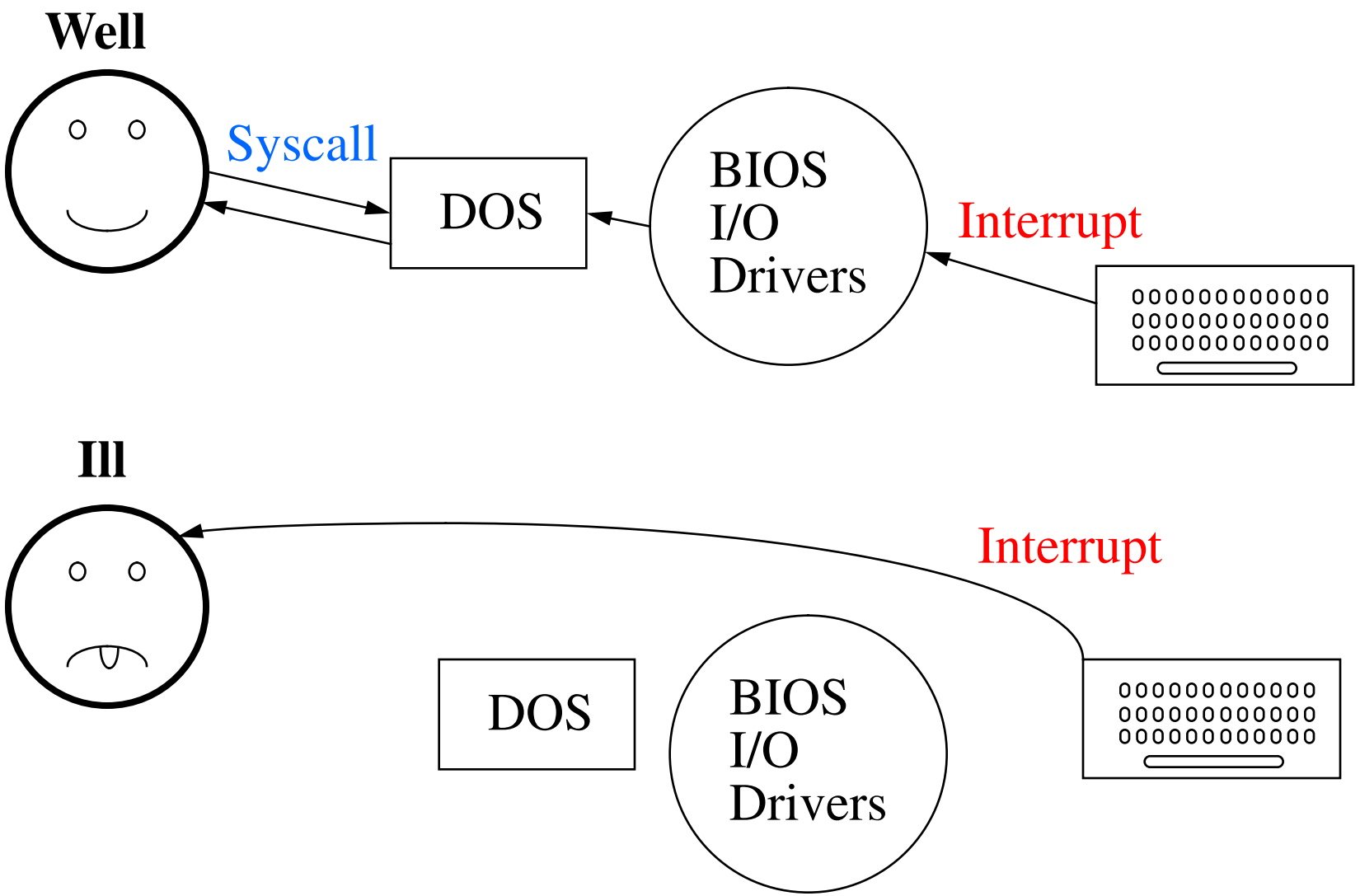
* We call `override_vectors()` at the start of execution

* Initialize the Interrupt Vector Table with Mdos values

* Store these values

* Compare Vector values during execution
  - Equal -> Well-behaved
  - Different -> Ill-behaved

