System Calls

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2002 Linux kernel trace seminar

Agenda

- What is the system call ?
- How system calls are invoked ?
- Flow control for system call
- System calls
  - system_call
  - lcall7 / lcall27

System calls

- Application point of view : just a function call
- Kernel point of view : service provider

What is a System Call?

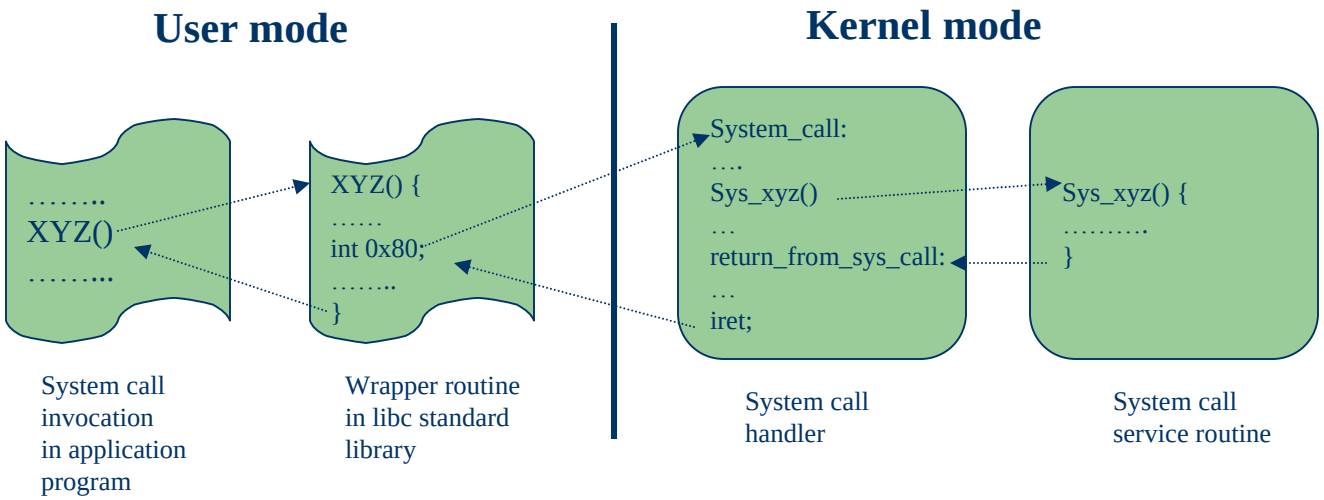
- Interface between user process and kernel
- Occurs when a user process requests a service the kernel provides by calling a special function
- System calls guard access to resources that the kernel manages
  - I/O (open,close,read,write and poll….)
  - Process(fork,execve,kill …..)
  - Time(time, settimeofday….)
  - Memory(mmap,brk……)

What is a System Call?(Cont)

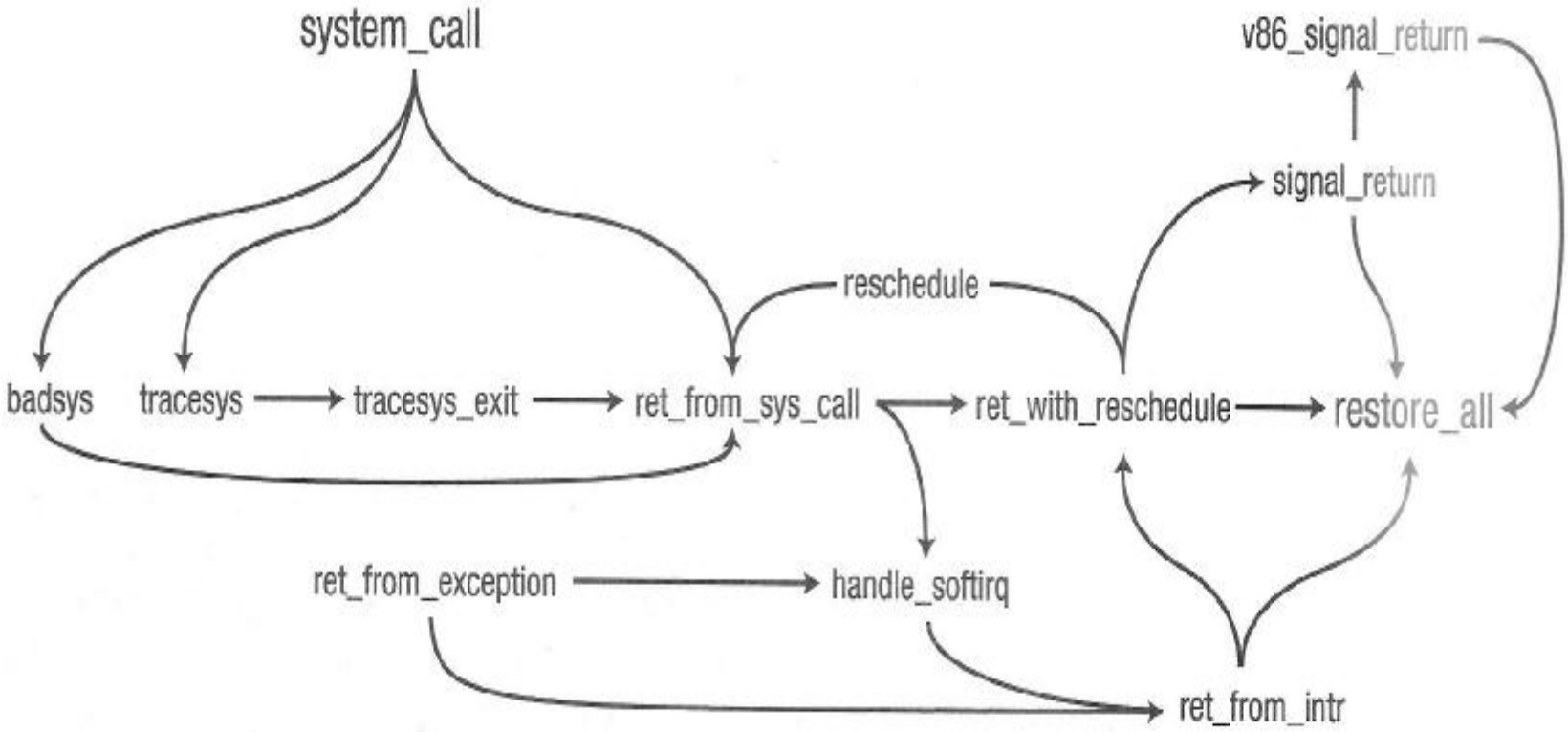
- Return value
  - By conventional, zero or positive to indicate success; negative return value to indicate an error
  - A few system calls can return large negative values even on success(such as lseek)

