Лабораторная работа №16

Программный RAID

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Цель работы

Освоить принципы работы программных RAID-массивов в Linux и получить практические навыки их создания, настройки и администрирования с использованием утилиты **mdadm**.

Ход выполнения работы

Создание RAID 1: подготовка дисков

Проверка наличия подключённых дисков и подготовка их к использованию в RAID-массиве.

```
ivschemelev@ivschemelev:~$ su
Password:
root@ivschemelev:/home/ivschemelev#
root@ivschemelev:/home/ivschemelev# fdisk -l | grep /dev/sd
Disk /dev/sdb: 1.5 GiB, 1610612736 bytes, 3145728 sectors
/dev/sdb1          2048 1230847 1228800  600M 8e Linux LVM
/dev/sdb2       1230848 2152447  921600  450M 8e Linux LVM
Disk /dev/sda: 1.5 GiB, 1610612736 bytes, 3145728 sectors
/dev/sda1          2048  616447  614400  300M 8e Linux LVM
/dev/sda2        616448 1230847  614400  300M 8e Linux LVM
Disk /dev/sdd: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sdc: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sde: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sdf: 50 GiB, 53687091200 bytes, 104857600 sectors
/dev/sdf1       2048    4095    2048   1M BIOS boot
/dev/sdf2       4096 2101247 2097152   1G Linux extended boot
/dev/sdf3 2101248 104855551 102754304  49G Linux LVM
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# sfdisk /dev/sdc <<EOF
;
EOF
Checking that no-one is using this disk right now ... OK

Disk /dev/sdc: 512 MiB, 536870912 bytes, 1048576 sectors
Disk model: VBOX HARDDISK
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

>>> Created a new DOS (MBR) disklabel with disk identifier 0x6d0b2ca3.
/dev/sdc1: Created a new partition 1 of type 'Linux' and of size 511 MiB.
/dev/sdc2: Done.

New situation:
Disklabel type: dos
Disk identifier: 0x6d0b2ca3

Device     Boot Start     End Sectors  Size Id Type
/dev/sdc1        2048 1048575 1046528  511M 83 Linux

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
root@ivschemelev:/home/ivschemelev# 
```

```
root@ivschemelev:/home/ivschemelev# sfdisk --print-id /dev/sdd 1
sfdisk: print-id is deprecated in favour of --part-type
83
root@ivschemelev:/home/ivschemelev# sfdisk --print-id /dev/sde 1
sfdisk: print-id is deprecated in favour of --part-type
83
root@ivschemelev:/home/ivschemelev# sfdisk --print-id /dev/sdc 1
sfdisk: print-id is deprecated in favour of --part-type
83
root@ivschemelev:/home/ivschemelev# sfdisk -T | grep -i raid
fd  Linux raid autodetect
root@ivschemelev:/home/ivschemelev# sfdisk --change-id /dev/sdd 1 fd
sfdisk: change-id is deprecated in favour of --part-type

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
root@ivschemelev:/home/ivschemelev# sfdisk --change-id /dev/sde 1 fd
sfdisk: change-id is deprecated in favour of --part-type

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
root@ivschemelev:/home/ivschemelev# sfdisk --change-id /dev/sdc 1 fd
sfdisk: change-id is deprecated in favour of --part-type

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# sfdisk -l /dev/sdd
Disk /dev/sdd: 512 MiB, 536870912 bytes, 1048576 sectors
Disk model: VBOX HARDDISK
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x9e70955a

Device     Boot Start      End Sectors  Size Id Type
/dev/sdd1        2048 1048575 1046528  511M fd Linux raid autodetect
root@ivschemelev:/home/ivschemelev# sfdisk -l /dev/sde
Disk /dev/sde: 512 MiB, 536870912 bytes, 1048576 sectors
Disk model: VBOX HARDDISK
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0xe9cb286d

Device     Boot Start      End Sectors  Size Id Type
/dev/sde1        2048 1048575 1046528  511M fd Linux raid autodetect
root@ivschemelev:/home/ivschemelev# sfdisk -l /dev/sdc
Disk /dev/sdc: 512 MiB, 536870912 bytes, 1048576 sectors
Disk model: VBOX HARDDISK
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x6d0b2ca3

Device     Boot Start      End Sectors  Size Id Type
/dev/sdc1        2048 1048575 1046528  511M fd Linux raid autodetect
root@ivschemelev:/home/ivschemelev#
```