Well-Behaved & Ill-Behaved DOS Programs



eXtended Memory Support

* History of XMS:
  - “Discovery” of the HMA
  - VDISK

* How it works:
  - Memory above 1 Meg Address Barrier
  - XMS Manager below 1 Meg supplies entry point
  - XMM transfers blocks of memory back and forth

* How we do it:
  - Support XMS calls in the Monitor thread
  - Use VM and Pager to remap VM into User Specified Areas

Expanded Memory Support

* History of DOS memory expansion
    - 640K barrier

* How it works:
    - Holes in HMA
    - Banks of RAM on Expansion slot card
    - EMM manager supplies entry point INT 0x67

* How we do it:
    - Support INT 0x67 calls in the Monitor thread
    - Use VM and Pager to remap VM chunks into HMA hole

Monitor Thread Video Support

* Redirect all video calls but console I/O

* Console I/O special case:
  - DOS programs are silly wrt tty output
  - Monitor thread intercepts all DOS strings commands
  - Incredibly slow

* SuperVGA support

Monitor Thread Disk Support

* Monitor thread support:
  - DOS Hard Disk Support
    - Setup hard disk vtoc to point to DOS HD parition
    - Supports DOS HUGE file systems, systid = 1,4,6
    - Utilizes “/dev/dosdisk” file
  - Floppy Disks support
    - Raw device file access or floppy image support
    - Utilizes “ms.dos” file

User Level Support

* Multithreaded Mach Task:
  - Exception Handler Thread (Monitor)
    - Disk Emulation
    - EMS, XMS Emulation
    - Video Support
  - I/O Threads
    - Timer Thread
    - Mouse Thread
    - Keyboard Thread

Mach DOS Kernel Support

* V86 Thread Maintenance:
  - `thread_get_state, thread_set_state`
  - Thread flavors
    - `I386_THREAD_STATE`
    - `I386_ISA_PORT_MAP_STATE`
    - `I386_V86_ASSIST_STATE`
* Emulation of Hardware V86 Faults:
  - enable/disable interrupts (STI/CLI)
  - push or pop flag register (PUSHF/POPF)
  - return from interrupt (IRET)
* Simulation of External Interrupts Within the V86 Thread

4 Things to Remember:

1. We setup VM to look like DOS

2. We load the actual DOS boot code into the VM

3. Setup a special thread in V86 mode to point to boot code

4. Let V86 thread run and have the monitor thread catch any instructions that cause exceptions

Run Time Narration Continued...

5. Load DOS Boot Image
   - Use DOS Hard Disk partition or Floppy Drive/Image
   - DOS boot address is 0x0070:0000

6. Setup V86 Thread
   - Use `thread_set_state` to create V86 mode thread
   - Set the exception port to handle GP faults
   - Setup the thread's registers
   - enable I/O ports for the thread

7. Create the I/O threads

8. Resume I/O threads and V86 thread

9. Service V86 thread's Exception Port

What Happens at Run time?

1. Mach DOS (Mdos) code loaded high at 3 Meg

2. Checks to make sure running on console

3. Sets up task's VM:
   - VM allocates DOS address space from 0 to 3 Meg
   - Maps in the VGA RAM and BIOS ROM at 0xa0000
   - Uses External Pager to create High Memory Area Wrap at 1 Meg
   - Create EMS and XMS VM and initialize their data structures

4. Intialize the VGA
   - Saves the startup VGA register state (70 Registers)
   - Allocate VM for VGA RAM (256K currently)
   - Store VGA Fonts and Memory for Exit and Pausing

How DOS Programs Operate

System Calls:

- Load Registers with parameters
- Call OS with the INT n instruction
- Return values in Registers

BIOS:

- ROM device drivers for resident hardware
- Interface exported to user via INT call

DOS:

