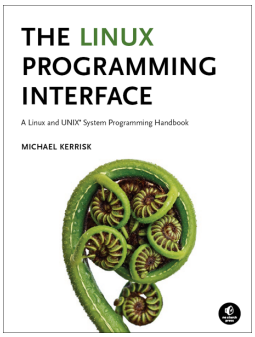
man7.org
Training and Consulting

Linux/UNIX System Programming Fundamentals

Course code: M7D-SPINTRO01

This two-day course provides a sound understanding of the basic operating system features and low-level interfaces (principally, system calls and library functions) that are used to build system-level applications on Linux and UNIX systems ranging from embedded processors to enterprise servers. Detailed presentations coupled with many carefully designed practical exercises provide participants with the knowledge needed to write complex system-level applications. The course provides the fundamental knowledge that is required by the follow-on course *Linux/UNIX IPC Programming* (M7D-IPC02) and also provides the recommended preparation for the course *Linux Security and Isolation APIs* (M7D-SECISOL02).



Audience and prerequisites

The audience for this course includes programmers developing and porting system-level applications for Linux and UNIX systems, embedded application developers, security engineers, site reliability engineers, and DevOps engineers.

To get the most out of the course, participants should have:

- Good reading knowledge of the C programming language
- Solid programming experience in a language suitable for completing the course exercises (e.g., C, C++, D, Go, Rust, or Python)
- Knowledge of basic UNIX/Linux shell commands

Previous system programming experience is *not* required.

Course duration and format

Two days, with up to 40% devoted to practical sessions.

Course materials

- Course books (written by the trainer) that include all slides and exercises presented in the course
- A copy of the trainer's book, *The Linux Programming Interface*
- Numerous example programs written by the course trainer

Course inquiries and bookings

For inquiries about courses and consulting, you can contact us in the following ways:

- Email: training@man7.org
- Phone: +49 (89) 2488 6180 (German landline)

Prices and further details

For course prices and further information, please visit the course web page, `http://man7.org/training/spintro/`.

About the trainer

Michael Kerrisk has a unique set of qualifications and experience that ensure that course participants receive training of a very high standard:

- He has been programming on UNIX systems since 1987.
- He has more than two decades of experience as a teacher and trainer, and first began teaching UNIX system programming courses in 1989.
- He is the author of *The Linux Programming Interface*, a 1550-page book acclaimed as the definitive work on Linux system programming.
- He has been actively involved in Linux development, working with kernel developers on testing, review, and design of new Linux kernel–user-space APIs.
- Since 2000, he has been the involved in the Linux *man-pages* project, which provides the manual pages documenting Linux system calls and C library APIs, and was the project maintainer from 2004 to 2021.

Linux/UNIX System Programming Fundamentals: course contents in detail

Topics marked with an asterisk (*) are optional, and will be covered as time permits

1. **Course Introduction**
2. **Fundamental Concepts**
   - System calls and library functions
   - Error handling
   - System data types
   - Notes on code examples
3. **File I/O**
   - File I/O overview
   - *open()*, *read()*, *write()*, and *close()*
4. **File I/O Buffering**
   - Kernel buffering
   - User-space (*stdio*) buffering
   - Controlling kernel buffering
5. **File I/O: Further Details**
   - The file offset and *lseek()*
   - Atomicity
   - Relationship between file descriptors and open files
   - Duplicating file descriptors
   - File status flags (and *fcntl()*)
   - Other file I/O interfaces (*)
6. **Files**
   - Inodes
   - Retrieving file information: *stat()*
   - File type and mode
   - The process umask
   - Changing file attributes
7. **Directories and Links (*)**
   - Directories and (hard) links
   - Symbolic links
   - Hard links: system calls and library functions
   - Symbolic links: system calls and library functions
   - Current working directory
   - Operating relative to a directory (*openat()* etc.)
   - Scanning directories
8. **Processes**
   - Process IDs
   - Process memory layout
   - Command-line arguments
   - The environment list
   - Process credentials
   - Process groups and sessions (*)
   - Nonlocal gotos
   - The `/proc` filesystem
9. **Signals**
   - Overview of signals
   - Signal dispositions
   - Useful signal-related functions
   - Signal handlers
   - Signal sets, the signal mask, and pending signals
   - Designing signal handlers
10. **Signals: Signal Handlers**
    - Async-signal-safe functions
    - Interrupted system calls
    - `SA_SIGINFO` signal handlers
    - The signal trampoline (*)
11. **Process Creation and Termination**
    - Creating a new process: *fork()*
    - File descriptors and *fork()*
    - Process termination
    - Monitoring child processes
    - Orphans and zombies
    - The `SIGCHLD` signal
    - PID file descriptors
12. **Executing Programs**
    - Executing programs: *execve()*
    - The *exec()* library functions
    - File descriptors and *exec()*
    - Process attributes during *fork()* and *exec()*
13. **System Call Tracing with *strace* (*)**
    - Getting started
    - Tracing child processes
    - Filtering *strace* output