

Лабораторная работа №10

Основы работы с модулями ядра операционной системы

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Цель работы

Получение практических навыков управления модулями ядра, их загрузки, выгрузки и обновления ядра в операционной системе **Rocky Linux**.

Ход выполнения работы

```
haoladar@haoladar:~$ su
Password:
root@haoladar:/home/haoladar# lspci -k
00:00.0 Host bridge: Intel Corporation 440FX - 82441FX PMC [Natoma] (rev 02)
00:01.0 ISA bridge: Intel Corporation 82371SB PIIX3 ISA [Natoma/Triton II]
00:01.1 IDE interface: Intel Corporation 82371AB/EB/MB PIIX4 IDE (rev 01)
Kernel driver in use: ata_piix
Kernel modules: ata_piix, ata_generic
00:02.0 VGA compatible controller: VMware SVGA II Adapter
Subsystem: VMware SVGA II Adapter
Kernel driver in use: vmwgfx
Kernel modules: vmwgfx
00:03.0 Ethernet controller: Intel Corporation 82540EM Gigabit Ethernet Controller (rev 02)
Subsystem: Intel Corporation PRO/1000 MT Desktop Adapter
Kernel driver in use: e1000
Kernel modules: e1000
00:04.0 System peripheral: InnoTek Systemberatung GmbH VirtualBox Guest Service
Kernel driver in use: vboxguest
Kernel modules: vboxguest
00:05.0 Multimedia audio controller: Intel Corporation 82801AA AC'97 Audio Controller (rev 01)
Subsystem: Dell Device 0177
Kernel driver in use: snd_intel8x0
Kernel modules: snd_intel8x0
00:06.0 USB controller: Apple Inc. KeyLargo/Intrepid USB
Kernel driver in use: ohci-pci
00:07.0 Bridge: Intel Corporation 82371AB/EB/MB PIIX4 ACPI (rev 08)
Kernel driver in use: piix4_smbus
Kernel modules: i2c_piix4
00:0b.0 USB controller: Intel Corporation 82801FB/FBM/FR/FW/FRW (ICH6 Family) USB2 EHCI Controller
Kernel driver in use: ehci-pci
00:0d.0 SATA controller: Intel Corporation 82801HM/HEM (ICH8M/ICH8M-E) SATA Controller [AHCI mode] (rev 02)
Kernel driver in use: ahci
Kernel modules: ahci
root@haoladar:/home/haoladar# █
```

Рис. 1: Список устройств и модулей ядра (lspci -k)

Управление модулями ядра

```
root@haoladar:/home/haoladar#  
root@haoladar:/home/haoladar# lsmod | sort  
ac97_bus             12288    1 snd_ac97_codec  
ahci                  57344    3  
ata_generic          16384    0  
ata_piix              45056    1  
cdrom                 90112    2 isofs,sr_mod  
crc32c_intel         16384    0  
crc32_pclmul         12288    0  
crt10dif_pclmul      12288    1  
dm_log               24576    2 dm_region_hash,dm_mirror  
dm_mirror            28672    0  
dm_mod               245760    9 dm_multipath,dm_log,dm_mirror  
dm_multipath         53248    0  
dm_region_hash       28672    1 dm_mirror  
drm_ttm_helper       16384    2 vmwgfx  
e1000                200704    0  
fuse                 253952    5  
ghash_clmulni_intel  16384    0  
i2c_piix4            36864    0  
i2c_smbus            20480    1 i2c_piix4  
intel_pmc_core       126976    0  
intel_rapl_common    53248    1 intel_rapl_msr  
intel_rapl_msr       20480    0  
intel_uncore_frequency_common 16384    0  
intel_vsec           20480    1 intel_pmc_core  
ip_set               69632    0  
isofs                69632    1  
joydev               28672    0  
libahci              69632    1 ahci  
libata               512000    4 ata_piix,libahci,ahci,ata_generic  
loop                 45056    0  
Module              Size Used by  
nf_conntrack         204800    2 nf_nat,nft_ct  
nf_defrag_ipv4       12288    1 nf_conntrack  
nf_defrag_ipv6       24576    1 nf_conntrack  
nf_nat                69632    1 nft_chain_nat
```

```
root@haoladar: /home/haoladar#  
root@haoladar: /home/haoladar# lsmod | grep ext4  
root@haoladar: /home/haoladar# modprobe ext4  
root@haoladar: /home/haoladar# lsmod | grep ext4  
ext4                1187840  0  
mbcache              16384    1 ext4  
jbd2                  217088    1 ext4  
root@haoladar: /home/haoladar#  
root@haoladar: /home/haoladar# modprobe ext4  
root@haoladar: /home/haoladar# modinfo ext4  
filename:             /lib/modules/6.12.0-55.12.1.el10_0.x86_64/kernel/fs/ext4/ext4.ko.xz  
softdep:              pre: crc32c  
license:              GPL  
description:          Fourth Extended Filesystem  
author:               Remy Card, Stephen Tweedie, Andrew Morton, Andreas Dilger, Theodore Ts'o and others  
alias:                fs-ext4  
alias:                ext3  
alias:                fs-ext3  
alias:                ext2  
alias:                fs-ext2  
rhelversion:          10.0  
srcversion:           CBA9BD0FC931061AEC0A8F4  
depends:               jbd2,mbcache  
intree:               Y  
name:                 ext4  
retpoline:            Y  
vermagic:             6.12.0-55.12.1.el10_0.x86_64 SMP preempt mod_unload modversions  
sig_id:               PKCS#7  
signer:               Rocky kernel signing key  
sig_key:              57:BC:A1:34:94:0D:57:12:99:67:28:D8:C0:8B:1C:4B:8C:8A:13:06  
sig_hashalgo:         sha256  
signature:            05:D7:3D:A0:55:EA:4A:16:70:78:23:1F:C7:9A:17:C6:A9:9C:B5:71:
```