How System Calls Are Invoked?

- system_call : entry point for all system calls
- lcall7 : used for iBCS2
- lcall27 : used for Solaries/x86 support

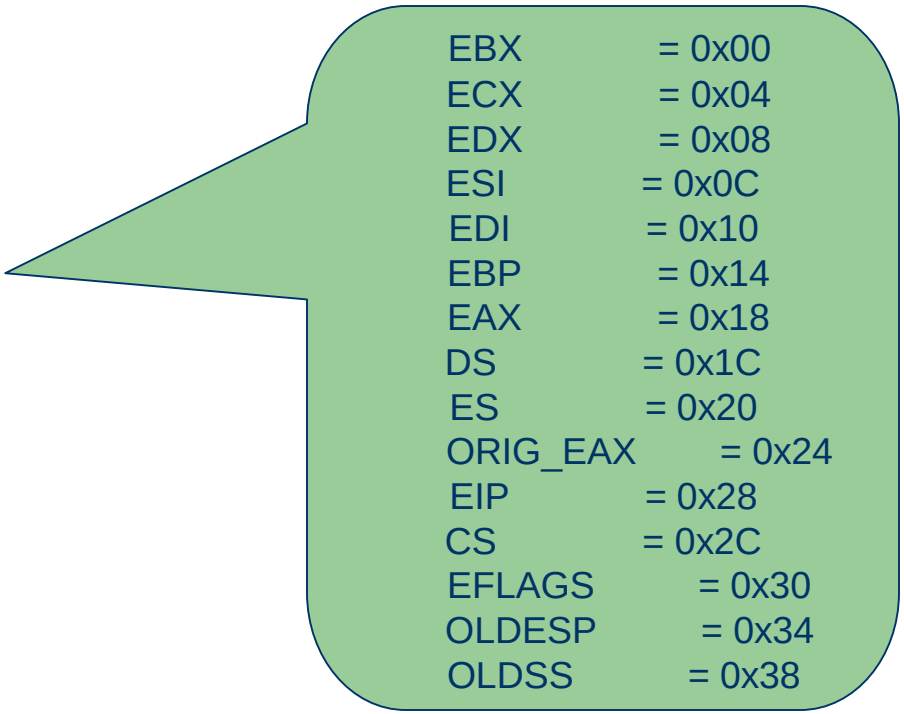


Flow control for system_call



Stack layout

0(%esp) - %ebx
4(%esp) - %ecx
8(%esp) - %edx
C(%esp) - %esi
10(%esp) - %edi
14(%esp) - %ebp
18(%esp) - %eax
1C(%esp) - %ds
20(%esp) - %es
24(%esp) - orig_eax
28(%esp) - %eip
2C(%esp) - %cs
30(%esp) - %eflags
34(%esp) - %oldesp
38(%esp) - %oldss



Sys_call_table

```
ENTRY(sys_call_table)
        .long SYMBOL_NAME(sys_ni_syscall) /* 0  -  old "setup()"
system call*/
        .long SYMBOL_NAME(sys_exit)
        .long SYMBOL_NAME(sys_fork)
        .long SYMBOL_NAME(sys_read)
        .long SYMBOL_NAME(sys_write)
        .long SYMBOL_NAME(sys_open)                    /* 5 */
        .long SYMBOL_NAME(sys_close)
        .long SYMBOL_NAME(sys_waitpid)
        .long SYMBOL_NAME(sys_creat)
        .long SYMBOL_NAME(sys_link)
         ……..
         ……..
         ……...
```

