

# Лабораторная работа 16

Программный RAID (mdadm)

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Освоить работу с RAID-массивами при помощи утилиты **mdadm**.

# Проверка дисков в системе

```
Activities Terminal Sep 9 18:19 en
root@ndbaranov:~

[root@ndbaranov ~]# fdisk -l | grep /dev/sd
Disk /dev/sda: 40 GiB, 42949672960 bytes, 83886080 sectors
/dev/sda1 *      2048 2099199 2097152 16 83 Linux
/dev/sda2      2099200 83886079 81786880 396 8e Linux LVM
Disk /dev/sdc: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sdb: 512 MiB, 536870912 bytes, 1048576 sectors
Disk /dev/sdd: 512 MiB, 536870912 bytes, 1048576 sectors
[root@ndbaranov ~]# 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 disklabel with disk identifier 0x86f7b2df.
/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: 0x86f7b2df

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

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
[root@ndbaranov ~]# sfdisk /dev/sde <<EOF
;
EOF
sfdisk: cannot open /dev/sde: No such file or directory
[root@ndbaranov ~]# 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 disklabel with disk identifier 0x5cdb51df.
/dev/sdc1: Created a new partition 1 of type 'Linux' and of size 511 MiB.
/dev/sdc2: Done.
```

# Создание разделов на дисках

```
Activities Terminal Sep 9 18:20 en
root@ndbaranov:~

>>> Created a new DOS disklabel with disk identifier 0x5cdb51df.
/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: 0x5cdb51df

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@ndbaranov ~]# sfdisk /dev/sdb <<EOF
p
EOF
Checking that no-one is using this disk right now ... OK

Disk /dev/sdb: 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 disklabel with disk identifier 0x906b7901.
/dev/sdb1: Created a new partition 1 of type 'Linux' and of size 511 MiB.
/dev/sdb2: Done.

New situation:
Disklabel type: dos
Disk identifier: 0x906b7901

Device      Boot Start      End Sectors  Size Id Type
/dev/sdb1                2048 1048575 1046528   511M 83 Linux

The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
[root@ndbaranov ~]# sfdisk --print-id /dev/sdd 1
sfdisk: print-id is deprecated in favour of --part-type
83
[root@ndbaranov ~]# sfdisk --print-id /dev/sdb 1
sfdisk: print-id is deprecated in favour of --part-type
83
[root@ndbaranov ~]# sfdisk --print-id /dev/sdc 1
sfdisk: print-id is deprecated in favour of --part-type
83
[root@ndbaranov ~]#
```

# Изменение типа разделов на RAID

```
Activities Terminal Sep 9 18:21 en
root@ndbaranov:~

[root@ndbaranov ~]# 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@ndbaranov ~]# 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@ndbaranov ~]# sfdisk --change-id /dev/sdb 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@ndbaranov ~]# 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: 0x86f7b2df

Device      Boot Start      End Sectors  Size Id Type
/dev/sddl   2048 1048575 1046528 511M fd Linux raid autodetect
[root@ndbaranov ~]# 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: 0x5cdb51df

Device      Boot Start      End Sectors  Size Id Type
/dev/sdc1   2048 1048575 1046528 511M fd Linux raid autodetect
[root@ndbaranov ~]# sfdisk -l /dev/sdb
Disk /dev/sdb: 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: 0x906b7901

Device      Boot Start      End Sectors  Size Id Type
/dev/sdb1   2048 1048575 1046528 511M fd Linux raid autodetect
```

