Презентация по лабораторной работе №16

Программный RAID

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Цели и задачи работы

Цель лабораторной работы

Освоить принципы работы и администрирования RAID-массивов с использованием утилиты `mdadm`.

Задачи лабораторной работы

1 Проверить доступные диски

2 Создать RAID 1

3 Добавить hot spare-диск

4 Сымитировать сбой и восстановление массива

5 Преобразовать RAID 1 в RAID 5

6 Проанализировать работу массива и удалить его

Ход выполнения работы

Проверка доступных дисков

```
aasaenko@aasaenko:~$ su
Password:
root@aasaenko:/home/aasaenko# fdisk -l | grep /dev/sd
Disk /dev/sda: 40 GiB, 42949672960 bytes, 83886080 sectors
/dev/sda1     2048     4095     2048   1M BIOS boot
/dev/sda2     4096  2101247  2097152   1G Linux extended boot
/dev/sda3  2101248 83884031 81782784  39G Linux LVM
Disk /dev/sdd: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sdc: 1.5 GiB, 1610612736 bytes, 3145728 sectors
/dev/sdc1         2048  616447  614400  300M 8e Linux LVM
/dev/sdc2       616448 1230847  614400  300M 8e Linux LVM
Disk /dev/sde: 512 MiB, 536870912 bytes, 1048576 sectors
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/sdf: 512 MiB, 536870912 bytes, 1048576 sectors
root@aasaenko:/home/aasaenko# sfdisk /dev/sdd <<EOF
> ;
> EOF
Checking that no-one is using this disk right now ... OK

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

>>> Created a new DOS (MBR) disklabel with disk identifier 0x2c7c5ef2.
/dev/sdd1: Created a new partition 1 of type 'Linux' and of size 511 MiB.
/dev/sdd2: Done.

New situation:
Disklabel type: dos
Disk identifier: 0x2c7c5ef2

Device     Boot Start     End Sectors  Size Id Type
/dev/sdd1        2048 1048575 1046528  511M 83 Linux
```

Создание разделов и изменение их типа

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

Проверка состояния разделов

```
root@aasaenko:/home/aasaenko#
root@aasaenko:/home/aasaenko# 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: 0x2c7c5ef2

Device     Boot Start     End Sectors  Size Id Type
/dev/sdd1        2048 1048575 1046528  511M fd Linux raid autodetect
root@aasaenko:/home/aasaenko# 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: 0xbca356ee

Device     Boot Start     End Sectors  Size Id Type
/dev/sde1        2048 1048575 1046528  511M fd Linux raid autodetect
root@aasaenko:/home/aasaenko# sfdisk -l /dev/sdf
Disk /dev/sdf: 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: 0xa25f3497

Device     Boot Start     End Sectors  Size Id Type
/dev/sdf1        2048 1048575 1046528  511M fd Linux raid autodetect
root@aasaenko:/home/aasaenko#
```

Создание массива RAID 1

```
root@aasaenko:/home/aasaenko# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sde1
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@aasaenko:/home/aasaenko# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sde1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
root@aasaenko:/home/aasaenko# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 0 spares. Use mdadm --detail for more detail.
```

Рис. 4: Создание RAID-массива

Проверка состояния массива

```
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:22:27 2025
        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 : Wed Nov 19 15:22:29 2025
             State : clean
    Active Devices : 2
   Working Devices : 2
    Failed Devices : 0
     Spare Devices : 0

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : c993764b:8efdb82e:c250e7f3:997bbfbc
            Events : 17

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

Создание файловой системы и монтирование

```
root@aasaenko:/home/aasaenko#
root@aasaenko:/home/aasaenko# mkfs.ext4 /dev/md0
mke2fs 1.47.1 (20-May-2024)
Creating filesystem with 522240 1k blocks and 130560 inodes
Filesystem UUID: f02c85eb-c346-40d6-8061-6ec330cb8a50
Superblock backups stored on blocks:
        8193, 24577, 40961, 57345, 73729, 204801, 221185, 401409

Allocating group tables: done
Writing inode tables: done
Creating journal (8192 blocks): done
Writing superblocks and filesystem accounting information: done

root@aasaenko:/home/aasaenko# mkdir /data
mkdir: cannot create directory ‘/data’: File exists
root@aasaenko:/home/aasaenko# mkdir /data/mnt
root@aasaenko:/home/aasaenko# mount /dev/md0 /data/mnt/
root@aasaenko:/home/aasaenko#
```

Рис. 6: Создание ФС и монтирование

Работа с fstab

Настройка автомонтирования

Рис. 7: Редактирование fstab

Симуляция сбоя диска

```
root@aasaenko:/home/aasaenko# mdadm /dev/md0 --fail /dev/sde1
root@aasaenko:/home/aasaenko# mdadm /dev/md0 --remove /dev/sde1
mdadm: hot removed /dev/sde1 from /dev/md0
root@aasaenko:/home/aasaenko# mdadm /dev/md0 --add /dev/sdf1
mdadm: added /dev/sdf1
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:22:27 2025
        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 : Wed Nov 19 15:26:42 2025
             State : clean
    Active Devices : 2
   Working Devices : 2
    Failed Devices : 0
     Spare Devices : 0

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : c993764b:8efdb82e:c250e7f3:997bbfbc
            Events : 39

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       2       8       81        1      active sync   /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Очистка конфигурации RAID

```
root@aasaenko:/nome/aasaenko#
root@aasaenko:/home/aasaenko# umount /dev/md0
root@aasaenko:/home/aasaenko# mdadm --stop /dev/md0
mdadm: stopped /dev/md0
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdd1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sde1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Рис. 9: Удаление и очистка массива

Создание RAID 1 и добавление hot spare