System_call(1)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)    # PT_TRACESYS
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)             # save the return value
ENTRY(ret_from_sys_call)
   cli                             # need_resched and signals atomic test
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
#define SAVE_ALL
        cld;
        pushl %es;
        pushl %ds;
        pushl %eax;
        pushl %ebp;
        pushl %edi;
        pushl %esi;
        pushl %edx;
        pushl %ecx;
        pushl %ebx;
movl $(__KERNEL_DS),%edx;
        movl %edx,%ds;
        movl %edx,%es;
```

System_call(2)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)    # PT_TRACESYS
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)             # save the return value
ENTRY(ret_from_sys_call)
   cli             # need_resched and signals atomic test
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
#define GET_CURRENT(reg)
    movl $-8192, reg;
    andl %esp, reg
```

System_call(3)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)    # PT_TRACESYS
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)           # save the return value
ENTRY(ret_from_sys_call)
   cli             # need_resched and signals atomic test
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
movl $-ENOSYS,EAX(%esp)
jmp ret_from_sys_call
```

System_call(4)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)      # save the return value
ENTRY(ret_from_sys_call)
   cli             # need_resched and signals atomic te
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
tracesys:
    movl $-ENOSYS,EAX(%esp)
    call SYMBOL_NAME(syscall_trace)
    movl ORIG_EAX(%esp),%eax
    cmpl $(NR_syscalls),%eax
    jae tracesys_exit
    call *SYMBOL_NAME(sys_call_table)(,%eax,4)
    movl %eax,EAX(%esp)
tracesys_exit:
    call SYMBOL_NAME(syscall_trace)
    jmp ret_from_sys_call
```

System_call(5)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)    # PT_TRACESYS
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)      # save the return value
ENTRY(ret_from_sys_call)
   cli             # need_resched and signals atomic test
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
call SYMBOL_NAME(schedule)
jmp ret_from_sys_call
```

```
sti
testl $(VM_MASK),EFLAGS(%esp)
movl %esp,%eax
jne v86_signal_return
xorl %edx,%edx
call SYMBOL_NAME(do_signal)
jmp restore_all
```

System_call(6)

```
ENTRY(system_call)
   pushl %eax                  # save orig_eax
   SAVE_ALL
   GET_CURRENT(%ebx)
   cmpl $(NR_syscalls),%eax
   jae badsys
   testb $0x02,tsk_ptrace(%ebx)    # PT_TRACESYS
   jne tracesys
   call *SYMBOL_NAME(sys_call_table)(,%eax,4)
   movl %eax,EAX(%esp)      # save the return value
ENTRY(ret_from_sys_call)
   cli             # need_resched and signals atomic test
   cmpl $0,need_resched(%ebx)
   jne reschedule
   cmpl $0,sigpending(%ebx)
   jne signal_return
restore_all:
   RESTORE_ALL
```

```
#define RESTORE_ALL
   popl %ebx;
   popl %ecx;
   popl %edx;
   popl %esi;
   popl %edi;
   popl %ebp;
   popl %eax;
1:      popl %ds;
2:      popl %es;
   addl $4,%esp;
3:      iret;
```

lcall7

```
ENTRY(lcall7)
  pushfl     # We get a different stack layout with call
  pushl %eax # gates, which has to be cleaned up later..
  SAVE_ALL               # due to call gates,
  movl EIP(%esp),%eax     # this is eflags, not eip..
  movl CS(%esp),%edx      # this is eip..
  movl EFLAGS(%esp),%ecx  # and this is cs..
  movl %eax,EFLAGS(%esp)  #
  movl %edx,EIP(%esp)     # Now we move them to their
  movl %ecx,CS(%esp)      # "normal" places
  movl %esp,%ebx
  pushl %ebx
  andl $-8192,%ebx        # GET_CURRENT
  movl exec_domain(%ebx),%edx  # Get the execution domain
  movl 4(%edx),%edx       # Get lcall7 handler for domain
  pushl $0x7
  call *%edx
  addl $4, %esp
  popl %eax
  jmp ret_from_sys_call
```

lcall27

```
ENTRY(lcall27)
  pushfl      # We get a different stack layout with call
  pushl %eax  # gates, which has to be cleaned up later..
  SAVE_ALL              # due to call gates,
  movl EIP(%esp),%eax     # this is eflags, not eip..
  movl CS(%esp),%edx      # this is eip..
  movl EFLAGS(%esp),%ecx  # and this is cs..
  movl %eax,EFLAGS(%esp)  #
  movl %edx,EIP(%esp)     # Now we move them to their
  movl %ecx,CS(%esp)      # "normal" places
  movl %esp,%ebx
  pushl %ebx
  andl $-8192,%ebx        # GET_CURRENT
  movl exec_domain(%ebx),%edx  # Get the execution domain
  movl 4(%edx),%edx       # Get lcall7 handler for domain
  pushl $0x27
  call *%edx
  addl $4, %esp
  popl %eax
  jmp ret_from_sys_call
```

Reference

- Linux Core Kernel Commentary
  second edition
- Understanding the LINUX KERNEL
  O'reilly
- Cross-Referencing Linux
  - http://lxr.linux.no/