

Лабораторная работа №10

Основы работы с модулями ядра операционной системы

Сулейм Гамбердов

22 октября 2025

Российский университет дружбы народов, Москва, Россия

Цель работы

Основная цель

Получить навыки работы с утилитами управления модулями ядра операционной системы Linux.

Ход выполнения работы

Просмотр устройств и драйверов

```
sigamberdov@sigamberdov:~$ su
Password:
root@sigamberdov:/home/sigamberdov# 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@sigamberdov:/home/sigamberdov#
```

Просмотр загруженных модулей

```
root@sigamberdov:/home/sigamberdov# 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
crct10dif_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_msrf
intel_rapl_msrf     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
```

Загрузка модуля ext4

```
root@sigamberdov:/home/sigamberdov# lsmod | grep ext4
root@sigamberdov:/home/sigamberdov# modprobe ext4
root@sigamberdov:/home/sigamberdov# lsmod | grep ext4
ext4                  1187840  0
mbcache                  16384  1 ext4
jbd2                   217088  1 ext4
root@sigamberdov:/home/sigamberdov# 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: Информация о модуле ext4

Выгрузка модулей ext4 и xfs

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

Работа с модулем bluetooth

```
root@sigamberdov:/home/sigamberdov# lsmod | grep bluetooth
root@sigamberdov:/home/sigamberdov# modprobe bluetooth
root@sigamberdov:/home/sigamberdov# lsmod | grep bluetooth
bluetooth           1114112  0
rfkill                  40960  4 bluetooth
root@sigamberdov:/home/sigamberdov# 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:ED:90:EB:62:89:91:D2:C8:4A:25:FA:9D:
```

Работа с модулем bluetooth

```
sigkey.
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:
              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_erm:Disable enhanced retransmission mode (bool)
parm:        enable_ecred:Enable enhanced credit flow control mode (bool)
root@sigamberdov:/home/sigamberdov#
root@sigamberdov:/home/sigamberdov# modprobe -r bluetooth
root@sigamberdov:/home/sigamberdov#
```

Обновление ядра

```
root@sigamberdov:/home/sigamberdov#
root@sigamberdov:/home/sigamberdov# uname -r
6.12.0-55.12.1.el10_0.x86_64
root@sigamberdov:/home/sigamberdov# dnf list kernel
Rocky Linux 10 - BaseOS                                8.4 kB/s | 4.3 kB   00:00
Rocky Linux 10 - AppStream                             7.8 kB/s | 4.3 kB   00:00
Rocky Linux 10 - Extras                               10 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@sigamberdov:/home/sigamberdov#
```

Рис. 7: Список доступных версий ядра

Обновление ядра

```
xorg-x11-server-Xwayland-24.1.5-4.el10_0.x86_64
yum-4.20.0-14.el10_0.rocky.0.1.noarch
zlib-ng-compat-2.2.3-1.el10.rocky.0.1.x86_64
zlib-ng-compat-devel-2.2.3-1.el10.rocky.0.1.x86_64
Installed:
  kernel-6.12.0-55.37.1.el10_0.x86_64
  kernel-devel-6.12.0-55.37.1.el10_0.x86_64
  kernel-modules-core-6.12.0-55.37.1.el10_0.x86_64
  libatomic-14.2.1-7.el10.x86_64
                                         kernel-core-6.12.0-55.37.1.el10_0.x86_64
                                         kernel-modules-6.12.0-55.37.1.el10_0.x86_64
                                         kernel-modules-extra-6.12.0-55.37.1.el10_0.x86_64
                                         libdex-0.8.1-1.el10.x86_64

Complete!
root@sigamberdov:/home/sigamberdov# dnf update kernel
Last metadata expiration check: 0:02:20 ago on Fri 17 Oct 2025 12:05:48 PM MSK.
Dependencies resolved.
Nothing to do.
Complete!
root@sigamberdov:/home/sigamberdov# dnf update
Last metadata expiration check: 0:02:25 ago on Fri 17 Oct 2025 12:05:48 PM MSK.
Dependencies resolved.
Nothing to do.
Complete!
root@sigamberdov:/home/sigamberdov# dnf upgrade --refresh
Rocky Linux 10 - BaseOS
Rocky Linux 10 - AppStream
Rocky Linux 10 - Extras
Dependencies resolved.
Nothing to do.
Complete!
root@sigamberdov:/home/sigamberdov#
```

Обновление ядра

```
sigamberdov@sigamberdov:~$ uname -r
6.12.0-55.37.1.el10_0.x86_64
sigamberdov@sigamberdov:~$ hostnamectl
    Static hostname: sigamberdov.localdomain
          Icon name: computer-vm
            Chassis: vm 🖥
        Machine ID: 3beb2f1ba4c140e4864ccbc28684d382
          Boot ID: dd22869b5fa240698f85b9794a304878
      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
sigamberdov@sigamberdov:~$ █
```

Итоги работы

Вывод

В ходе выполнения лабораторной работы были изучены основные принципы работы с модулями ядра Linux.

Рассмотрены команды для просмотра устройств, загрузки, выгрузки и анализа параметров модулей, а также процесс обновления ядра.

Полученные навыки позволяют эффективно администрировать систему и управлять её компонентами на уровне ядра.