Рис. 3: Загрузка модуля ext4

```
sig_key:      57:BC:A1:34:94:0D:57:12:99:67:28:D8:C0:8B:1C:4B:8C:8A:13:06
sig_hashalgo: sha256
signature:    05:D7:3D:A0:55:EA:4A:16:70:78:23:1F:C7:9A:17:C6:A9:9C:B5:71:
              6B:EB:97:2C:94:5A:49:CB:07:A0:85:2E:27:8D:C4:01:27:43:2A:C8:
              B8:37:9C:AB:EF:B7:D9:AC:70:98:F6:2B:1B:A6:9D:7D:62:0E:8C:2E:
              4E:D6:0E:3F:B9:33:E7:D9:8E:05:F0:70:09:81:08:5F:1E:26:99:E4:
              C2:33:CD:4A:01:B2:F3:17:11:06:81:B2:F8:C6:23:85:76:76:43:9B:
              00:78:01:A7:51:FA:AC:9F:25:39:88:1C:FF:27:C2:AF:0B:30:64:BA:
              D6:FB:2C:81:43:AA:61:09:3E:6B:C8:5C:43:D2:B1:BB:8F:E4:99:95:
              45:FE:EF:EC:B8:E0:3F:A1:50:E8:31:E2:8C:F2:5D:EF:15:87:2D:54:
              98:24:93:D0:B7:A8:17:6B:E7:5A:23:6B:DB:9D:1C:CC:42:F1:5B:2B:
              D5:48:EE:F5:A4:EA:FC:0E:D4:AD:8B:FB:A9:0B:53:DD:33:AD:DA:F4:
              73:F5:28:0B:2B:19:84:75:BB:B6:D5:2E:34:3E:89:53:FB:FD:78:C6:
              FB:83:F0:1D:75:8B:8C:96:8D:87:62:27:B0:58:99:A0:A0:23:E2:A7:
              2B:E7:E7:25:2C:AB:D2:68:A2:C9:44:30:39:FF:46:82:CC:80:DF:CB:
              3A:10:6D:7F:43:6F:35:78:A0:96:EA:BC:3C:31:E4:5F:15:DB:8E:C4:
              01:8F:DB:E7:F9:0D:AF:80:8F:C2:59:13:7D:01:5E:78:18:AE:ED:F8:
              FA:7A:C2:3E:9E:63:B4:57:50:92:28:E8:95:2D:D3:44:C5:8B:F5:C8:
              0A:BE:F5:96:B5:D8:DE:8F:91:DA:85:E5:BF:A2:7D:9B:2A:4C:AD:4E:
              07:54:52:A9:F2:62:B6:D7:58:9F:2E:8D:6A:C2:F4:8E:98:32:EB:14:
              E6:BE:EE:3B:C5:98:36:95:53:D8:61:BD:41:8A:FF:4B:AC:49:70:B2:
              19:94:AF:2A

root@haoladar:/home/haoladar#
root@haoladar:/home/haoladar# modprobe -r ext4
root@haoladar:/home/haoladar# modprobe -r ext4
root@haoladar:/home/haoladar# modprobe -r xfs
modprobe: FATAL: Module xfs is in use.
root@haoladar:/home/haoladar# modprobe -r xfs
modprobe: FATAL: Module xfs is in use.
root@haoladar:/home/haoladar#
```