Рис. 5: Создание RAID 1

```
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
            Version : 1.2
      Creation Time : Sat Jan 17 14:01:57 2026
         Raid Level : raid1
         Array Size : 522240 (510.00 MiB 534.77 MB)
      Used Dev Size : 522240 (510.00 MiB 534.77 MB)
       Raid Devices : 2
      Total Devices : 2
        Persistence : Superblock is persistent

        Update Time : Sat Jan 17 14:01:59 2026
              State : clean
     Active Devices : 2
    Working Devices : 2
     Failed Devices : 0
      Spare Devices : 0

Consistency Policy : resync

               Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
               UUID : bfae9416:9ca2c450:7d26356d:013112d7
             Events : 17

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1
root@ivschemelev:/home/ivschemelev#
```

Рис. 7: Настройка автомонтирования

```
root@ivschemelev:/home/ivschemelev# mount | grep md0
/dev/md0 on /data type ext4 (rw,relatime,seclabel)
root@ivschemelev:/home/ivschemelev# mdadm /dev/md0 --fail /dev/sde1
root@ivschemelev:/home/ivschemelev# mdadm /dev/md0 --remove /dev/sde1
mdadm: hot removed /dev/sde1 from /dev/md0
root@ivschemelev:/home/ivschemelev# mdadm /dev/md0 --add /dev/sdc1
mdadm: added /dev/sdc1
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Sat Jan 17 14:01:57 2026
        Raid Level : raid1
        Array Size : 522240 (510.00 MiB 534.77 MB)
     Used Dev Size : 522240 (510.00 MiB 534.77 MB)
      Raid Devices : 2
     Total Devices : 2
       Persistence : Superblock is persistent

       Update Time : Sat Jan 17 14:05:38 2026
             State : clean
    Active Devices : 2
   Working Devices : 2
    Failed Devices : 0
     Spare Devices : 0

Consistency Policy : resync

              Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
              UUID : bfae9416:9ca2c450:7d26356d:013112d7
            Events : 39

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       2       8       33        1      active sync   /dev/sdc1
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sde1
To optimalize recovery speed, it is recommended to enable write-indent bitmap, do you want to enable it now? [y/N]?
mdadm: assuming no.
mdadm: Note: this array has metadata at the start and
    may not be suitable as a boot device.  If you plan to
    store '/boot' on this device please ensure that
    your boot-loader understands md/v1.x metadata, or use
    --metadata=0.90
mdadm: size set to 522240K
Continue creating array [y/N]? y
mdadm: Defaulting to version 1.2 metadata
mdadm: array /dev/md0 started.
root@ivschemelev:/home/ivschemelev# mdadm --add /dev/md0 /dev/sdc1
mdadm: added /dev/sdc1
root@ivschemelev:/home/ivschemelev# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
root@ivschemelev:/home/ivschemelev# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdc1[2](S) sde1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
root@ivschemelev:/home/ivschemelev# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 1 spare. Use mdadm --detail for more detail.
root@ivschemelev:/home/ivschemelev#
```

