
Contents

Foreword	vii
Preface	ix
1 LINUX – the operating system	1
1.1 Main characteristics	3
1.2 Linux distributions	5
2 Compiling the kernel	6
2.1 Where is everything?	6
2.2 Compiling	9
2.3 Additional configuration facilities	11
3 Introduction to the kernel	15
3.1 Important data structures	20
3.1.1 The task structure	20
3.1.2 The process table	29
3.1.3 Files and inodes	31
3.1.4 Dynamic memory management	33
3.1.5 Queues and semaphores	34
3.1.6 System time and timers	36
3.2 Main algorithms	37
3.2.1 Signals	37
3.2.2 Interrupts	39
3.2.3 Booting the system	41
3.2.4 Timer interrupt	44
3.2.5 The scheduler	47

3.3	Implementing system calls	51	5.5.1	Access permissions, numbers and keys	125
3.3.1	How do system calls actually work?	51	5.5.2	Semaphores	126
3.3.2	Examples of simple system calls	53	5.5.3	Message queues	130
3.3.3	Examples of more complex system calls	55	5.5.4	Shared memory	133
3.3.4	Implementing a new system call	65	5.5.5	The <code>ipcs</code> and <code>ipcrm</code> commands	137
4	Memory management	70	5.6	IPC with sockets	138
4.1	The architecture-independent memory model in LINUX	72	5.6.1	A simple example	139
4.1.1	Pages of memory	72	5.6.2	The implementation of UNIX domain sockets	143
4.1.2	Virtual address space	72	6	The LINUX file system	148
4.1.3	Converting the linear address	73	6.1	Basic principles	149
4.1.4	The page directory	74	6.2	The representation of file systems in the kernel	152
4.1.5	The page middle directory	75	6.2.1	Mounting	153
4.1.6	The page table	76	6.2.2	Superblock operations	155
4.2	The virtual address space for a process	79	6.2.3	The inode	158
4.2.1	The user segment	79	6.2.4	Inode operations	161
4.2.2	Virtual memory areas	81	6.2.5	The file structure	165
4.2.3	The system call <code>brk</code>	85	6.2.6	File operations	165
4.2.4	Mapping functions	86	6.2.7	Opening a file	169
4.2.5	The kernel segment	86	6.2.8	The directory cache	172
4.2.6	Static memory allocation in the kernel segment	88	6.3	The <i>Proc</i> file system	173
4.2.7	Dynamic memory allocation in the kernel segment	88	6.4	The <i>Ext2</i> file system	179
4.3	Block device caching	92	6.4.1	The structure of the <i>Ext2</i> file system	180
4.3.1	Block buffering	92	6.4.2	Directories in the <i>Ext2</i> file system	182
4.3.2	The <code>update</code> and <code>bdflush</code> processes	94	6.4.3	Block allocation in the <i>Ext2</i> file system	183
4.3.3	List structures for the buffer cache	95	6.4.4	Extensions of the <i>Ext2</i> file system	184
4.3.4	Using the buffer cache	96	7	Device drivers under LINUX	186
4.4	Paging under LINUX	98	7.1	Character and block devices	188
4.4.1	Page cache and management	100	7.2	Polling and interrupts	190
4.4.2	Finding a free page	101	7.2.1	Polling mode	190
4.4.3	Page errors and reloading a page	106	7.2.2	Interrupt mode	191
5	Inter-process communication	108	7.2.3	Interrupt sharing	193
5.1	Synchronization in the kernel	110	7.2.4	Bottom halves	194
5.2	Communication via files	114	7.2.5	Task queues	196
5.2.1	Locking entire files	115	7.2.6	DMA mode	198
5.2.2	Locking file areas	116	7.3	The hardware	200
5.3	Pipes	119	7.3.1	Hardware detection	203
5.4	Debugging using <code>ptrace</code>	121	7.3.2	Automatic interrupt detection	205
5.5	System V IPC	125	7.4	Implementing a driver	207
			7.4.1	The setup function	209
			7.4.2	<code>init</code>	210
			7.4.3	<code>open</code> and <code>release</code>	212