Рис. 4: Попытка выгрузки модулей ext4 и xfs

Проверка и загрузка модуля bluetooth

```
root@haoladar:/home/haoladar#  
root@haoladar:/home/haoladar# lsmod | grep bluetooth  
root@haoladar:/home/haoladar# modprobe bluetooth  
root@haoladar:/home/haoladar# lsmod | grep bluetooth  
bluetooth                1114112  0  
rfkill                    40960  4 bluetooth  
root@haoladar:/home/haoladar# modinfo bluetooth  
filename:                /lib/modules/6.12.0-55.12.1.el10_0.x86_64/kernel/net/bluetooth/bluetooth.ko.xz  
alias:                   net-pf-31  
license:                 GPL  
version:                 2.22  
description:             Bluetooth Core ver 2.22  
author:                 Marcel Holtmann <marcel@holtmann.org>  
rhelversion:            10.0  
srcversion:              5F9AA895ADC3BA3840211D1  
depends:                  rfkill  
intree:                 Y  
name:                   bluetooth  
retpoline:              Y  
vermagic:               6.12.0-55.12.1.el10_0.x86_64 SMP preempt mod_unload modversions  
sig_id:                 PKCS#7  
signer:                 Rocky kernel signing key  
sig_key:                57:BC:A1:34:94:0D:57:12:99:67:28:D8:C0:8B:1C:4B:8C:8A:13:06  
sig_hashalgo:           sha256  
signature:              2E:24:0B:EE:9E:E6:A3:58:91:2A:D3:87:25:A3:1B:46:06:89:06:BC:  
4A:99:10:8D:7A:0F:1E:FF:92:59:FD:59:74:DB:7E:42:40:14:03:C9:  
43:D0:A3:4F:F3:10:71:07:4D:FF:34:52:96:1A:8B:90:9C:DF:D8:FB:  
07:E9:07:16:2E:8D:4B:23:0C:92:93:0B:88:E9:82:6B:06:1B:BD:25:  
69:7D:37:70:CC:C2:A5:08:85:C9:34:D9:69:1C:28:BB:81:B0:8A:C7:  
9F:AD:5D:46:AB:C1:B2:B1:C4:E3:8B:1A:12:5D:E2:52:D0:42:DD:FD:  
2B:D0:5A:51:5C:6E:AD:0D:FD:90:EB:62:89:91:D2:C8:4A:25:EA:9D:  
CA:B9:BE:27:C7:BB:85:D6:A5:A1:7B:8B:DE:E2:CC:26:F3:D6:D1:D2:  
8C:FF:82:18:76:56:0C:DE:85:BB:B2:BD:8C:56:99:B6:21:B5:3A:ED:  
15:E8:CC:3D:5F:C9:84:65:1C:94:DD:98:ED:03:D3:6D:DE:F3:B7:31:  
19:34:07:1F:19:4A:82:C6:F5:82:F3:3C:87:38:F3:A7:69:66:0E:3B:
```