# Создание массива RAID 1

```
Activities Terminal Sep 9 18:24 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sdb1
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@ndbaranov ~]# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdb1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
[root@ndbaranov ~]# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 0 spares. Use mdadm --detail for more detail.
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
   Version : 1.2
  Creation Time : Tue Sep  9 18:23:03 2025
    Raid Level : raid1
   Array Size : 522240 (510.00 MiB 524.77 MB)
  Used Dev Size : 522240 (510.00 MiB 534.77 MB)
   Raid Devices : 2
  Total Devices : 2
 Persistence : Superblock is persistent

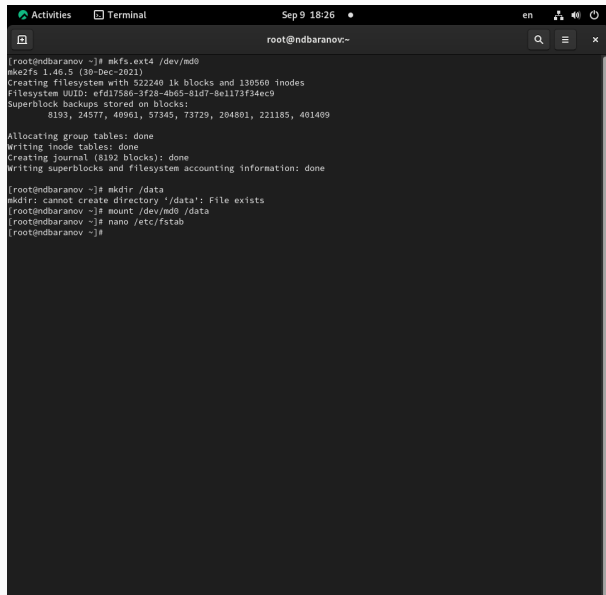
   Update Time : Tue Sep  9 18:23:06 2025
     State : clean
   Active Devices : 2
 Working Devices : 2
 Failed Devices : 0
  Spare Devices : 0

Consistency Policy : resync

   Name : ndbaranov:0 (local to host ndbaranov)
  UUID : aafd8cf7:d51c7962:8cbe91d:61fd0d67
   Events : 17

   Number Major Minor RaidDevice State
    0         8      49         0 active sync  /dev/sdd1
    1         8     17         1 active sync  /dev/sdb1
[root@ndbaranov ~]#
```

# Создание ФС и настройка /etc/fstab



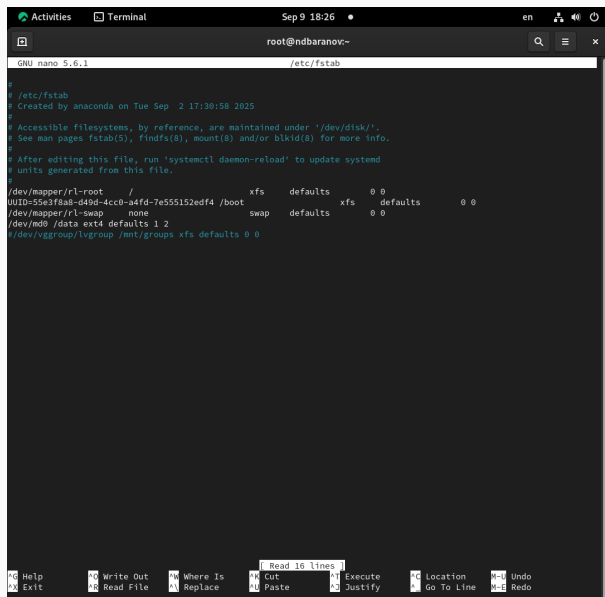
```
[root@ndbaranov ~]# mkfs.ext4 /dev/md0
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 522240 1k blocks and 130560 inodes
Filesystem UUID: efd17586-3f28-4b65-81d7-8e1173f34ec9
Superblock backups stored on blocks:
    8193, 24577, 40961, 57345, 73729, 204801, 221185, 401409

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

[root@ndbaranov ~]# mkdir /data
mkdir: cannot create directory '/data': File exists
[root@ndbaranov ~]# mount /dev/md0 /data
[root@ndbaranov ~]# nano /etc/fstab
[root@ndbaranov ~]#
```



# Проверка записи в /etc/fstab



The screenshot shows a terminal window with the title bar "Activities Terminal" and the date "Sep 9 18:26". The terminal prompt is "root@ndbaranov:~". The user is editing the file "/etc/fstab" using the "nano 5.6.1" editor. The file content is as follows:

```
#  
# /etc/fstab  
# Created by anaconda on Tue Sep  2 17:30:58 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.  
#  
/dev/mapper/rl-root    /                    xfs     defaults    0 0  
UUID=55e3f8a8-d49d-4cc0-a4fd-7e555152edf4 /boot                xfs     defaults    0 0  
/dev/mapper/rl-swap    none                swap    defaults    0 0  
/dev/md0 /data ext4 defaults 1 2  
#/dev/vggroup/lvgroup /mnt/groups xfs defaults 0 0
```

At the bottom of the terminal, there is a status bar with various keyboard shortcuts: "H Help", "X Exit", "O Write Out", "R Read File", "W Where Is", "A Replace", "C Cut", "U Paste", "E Execute", "J Justify", "L Location", "G Go To Line", "U Undo", and "E Redo". A tooltip "Read 16 lines" is visible over the status bar.

