

OS 2021 Problem Sheet #12

Problem 12.1: *redundant arrays of independent disks* (1+1+1+1+1 = 5 points)

You are given n identical storage disks, each disk has a failure probability p . Lets assume disks fail independently from each other.

- What is the failure probability F_0 of a RAID 0 (striping) configuration of all n disks? Derive a general expression for $F_0(p, n)$.
- What is the failure probability F_1 of a RAID 1 (mirroring) configuration of all n disks? Derive a general expression for $F_1(p, n)$.
- A RAID 10 combines a RAID 1 with a RAID 0. Lets assume that n is an even number and that pairs of two disks are put into RAID 1 configurations and the resulting $\frac{n}{2}$ RAID 1 configurations are put into a RAID 0. What is the resulting failure probability $F_{10}(p, n)$?
- A RAID 01 combines a RAID 0 with a RAID 1. Lets assume that n is an even number and that $\frac{n}{2}$ disks are put into two RAID 0 configurations and the resulting two RAID 0 configurations are put into a RAID 1. What is the resulting failure probability $F_{01}(p, n)$?
- If you can choose between a RAID 10 and a RAID 01, which configuration do you prefer? Explain.

Problem 12.2: *logical volume management* (1+1+1+1+1 = 5 points)

On Linux, you can create block storage devices that using a regular file as the backend storage. This is useful for experimentation and debugging. You will use this to create physical and logical volumes.

You may want to do this exercise on a virtual machine to make sure you avoid any catastrophic results by accidentally mistyping a command.

Creating block devices on top of regular files is accomplished by loop devices. First, you have to load to the loop kernel module:

```
sudo modprobe loop
```

Next, you create 5 storage devices, each having a capacity of 20 MB.

```
for i in $(seq 0 4) ; do
  img=loop$i.img
  dev=/dev/loop$i
  dd if=/dev/zero of=$img bs=1M count=20
  sudo losetup $dev $img
done
```

To list your loop devices, you can use this command:

```
sudo losetup -a
```

To remove all loop devices and the files, you can run this loop:

```
for i in $(seq 0 4) ; do
    img=loop$i.img
    dev=/dev/loop$i
    sudo losetup -d $dev
    rm $img
done
```

In order to create logical volumes, you need to install the `lvm2` package (if not installed yet). On Debian or Ubuntu systems, the package can be installed by using the following command:

```
sudo apt-get install lvm2
```

You can get an overview over the `lvm` commands in the `lvm` man page in section 8 of the Unix manual. Every individual `lvm` command has its own man page in section 8 as well.

Carry out the following experiments and provide the requested information:

- a) Create a volume group named `vg0` that consists of the three physical volumes `/dev/loop0`, `/dev/loop1`, and `/dev/loop2`. Document the commands that you have used and show the output of the commands `sudo pvs` and `sudo vgs`. Look at the `PSize`, what do you observe?
- b) Within volume group `vg0`, create a logical volume `lv0` with a size of 20 MB. Create a file system in `lv0` and mount it on `/mnt`. Show the output of the commands `sudo lvs`, `sudo pvs`, and `sudo df /mnt`.
- c) You need to grow the file system on `lv0` to about 60 MB. What are the commands that you use and why? Show the the output of the commands `sudo lvs`, `sudo pvs`, and `sudo df /mnt`.
- d) Create a snapshot logical volume called `lv0s` of `lv0`. Show the output of the commands `sudo pvs` and `sudo lvs`. Write a short message into the file in `/mnt/msg.txt` (assuming `lv0` is still mounted on `/mnt`). Show the output of the command `sudo lvs` again. What has changed and why? Mount the snapshot volume and verify that the file does not exist in the snapshot file system.
- e) Remove all logical volumes from `vg0` and make sure all loop devices have been added as physical volumes to `vg0`. Create a RAID 1 logical volume `lv0r1` with the size of 12Mb. Which physical volumes are used to store the data of `lv0r1`? Create a RAID 5 logical volume `lv1r5` using all the remaining free physical extents. Show the output of the command `sudo lvs`. What is the size of `lv1r5` and what is the size of the physical volumes providing storage for `lv1r5`?