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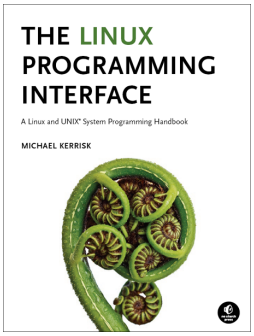
Training and Consulting

Linux/UNIX Threads and IPC Programming

Course code: M7D-TIPC01

This course provides a grounding in multithreaded programming using POSIX threads as well as a deep understanding of various IPC (interprocess communication) techniques that can be used to build cooperating multiprocess applications. Detailed presentations coupled with many carefully designed practical exercises provide participants with the knowledge needed to write complex system, network, and multithreaded applications.



Audience and prerequisites

The audience for this course includes programmers developing and porting system-level and network 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

Some system programming background is assumed. Where necessary, such background can be gained from either the *Linux System Programming Fundamentals* (M7D-SPINTRO01) or the *Linux System Programming Essentials* (M7D-SPESSO01) course.

Course duration and format

Three 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
- An electronic 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, dates, and further details

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

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 Threads and IPC Programming: course contents in detail

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

1. **Threads: Introduction**
   - Overview of threads
   - Pthreads API basics
   - Thread creation and termination
   - Thread IDs
   - Joining and detaching threads
   - Thread attributes
   - Signals and threads
   - Threads and process control
2. **Threads: Synchronization**
   - Shared resources and critical sections
   - Mutexes
   - Locking and unlocking a mutex
   - Condition variables
   - Signaling and waiting on condition variables
   - Further details on signaling condition variables
   - Dynamically initialized synchronization primitives
   - Other synchronization primitives
3. **IPC: Introduction and Overview (*)**
   - Categorizing IPC
   - Choosing an IPC mechanism
4. **Pipes and FIFOs**
   - Creating and using pipes
   - FIFOs
   - Connecting filters with pipes
5. **Sockets: Introduction**
   - Socket types and domains
   - Creating and binding a socket (*socket()* and *bind()*)
   - Overview of stream sockets
   - *listen()* and pending connections
   - *accept()* and *connect()*
   - I/O on stream sockets
   - Overview of datagram sockets
   - I/O on datagram sockets
6. **Internet Domain Sockets**
   - Internet domain sockets
   - Data-representation issues
   - Presentation-format addresses
   - Loopback and wildcard addresses
   - Internet domain stream sockets example
7. **Internet Domain Sockets: Address Conversion**
   - Host addresses and port numbers
   - Host and service conversion
   - Internet domain sockets example with *getaddrinfo()*
8. **Sockets: Further Details**
   - Socket shutdown (*shutdown()*)
   - Socket options
   - TCP TIME-WAIT state and `SO_REUSEADDR`
9. **UNIX Domain Sockets**
   - UNIX domain stream sockets
   - UNIX domain datagram sockets
   - Further details of UNIX domain sockets
10. **Alternative I/O Models**
    - Nonblocking I/O
    - Signal-driven I/O
    - I/O multiplexing: *poll()*
    - Event-loop programming
11. **Alternative I/O Models: *epoll***
    - Problems with *poll()* and *select()*
    - The *epoll* API
    - Creating an *epoll* instance: *epoll_create()*
    - Populating the interest list: *epoll_ctl()*
    - *epoll* events
    - Waiting for events: *epoll_wait()*
    - Performance considerations
    - Edge-triggered notification
    - *epoll* API quirks
12. **POSIX Semaphores**
    - Named semaphores
    - Semaphore operations
    - Unnamed semaphores
13. **POSIX Shared Memory**
    - Creating and opening a shared memory object
    - Mapping a shared memory object (*mmap()*)
    - Using shared memory objects
    - Synchronizing access to shared memory