7.4.4	read and write	214	8.7.3	Functions of TCP	273
7.4.5	IOCTL	217	8.8	The packet interface – an alternative?	277
7.4.6	select	219	9	Modules and debugging	279
7.4.7	lseek	220	9.1	What are modules?	279
7.4.8	mmap	220	9.2	Implementation in the kernel	280
7.4.9	readdir, fsync and fasync	221	9.2.1	Signatures of symbols	283
7.4.10	check_media_change and revalidate	221	9.3	What can be implemented as a module?	283
7.5	An example of DMA operation	221	9.4	Parameter passing	285
8	Network implementation	227	9.5	The kernel daemon	285
8.1	Introductory summary	228	9.6	An example module	287
8.1.1	The layer model of the network implementation	229	9.7	Debugging	289
8.1.2	Getting the data from A to B	230	9.7.1	Changes are the beginning of the end	289
8.2	Important structures	234	9.7.2	The best debugger – printk()	290
8.2.1	The socket structure	234	9.7.3	Debugging with gdb	291
8.2.2	The sk_buff structure – buffer management in the network	235	10	Multi-processing	293
8.2.3	The INET socket – a special part of a socket	239	10.1	The Intel multi-processor specification	293
8.2.4	Protocol operations in the proto structure	243	10.2	Problems with multi-processor systems	295
8.2.5	The general structure of a socket address	246	10.3	Changes to the kernel	296
8.3	Network devices under LINUX	247	10.3.1	Kernel initialization	296
8.3.1	Ethernet	254	10.3.2	Scheduling	297
8.3.2	SLIP and PLIP	255	10.3.3	Message exchange between processors	298
8.3.3	The loopback device	255	10.3.4	Entering kernel mode	298
8.3.4	The dummy device	255	10.3.5	Interrupt handling	299
8.4	ARP – the Address Resolution Protocol	256	10.4	Compiling LINUX SMP	300
8.5	IP	259	APPENDIX A – System calls	301	
8.5.1	IP – general introduction	259	A.1	Process management	302
8.5.2	IP functions	260	A.2	The file system	339
8.5.3	Routing	263	A.3	Communication	370
8.5.4	IP multicasting and IGPM	265	A.4	Memory management	373
8.5.5	IP packet filters	267	A.5	Initialization	378
8.5.6	IP accounting and IP firewalling	268	A.6	All that remains	379
8.6	UDP	269	APPENDIX B – Kernel-related commands	380	
8.6.1	Functions of UDP	269	B.1	free – synopsis of the system memory	380
8.6.2	Other functions	271	B.2	ps – display of process statistics	381
8.7	TCP	271	B.3	Additional kernel configuration	386
8.7.1	General notes on TCP	271	B.4	top – the CPU charts	387
8.7.2	The TCP communication end-point – a finite state machine	272	B.5	init – primus inter pares	389
			B.6	shutdown – shutting down the system	395
			B.7	strace – monitoring a process	396

B.8	Configuring the network interface	400
B.9	traceroute – Ariadne’s thread in the Internet	400
B.10	Configuring a serial interface	403
B.11	Configuring a parallel interface	405
B.12	mount	407
APPENDIX C – The <i>Proc</i> file system		415
C.1	The <code>/proc/</code> directory	415
C.2	The <code>net/</code> directory	421
C.3	The <code>self/</code> directory	422
C.4	The <code>sys/</code> directory	426
APPENDIX D – The boot process		428
D.1	Carrying out the boot process	428
D.2	LILO – the Linux loader	431
D.2.1	LILO started by MS-DOS MBR	431
D.2.2	LILO started by a boot manager	431
D.2.3	LILO in the master boot record	432
D.2.4	LILO files	432
D.2.5	LILO boot parameters	437
D.2.6	LILO start-up messages	439
D.2.7	Error messages	439
APPENDIX E – Useful kernel functions		441
References		457
Index		461