```
root@aasaenko:/home/aasaenko# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sde1
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@aasaenko:/home/aasaenko# mdadm --add /dev/md0 /dev/sdf1
mdadm: added /dev/sdf1
root@aasaenko:/home/aasaenko# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
root@aasaenko:/home/aasaenko# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdf1[2](S) sde1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

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

Рис. 10: Создание RAID 1

Добавление hot spare-диска

```
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:30:06 2025
        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 : Wed Nov 19 15:30:26 2025
             State : clean
    Active Devices : 2
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 1

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : 1a83f7bb:f18d34ad:c581f763:6300d5a5
            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       81        -      spare   /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Сбой диска и автоматическое восстановление

```
root@aasaenko:/home/aasaenko# mdadm /dev/md0 --fail /dev/sde1
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:30:06 2025
        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 : Wed Nov 19 15:31:34 2025
             State : clean
    Active Devices : 2
   Working Devices : 2
    Failed Devices : 1
     Spare Devices : 0

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : 1a83f7bb:f18d34ad:c581f763:6300d5a5
            Events : 37

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       2       8       81        1      active sync   /dev/sdf1

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

```
root@aasaenko:/home/aasaenko#
root@aasaenko:/home/aasaenko# umount /dev/md0
root@aasaenko:/home/aasaenko# mdadm --stop /dev/md0
mdadm: stopped /dev/md0
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdd1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sde1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Рис. 13: Очистка суперблоков

Исходный RAID 1 и добавление третьего диска

```
root@aasaenko:/home/aasaenko# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sde1
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@aasaenko:/home/aasaenko# mdadm --add /dev/md0 /dev/sdf1
mdadm: added /dev/sdf1
root@aasaenko:/home/aasaenko# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
root@aasaenko:/home/aasaenko# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdf1[2](S) sde1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

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

Рис. 14: Создание RAID 1 и добавление диска

```
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:34:22 2025
        Raid Level : raid1
        Array Size : 522240 (510.00 MiB 534.77 MB)
```

Изменение уровня массива на RAID 5

```
root@aasaenko:/home/aasaenko# mdadm --grow /dev/md0 --level=5
mdadm: level of /dev/md0 changed to raid5
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:34:22 2025
        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 : Wed Nov 19 15:36:01 2025
             State : clean
    Active Devices : 2
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 1

            Layout : left-symmetric
        Chunk Size : 64K

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : 4ad47c8c:680df8ae:041fe1a3:b3c59cb4
            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       81        -      spare   /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Увеличение числа дисков RAID 5

```
root@aasaenko:/home/aasaenko# mdadm --grow /dev/md0 --raid-devices=3
root@aasaenko:/home/aasaenko# mdadm --detail /dev/md0
/dev/md0:
           Version : 1.2
     Creation Time : Wed Nov 19 15:34:22 2025
        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 : Wed Nov 19 15:37:49 2025
             State : clean
    Active Devices : 3
   Working Devices : 3
    Failed Devices : 0
     Spare Devices : 0

            Layout : left-symmetric
        Chunk Size : 64K

Consistency Policy : resync

              Name : aasaenko.localdomain:0  (local to host aasaenko.localdomain)
              UUID : 4ad47c8c:680df8ae:041fe1a3:b3c59cb4
            Events : 36

    Number   Major   Minor   RaidDevice State
       0       8       49        0      active sync   /dev/sdd1
       1       8       65        1      active sync   /dev/sde1
       2       8       81        2      active sync   /dev/sdf1
root@aasaenko:/home/aasaenko#
```

```
root@aasaenko:/home/aasaenko#
root@aasaenko:/home/aasaenko# umount /dev/md0
root@aasaenko:/home/aasaenko# mdadm --stop /dev/md0
mdadm: stopped /dev/md0
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdd1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sde1
root@aasaenko:/home/aasaenko# mdadm --zero-superblock /dev/sdf1
root@aasaenko:/home/aasaenko#
```

Рис. 18: Очистка RAID 5

Очистка массива и fstab

```
 GNU nano 8.1                                    /etc/fstab

#
# /etc/fstab
# Created by anaconda on Tue Sep  9 17:07:12 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
UUID=d83390cc-2d84-4fc0-bd05-ca91de963a39 /                       xfs     defaults        0 0
UUID=d9debe2a-1f0b-4b38-9b19-869a45d892f1 /boot                   xfs     defaults        0 0
UUID=410f9eed-3ac0-4e21-a5aa-32b986aae5a0 none                    swap    defaults        0 0
/dev/vgdata/lvdata                        /mnt/data               ext4    defaults        1 2
/dev/vggroup/lvgroup                      /mnt/groups             xfs     defaults        1 2

#/dev/md0                                 /data/mnt               ext4    defaults        1 2
#UUID=1c1cab63-3081-41d8-af2c-137661cbe1d9      /mnt/data       xfs     defaults        1 2
#UUID=d6d2a497-accc-4b14-844a-25daaeb6123a      /mnt/data-ext   ext4    defaults        1 2
#UUID=904e0395-6ea3-4257-aceb-955c098ab5f2      none    swap    defaults        0 0
```

Рис. 19: fstab с закомментированной строкой

Выводы по проделанной работе

Вывод

В ходе лабораторной работы были изучены:

- создание, конфигурация и диагностика RAID-массивов;
- работа с горячими резервами (hot spare);
- восстановление массива после сбоя диска;
- конвертация RAID 1 в RAID 5 и расширение массива;
- настройка автомонтирования и очистка метаданных.

Полученные навыки важны для обеспечения отказоустойчивости и надежности систем хранения данных.