System Calls

What to Expect?

- W's of System Calls
- System Call vs Library Function
- System Call Tracing
- Hands-On

W's of System Calls

- User programs vs Kernel programs
  - Runs in different spaces
  - Runs with different privileges
  - User space not allowed access to Kernel space
  - But they need the Kernel services
- OS provides service points
  - For User programs
  - To request services from the Kernel
- In Linux, these are called System Calls

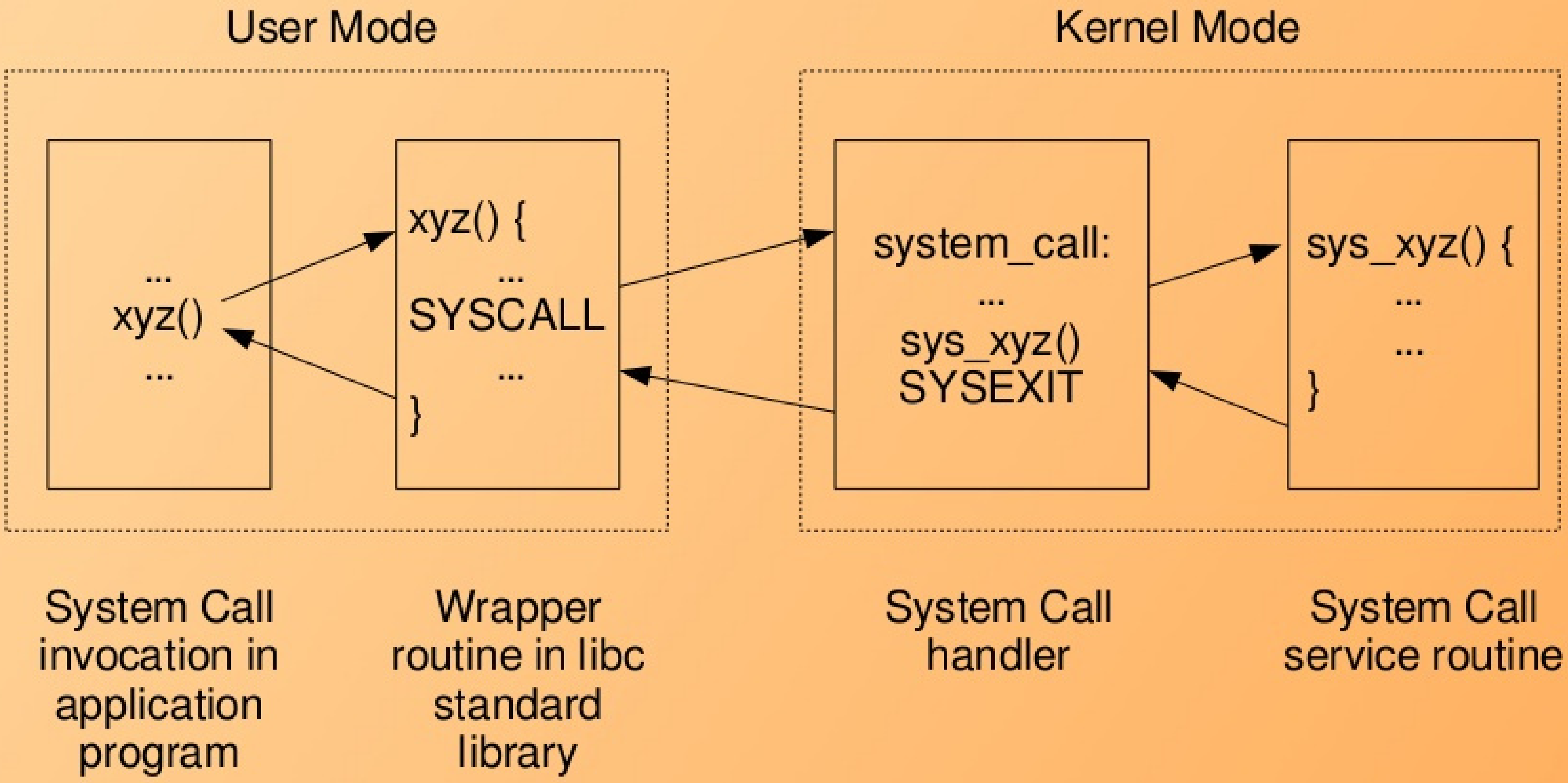
System Calls in Linux

- About 300 in count
- Listing: /usr/include/asm/unistd.h
- Provide layer between
  - Kernel Space (typically hardware)
  - User Space (typically user process)
- Serve three purposes
  - Provide an Abstracted h/w interface for user space
  - Ensures System security and stability
  - Makes Process Management easier

Working of a Linux System Call

- Implemented as an ordinary function in the Linux Kernel
- Executes like others in the Kernel Space
- However, the call to that function isn't ordinary
- When a user program makes a system call
  - Arguments are packaged up and handed to the kernel
  - A special procedure is required to transfer control to the kernel
  - Kernel takes over execution of the program until the call completes
  - Kernel transfers control back to the program with return value
- Special procedure is typically achieved using “trap”

System Call Execution Flow



Linux System Call Wrappers

- Every System Call has standard steps
- GNU C library (glibc) abstracts them
  - By wrapping with functions of same name
  - For easy invocation
- Examples
  - I/O functions: open, read, ...
- We rarely invoke direct system calls
  - But rather these system call (wrapper) functions
- Any Exception?
  - Custom defined system call – using syscall(sno, ...)

Contrast with a Library Function

- A library function is an ordinary function
- It resides in a library external to the program
  - But in the User Space only
- Moreover, the call to it is also ordinary
  - Arguments placed in processor registers or the stack
  - Execution transferred to the start of the function
    - Typically resides in a loaded shared library
    - In the User Space only
- Examples
  - fopen, printf, getopt, mkstemp (all from glibc)

Return Values

- Library functions often return pointers