- General Purpose OS code
- Interface exported to user via INT call

8086 Addressing and V86 Mode

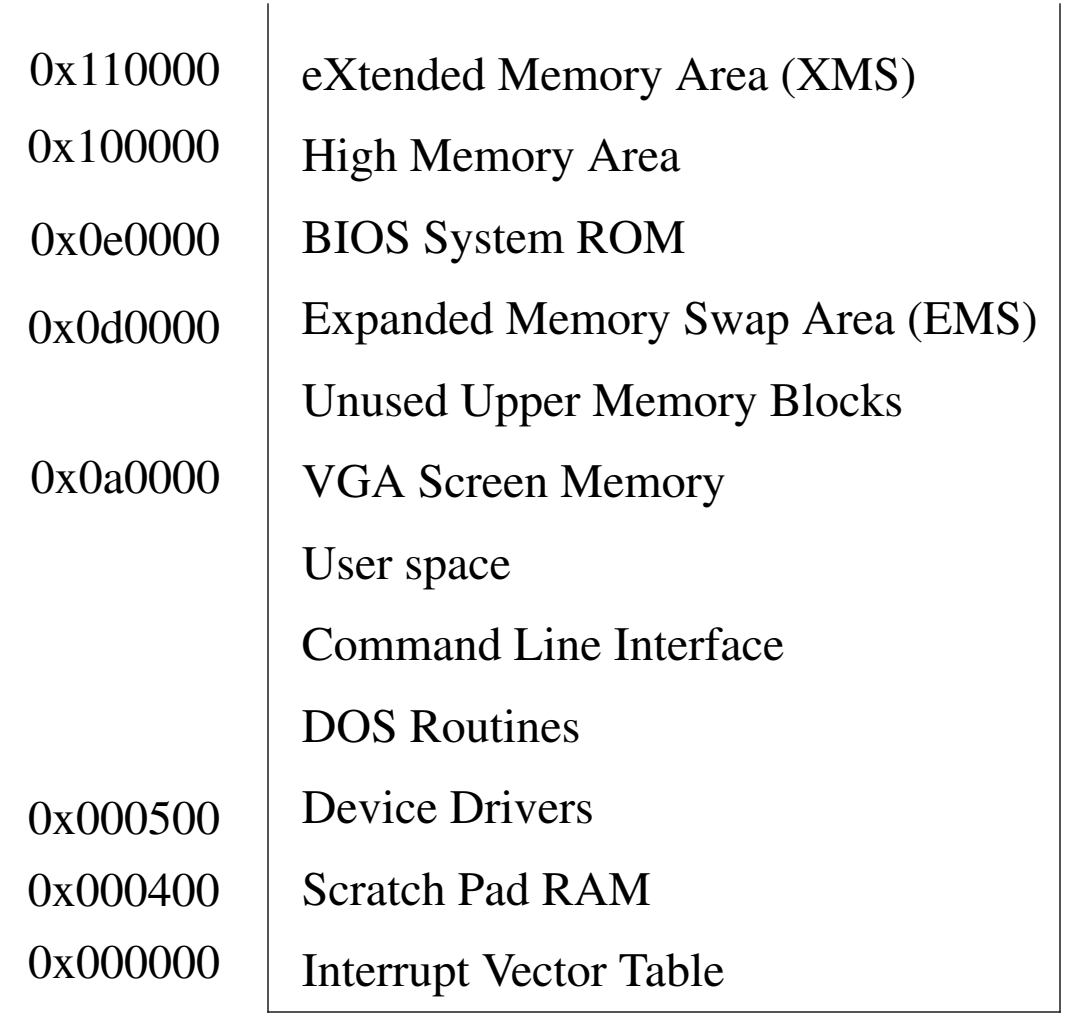
8086 Addressing:

- 16 bit Segment Register
- 16 bit Offset Register
- 20 bit Address = Segment << 4 + Offset
- Max address is 0x100000 (0x10FFEF)

Virtual 8086 Mode:

- Hardware mode operates with Virtual Memory
- Emulates 8086 instruction execution and addressing
- Privileged Operations cause General Protection Exceptions
- Exceptions handed to kernel

DOS Machine's Memory Layout



DOS Basics

* Memory layout of DOS machine

* 8086 Addressing Scheme

* Virtual 8086 (V86 Mode)

* How DOS programs operate

Outline

* Overview of Mach DOS work

* Brief review of DOS

* Kernel Changes

* User Level Implementation

Mach DOS Internals

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