# Имитация сбоя и замена диска

```
Activities Terminal Sep 9 18:29 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm /dev/md0 --fail /dev/sdb1
mdadm: set /dev/sdb1 faulty in /dev/md0
[root@ndbaranov ~]# mdadm /dev/md0 --remove /dev/sdb1
mdadm: hot removed /dev/sdb1 from /dev/md0
[root@ndbaranov ~]# mdadm /dev/md0 --add /dev/sdc1
mdadm: added /dev/sdc1
[root@ndbaranov ~]# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdc1[2] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
[root@ndbaranov ~]# umount /dev/md0
[root@ndbaranov ~]# mdadm --stop /dev/md0
mdadm: stopped /dev/md0
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdd1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdb1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdc1
[root@ndbaranov ~]#
```

# RAID 1 с горячим резервом

```
Activities Terminal Sep 9 18:30 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sdb1
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@ndbaranov ~]# mdadm --add /dev/md0 /dev/sdc1
mdadm: added /dev/sdc1
[root@ndbaranov ~]# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
the old version; use 'systemctl daemon-reload' to reload.
[root@ndbaranov ~]# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdc1[2](S) sdb1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
[root@ndbaranov ~]# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 1 spare. Use mdadm --detail for more detail.
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
   Version : 1.2
  Creation Time : Tue Sep  9 18:29:52 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 : Tue Sep  9 18:30:07 2025
   State : clean
 Active Devices : 2
 Working Devices : 3
 Failed Devices : 0
 Spare Devices : 1

Consistency Policy : resync

   Name : ndbaranov:0 (local to host ndbaranov)
  UUID : 55c874a8:a01089f0:24b52e30:df19bf6d
 Events : 16

   Number Major Minor RaidDevice State
    0         8      49        0 active sync  /dev/sdd1
    1         8     17        1 active sync  /dev/sdb1
```

# Автоматическое восстановление массива

```
Activities Terminal Sep 9 18:31 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm /dev/md0 --fail /dev/sdb1
mdadm: set /dev/sdb1 faulty in /dev/md0
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
    Version : 1.2
  Creation Time : Tue Sep  9 18:29:52 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 : Tue Sep  9 18:30:55 2025
      State : clean
  Active Devices : 2
 Working Devices : 2
 Failed Devices : 1
  Spare Devices : 0

Consistency Policy : resync

    Name : ndbaranov:0 (local to host ndbaranov)
   UUID : 55c874a8:a01089f0:24b52e30:df19bf6d
    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       17         -     faulty    /dev/sdb1
[root@ndbaranov ~]# umount /dev/md0
[root@ndbaranov ~]# mdadm --stop /dev/md0
mdadm: stopped /dev/md0
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdd1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdb1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdc1
[root@ndbaranov ~]#
```

# Преобразование RAID 1 → RAID 5

```
Activities Terminal Sep 9 18:32 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm --create --verbose /dev/md0 --level=1 --raid-devices=2 /dev/sdd1 /dev/sdb1
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@ndbaranov ~]# mdadm --add /dev/md0 /dev/sdc1
mdadm: added /dev/sdc1
[root@ndbaranov ~]# mount /dev/md0
mount: (hint) your fstab has been modified, but systemd still uses
the old version; use 'systemctl daemon-reload' to reload.
[root@ndbaranov ~]# cat /proc/mdstat
Personalities : [raid1]
md0 : active raid1 sdc1[2](S) sdb1[1] sdd1[0]
      522240 blocks super 1.2 [2/2] [UU]

unused devices: <none>
[root@ndbaranov ~]# mdadm --query /dev/md0
/dev/md0: 510.00MiB raid1 2 devices, 1 spare. Use mdadm --detail for more detail.
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
   Version : 1.2
  Creation Time : Tue Sep  9 18:32:03 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 : Tue Sep  9 18:32:14 2025
   State : clean
 Active Devices : 2
 Working Devices : 3
 Failed Devices : 0
  Spare Devices : 1


Consistency Policy : resync

   Name : ndbaranov:0 (local to host ndbaranov)
   UUID : 5ba01062:0362a693:bc995cae:766896ec
   Events : 16

   Number Major Minor RaidDevice State
    0         8      49        0 active sync  /dev/sdd1
    1         8     17        1 active sync  /dev/sdb1
```