Проверка параметров модуля bluetooth

```
sig_key: 57:BC:A1:34:94:0D:57:12:99:67:28:D8:C0:8B:1C:4B:8C:8A:13:06
sig_hashalgo: sha256
signature: 2E:24:0B:EE:9E:E6:A3:58:91:2A:D3:87:25:A3:1B:46:06:89:06:BC:
4A:99:10:8D:7A:0F:1E:FF:92:59:FD:59:74:DB:7E:42:40:14:03:C9:
43:D0:A3:4F:F3:10:71:07:4D:FF:34:52:96:1A:88:90:9C:DF:D8:FB:
07:E9:07:16:2E:8D:4B:23:0C:92:93:0B:88:E9:82:6B:06:1B:BD:25:
69:7D:37:70:CC:C2:A5:08:85:C9:34:D9:69:1C:28:BB:81:B0:8A:C7:
9F:AD:5D:46:AB:C1:B2:B1:C4:E3:8B:1A:12:5D:E2:52:D0:42:DD:FD:
2B:D0:5A:51:5C:6E:AD:0D:FD:90:EB:62:89:91:D2:C8:4A:25:EA:9D:
CA:B9:BE:27:C7:BB:85:D6:A5:A1:7B:8B:DE:E2:CC:26:F3:D6:D1:D2:
8C:FF:82:18:76:56:0C:DE:85:BB:B2:BD:8C:56:99:B6:21:B5:3A:ED:
15:E8:CC:3D:5F:C9:84:65:1C:94:DD:98:ED:03:D3:6D:DE:F3:B7:31:
19:34:07:1F:19:4A:82:C6:F5:82:F3:3C:87:38:F3:A7:69:66:0E:3B:
54:25:78:36:FC:A5:17:C0:5A:62:C5:4C:41:F6:FF:87:5F:0C:58:45:
AF:12:D3:12:5D:11:49:20:BD:B1:E1:A4:DB:BA:D3:18:B6:EE:D0:57:
EC:75:3A:A6:0D:E2:36:37:78:C6:BB:DD:9B:1C:67:EB:D2:A8:9F:16:
2B:8A:CF:8F:23:38:B4:7A:A9:92:49:86:D7:9F:08:7D:8A:92:7D:DD:
41:D6:4B:31:F6:45:31:D4:7E:6E:E1:D6:94:BA:D0:6A:12:CC:76:A2:
12:55:EF:6B:91:CB:45:F0:F5:75:0B:DD:7D:6B:D7:E1:B0:13:51:40:
29:D2:1D:3B:DD:E2:BF:AC:4B:77:67:BA:C8:95:16:41:00:9A:8F:96:
21:DC:9A:C2:B2:20:31:5C:EC:90:EA:B0:24:C3:5D:B9:72:31:B8:98:
DB:A9:4D:FE
parm: disable_esco:Disable eSCO connection creation (bool)
parm: disable_ertm:Disable enhanced retransmission mode (bool)
parm: enable_ecred:Enable enhanced credit flow control mode (bool)
root@haoladar:/home/haoladar#
root@haoladar:/home/haoladar#
root@haoladar:/home/haoladar# modprobe -r bluetooth
root@haoladar:/home/haoladar# modprobe -r bluetooth
root@haoladar:/home/haoladar#
```

```
root@haoladar:/home/haoladar#  
root@haoladar:/home/haoladar# uname -r  
6.12.0-55.12.1.el10_0.x86_64  
root@haoladar:/home/haoladar# dnf list kernel  
Rocky Linux 10 - BaseOS                                10 kB/s | 4.3 kB    00:00  
Rocky Linux 10 - AppStream                             17 kB/s | 4.3 kB    00:00  
Rocky Linux 10 - Extras                                5.0 kB/s | 3.1 kB    00:00  
Installed Packages  
kernel.x86_64                                           6.12.0-55.12.1.el10_0    @anaconda  
Available Packages  
kernel.x86_64                                           6.12.0-55.37.1.el10_0    baseos  
root@haoladar:/home/haoladar# dnf upgrade --refresh
```

Рис. 7: Список пакетов ядра и обновление системы

Завершение обновления и проверка версии

```
haoladar@haoladar:~$ uname -r
6.12.0-55.37.1.el10_0.x86_64
haoladar@haoladar:~$ hostnamectl
  Static hostname: haoladar.localdomain
    Icon name: computer-vm
    Chassis: vm 🖥️
  Machine ID: 680b0151ac144c679386de82018881d0
    Boot ID: ca47b22136e3420b817960b0c9a014f3
  Virtualization: oracle
  Operating System: Rocky Linux 10.0 (Red Quartz)
    CPE OS Name: cpe:/o:rocky:rocky:10::baseos
    OS Support End: Thu 2035-05-31
  OS Support Remaining: 9y 7month 1w 5d
    Kernel: Linux 6.12.0-55.37.1.el10_0.x86_64
    Architecture: x86-64
  Hardware Vendor: innotek GmbH
  Hardware Model: VirtualBox
  Firmware Version: VirtualBox
    Firmware Date: Fri 2006-12-01
    Firmware Age: 18y 10month 2w 2d
haoladar@haoladar:~$
```

Итоги работы

- Освоены команды управления модулями ядра (`lsmod`, `modprobe`, `modinfo`)
- Получены навыки загрузки и выгрузки модулей с параметрами
- Изучен процесс обновления ядра ОС **Rocky Linux**
- Закреплены практические приёмы администрирования системы