  - Example: FILE * fp = fopen("harry","r");
  - NULL indicates failure
- System calls usually return an integer
  - Example: int res = open(“harry”, O_RDONLY);
  - Return value
    - >= 0 indicates success
    - < 0, typically -1 indicates failure, and error is set in errno
- Note the counter intuitive return of System Calls
  - Opposite way round
  - Cannot use as Boolean

More Information

- Manual Sections
  - 2 System calls e.g. _exit, read, write
  - 3 Library calls e.g. exit, printf
  - 7 Miscellaneous e.g. ascii, fifo, pthreads
  - 9 POSIX Programmer Manual
- Info pages are also available

Tracing System Calls

- Command: strace <program> [args]
- Traces the execution of <program>
- And Lists
  - System Calls made by <program>
  - Signals received by <program>
- Controlled by various options
  - An interesting one is “-e”
- Example
  - strace cat /dev/null

Pros & Cons

- Pros
  - System calls provide direct & hence more control over the kernel services
  - Library functions abstract the nitty-gritty of architecture or OS specific details of the system calls
  - Library functions can provide wrappers over repeated set of system calls
- Cons
  - Library functions may have overheads
  - System calls at times may expose the underlying system dependency

Let's try some Examples

- System Call Invocation
- System calls vs Library functions
  - File Operations
- Observe the various system calls invoked
  - Use strace

System Call: access

- Helps to determine whether the calling process has access permission for a particular file
- int access(const char *pathname, int mode);
  - pathname – Path to the file
  - mode – Accessibility checks. F_OK or a mask consisting of bitwise or of R_OK, W_OK and X_OK

System Call: fcntl

- Is used for performing the various advanced operations on an open file descriptor
- It allows to place a read or write lock on the file
- More than one process can hold the read lock, while only one process can hold the write lock
- int fcntl(int fd, int cmd, ... /* arg */)
  - fd – File descriptor
  - cmd – Operation to perform
  - ... – Arguments

What all have we learnt?

- W's of System Calls
  - Working of a System Call & syscall()
  - System Call Wrapper Functions
- System Call vs Library Function
  - Pros & Cons
- System Call Tracing
- Hands-On

Any Queries?