# Изменение уровня RAID

```
Activities Terminal Sep 9 18:33 en
root@ndbaranov:~

[root@ndbaranov ~]# mdadm --grow /dev/md0 --level=5
mdadm: level of /dev/md0 changed to raid5
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
    Version : 1.2
  Creation Time : Tue Sep  9 18:32:03 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 : Tue Sep  9 18:32:49 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 : ndbaranov:0 (local to host ndbaranov)
    UUID : 5ba01062:0362a693:bc995cae:766896ec
    Events : 19

   Number Major Minor RaidDevice State
    0         8      49         0   active sync  /dev/sdd1
    1         8      17         1   active sync  /dev/sdb1
    2         8      33         -   spare      /dev/sdc1
[root@ndbaranov ~]# mdadm --grow /dev/md0 --raid-devices 3
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
    Version : 1.2
  Creation Time : Tue Sep  9 18:32:03 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 : 3
    Total Devices : 3
 Persistence : Superblock is persistent

    Update Time : Tue Sep  9 18:33:13 2025
      State : clean, reshaping
    Active Devices : 3
    Working Devices : 3
    Failed Devices : 0
    Spare Devices : 0
```

# Увеличение количества дисков

```
Activities Terminal Sep 9 18:33 en
root@ndbaranov:~

Layout : left-symmetric
Chunk Size : 64K

Consistency Policy : resync

Name : ndbaranov:0 (local to host ndbaranov)
UUID : 5ba01062:0362a693:bc995cae:766896ec
Events : 19

Number Major Minor RaidDevice State
0 8 49 0 active sync /dev/sdd1
1 8 17 1 active sync /dev/sdb1
2 8 33 - spare /dev/sdc1

[root@ndbaranov ~]# mdadm --grow /dev/md0 --raid-devices 3
[root@ndbaranov ~]# mdadm --detail /dev/md0
/dev/md0:
Version : 1.2
Creation Time : Tue Sep 9 18:32:03 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 : 3
Total Devices : 3
Persistence : Superblock is persistent

Update Time : Tue Sep 9 18:33:13 2025
State : clean, reshaping
Active Devices : 3
Working Devices : 3
Failed Devices : 0
Spare Devices : 0

Layout : left-symmetric
Chunk Size : 64K

Consistency Policy : resync

Reshape Status : 25% complete
Delta Devices : 1, (2->3)

Name : ndbaranov:0 (local to host ndbaranov)
UUID : 5ba01062:0362a693:bc995cae:766896ec
Events : 33

Number Major Minor RaidDevice State
0 8 49 0 active sync /dev/sdd1
1 8 17 1 active sync /dev/sdb1
2 8 33 2 active sync /dev/sdc1

[root@ndbaranov ~]#
```

# Завершение работы с массивом

```
Activities Terminal Sep 9 18:34 en
root@ndbaranov:~
[root@ndbaranov ~]# umount /dev/md0
umount: /dev/md0: no mount point specified.
[root@ndbaranov ~]# mdadm --stop /dev/md0
mdadm: error opening /dev/md0: No such file or directory
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdd1
mdadm: Unrecognised md component device - /dev/sdd1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdc1
[root@ndbaranov ~]# mdadm --zero-superblock /dev/sdb1
[root@ndbaranov ~]# nano /etc/fstab
[root@ndbaranov ~]#
```



- Получены навыки работы с **mdadm**
- Созданы массивы RAID 1 и RAID 5
- Отработаны сценарии сбоя и восстановления
- Освоено использование горячего резерва