Рис. 9: RAID 1 с hot spare

```
root@ivschemelev:/home/ivschemelev#
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Sat Jan 17 14:07:58 2026
        Raid Level : raid1
        Array Size : 522240 (510.00 MiB 534.77 MB)
     Used Dev Size : 522240 (510.00 MiB 534.77 MB)
      Raid Devices : 2
     Total Devices : 3
       Persistence : Superblock is persistent

       Update Time : Sat Jan 17 14:08:29 2026
             State : clean
    Active Devices : 2
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 1

Consistency Policy : resync

              Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
              UUID : ec64a403:c5f71fc3:fcd688b5:e4c110fd
            Events : 18

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1

       2       8       33        -      spare   /dev/sdc1
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# mdadm /dev/md0 --fail /dev/sde1
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
            Version : 1.2
      Creation Time : Sat Jan 17 14:07:58 2026
         Raid Level : raid1
         Array Size : 522240 (510.00 MiB 534.77 MB)
      Used Dev Size : 522240 (510.00 MiB 534.77 MB)
       Raid Devices : 2
      Total Devices : 3
        Persistence : Superblock is persistent

        Update Time : Sat Jan 17 14:09:56 2026
              State : clean
     Active Devices : 2
    Working Devices : 2
     Failed Devices : 1
      Spare Devices : 0

Consistency Policy : resync

               Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
               UUID : ec64a403:c5f71fc3:fcd688b5:e4c110fd
             Events : 37

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       2       8       33        1      active sync   /dev/sdc1

       1       8       65        -      faulty   /dev/sde1
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev#
root@ivschemelev:/home/ivschemelev# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sde1
To optimalize recovery speed, it is recommended to enable write-indent bitmap, do you want to enable it now? [y/N]?
mdadm: assuming no.
mdadm: Note: this array has metadata at the start and
    may not be suitable as a boot device.  If you plan to
    store `/boot' on this device please ensure that
    your boot-loader understands md/v1.x metadata, or use
    --metadata=0.90
mdadm: size set to 522240K
Continue creating array [y/N]? y
mdadm: Defaulting to version 1.2 metadata
mdadm: array /dev/md0 started.
root@ivschemelev:/home/ivschemelev# mdadm --add /dev/md0 /dev/sdc1
mdadm: added /dev/sdc1
root@ivschemelev:/home/ivschemelev# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
root@ivschemelev:/home/ivschemelev# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdc1[2](S) sde1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
root@ivschemelev:/home/ivschemelev# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 1 spare. Use mdadm --detail for more detail.
root@ivschemelev:/home/ivschemelev#
```

Рис. 12: RAID 1 перед преобразованием

```
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
          Version : 1.2
    Creation Time : Sat Jan 17 14:11:49 2026
       Raid Level : raid1
       Array Size : 522240 (510.00 MiB 534.77 MB)
    Used Dev Size : 522240 (510.00 MiB 534.77 MB)
     Raid Devices : 2
    Total Devices : 3
      Persistence : Superblock is persistent

      Update Time : Sat Jan 17 14:12:09 2026
            State : clean
   Active Devices : 2
  Working Devices : 3
   Failed Devices : 0
    Spare Devices : 1

Consistency Policy : resync

             Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
             UUID : 304cd325:247cbd0c:bed7440e:44abbb23
           Events : 18

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1

       2       8       33        -      spare   /dev/sdc1
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# mdadm --grow /dev/md0 --level=5
mdadm: level of /dev/md0 changed to raid5
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Sat Jan 17 14:11:49 2026
        Raid Level : raid5
        Array Size : 522240 (510.00 MiB 534.77 MB)
     Used Dev Size : 522240 (510.00 MiB 534.77 MB)
      Raid Devices : 2
     Total Devices : 3
       Persistence : Superblock is persistent

       Update Time : Sat Jan 17 14:13:49 2026
             State : clean
    Active Devices : 2
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 1

            Layout : left-symmetric
        Chunk Size : 64K

Consistency Policy : resync

              Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
              UUID : 304cd325:247cbd0c:bed7440e:44abbb23
            Events : 19

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1

       2       8       33        -      spare   /dev/sdc1
root@ivschemelev:/home/ivschemelev#
```

```
root@ivschemelev:/home/ivschemelev# mdadm --grow /dev/md0 --raid-devices=3
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md
mdadm: cannot open /dev/md: No such file or directory
root@ivschemelev:/home/ivschemelev# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Sat Jan 17 14:11:49 2026
        Raid Level : raid5
        Array Size : 1044480 (1020.00 MiB 1069.55 MB)
     Used Dev Size : 522240 (510.00 MiB 534.77 MB)
      Raid Devices : 3
     Total Devices : 3
       Persistence : Superblock is persistent

       Update Time : Sat Jan 17 14:14:27 2026
             State : clean
    Active Devices : 3
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 0

            Layout : left-symmetric
        Chunk Size : 64K

Consistency Policy : resync

              Name : ivschemelev.localdomain:0  (local to host ivschemelev.localdomain)
              UUID : 304cd325:247cbd0c:bed7440e:44abbb23
            Events : 37

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1
       2       8       33        2      active sync   /dev/sdc1
root@ivschemelev:/home/ivschemelev#
```

Итоги работы

Заключение

В ходе лабораторной работы были изучены основные режимы программного RAID в Linux. Получены практические навыки создания RAID 1, настройки горячего резерва, преобразования массива в RAID 5 и анализа его состояния, что подтверждает понимание принципов отказоустойчивого хранения данных.