

Лабораторная работа №10

Основы работы с модулями ядра операционной системы

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Цель работы

Основная цель

Получение навыков работы с утилитами управления модулями ядра операционной системы Linux.

Ход выполнения

Просмотр устройств и модулей ядра

```
amnauruzova@amnauruzova:~$ su
Password:
root@amnauruzova:/home/amnauruzova# 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: pixx4_smbus
    Kernel modules: i2c_piix4
00:0b.0 USB controller: Intel Corporation 82801FB/FBM/FR/fw/fw (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@amnauruzova:/home/amnauruzova#
```

Рис. 1: Вывод команды `lspci -k`

Просмотр загруженных модулей

```
root@amnauruzova:/home/amnauruzova# 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
crc32c_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
nf_conntrack     204800  2 nf_nat,nft_ct
nf_defrag_ipv4    12288  1 nf_conntrack
nf_defrag_ipv6    24576  1 nf_conntrack
```

Загрузка модуля ext4

```
root@amnauruzova:/home/amnauruzova# lsmod | grep ext4
root@amnauruzova:/home/amnauruzova# modprobe ext4
root@amnauruzova:/home/amnauruzova# lsmod | grep ext4
ext4                      1187840  0
mbcache                  16384  1 ext4
jbd2                     217088  1 ext4
root@amnauruzova:/home/amnauruzova# 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:
               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:R2:F3:17:11:06:R1:R2:FR:CA:23:85:76:76:43:9R:
```

Выгрузка модулей

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

Рис. 4: Выгрузка модулей ext4 и xfs

Загрузка модуля Bluetooth

```
root@amnauruzova:/home/amnauruzova# lsmod | grep bluetooth
root@amnauruzova:/home/amnauruzova# modprobe bluetooth
root@amnauruzova:/home/amnauruzova# lsmod | grep bluetooth
bluetooth           1114112  0
rfkill                40960  4 bluetooth
root@amnauruzova:/home/amnauruzova# 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:A1:34:94:00:57:12:99:67:28: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:80:4B:23:0C:92:93:0B:88:E9:82:6B:06:1B:BD:25:
               69:7D:37:70:CC:A5:08:85:C9:34:D9:69:1C:28:BB:81:B0:8A:C7:
               9F:4D:5D:46:4B:C1:R2:R1:C4:F3:8R:1A:12:5D:F2:52:D0:42:D0:FD:
```

Рис. 5: Загрузка модуля bluetooth

Информация о модуле Bluetooth

```
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@amnauruzova:/home/amnauruzova#  
root@amnauruzova:/home/amnauruzova# modprobe -r bluetooth  
root@amnauruzova:/home/amnauruzova# █
```

Рис. 6: Информация о модуле bluetooth и его выгрузка

Проверка версии ядра

```
root@amnauruzova:/home/amnauruzova#  
root@amnauruzova:/home/amnauruzova# uname -r  
6.12.0-55.12.1.el10_0.x86_64  
root@amnauruzova:/home/amnauruzova# dnf list kernel  
Rocky Linux 10 - BaseOS  
Rocky Linux 10 - AppStream  
Rocky Linux 10 - Extras  
Installed Packages  
kernel.x86_64  
Available Packages  
kernel.x86_64  
root@amnauruzova:/home/amnauruzova#
```

Рис. 7: Проверка версии ядра и пакетов

Обновление ядра

```
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@amnauruzova:/home/amnauruzova# dnf update kernel
Last metadata expiration check: 0:02:32 ago on Wed 15 Oct 2025 01:40:50 PM MSK.
Dependencies resolved.
Nothing to do.
Complete!
root@amnauruzova:/home/amnauruzova# dnf update
Last metadata expiration check: 0:02:36 ago on Wed 15 Oct 2025 01:40:50 PM MSK.
Dependencies resolved.
Nothing to do.
Complete!
root@amnauruzova:/home/amnauruzova# dnf upgrade --refresh
Rocky Linux 10 - BaseOS                               12 kB/s | 4.3 kB   00:00
Rocky Linux 10 - AppStream                            15 kB/s | 4.3 kB   00:00
Rocky Linux 10 - Extras                             12 kB/s | 3.1 kB   00:00
Dependencies resolved.
Nothing to do.
Complete!
root@amnauruzova:/home/amnauruzova#
```

Рис. 8: Обновление ядра и системы

Проверка после обновления

```
amnauruzova@amnauruzova:~$ uname -r
6.12.0-55.37.1.el10_0.x86_64
amnauruzova@amnauruzova:~$ hostnamectl
    Static hostname: amnauruzova.localdomain
              Icon name: computer-vm
                Chassis: vm 🖥
        Machine ID: 1c80a20b5c184a759c9cd8fa84bc080c
          Boot ID: 1f78f442531842b8ba4735762e7ebceb
      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 2w
          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
amnauruzova@amnauruzova:~$ █
```

Итоги работы

Вывод

В ходе лабораторной работы были изучены принципы управления модулями ядра Linux. Получены практические навыки загрузки, выгрузки и анализа модулей, а также обновления ядра операционной системы.