CSCI322 Lab Exercises

Lab 6

Objective

You will explore some features of ZFS.

ZFS is a combined file system and logical volume manager that can use the best of ability of available disks.

Do not start VMs now.

1. **Adding disks to the server VM**

- Select the *server* VM in the VirtualBox manager main window and click at the **Storage** section from the **Details** pane;
- Under the **Storage Devices**, click at Controller: SATA. Then click at the **Add Hard Disk** button (the green plus sign) and select Create new disk. Choose the followings:
  - Hard disk file type: VDI (default)
  - Storage on physical hard disk: Dynamically allocated (default)
  - File location and size: poolDisk1 and 1.0 GB
- Repeat the above to create another one disk called: poolDiskDisk2 of the size 1.0 GB
- Repeat the above to create another two disks called: poolDisk3 and poolDisk4 of the size 2.0 GB.

2. **Install ZFS**

- Now start the *server* VM;

The main components of ZFS are maintained as a standard Ubuntu package.

- Install the ZFS

```
sudo apt install zfsutils-linux
```

3. **Create a ZFS pool**

- Identify the newly created disks:

```
lsblk -o NAME,SIZE,FSTYPE,TYPE,MOUNTPOINT
```

You will four new disks, likely `/dev/sde`, `/dev/sdf`, `/dev/sdg` and `/dev/sdh`, if you have successfully created three disks in last week's lab. These will be the raw disks we use to build ZFS on.

- Create a mirrored pool (RAID0)

A zpool is a pool of storage made from a collection of VDEVs. One or more ZFS file systems (datassets) can be created from a ZFS pool. There are many ways to arrange disks to create a VDEV. In this exercise, we will create a VDEV of 2 disks in a mirror.

Create a pool from a mirrored VDEV made of the two 1GB disks:

```
sudo zpool create myZpool mirror /dev/sde /dev/sdf
```

where `myZpool` is the name of the pool.

- You can use the zpool command to check the status of ZFS pool:

```
zpool status
```

You will see the newly created pool `myZpool`. The `mirror-0` is the VDEV, a virtual device that representing the two disks.

- You can check the new space by typing:

```
df -h
```

You will see:

```
Filesystem    Size    Used    Avail    Use%    Mounted on
myZpool      880M     0      880M      0%     /myZpool
```

- Looking at ZFS pool properties

Like other file systems, ZFS has many properties such as size, free space, capacity and mount options etc.

```
zpool get health myZpool
```

You will see that the the **health** of pool `myZpool` is `ONLINE`.

```
zpool get size,free,allocated myZpool
```

You will see the total size, free and used space of the pool.

4. **Create datasets (file systems)**

Files are stored in datasets in a ZFS pool. A dataset will continue to place files in the pool until the pool is filled. You can put quotas on detasets to limiting dataset size that is not covered in this lab.

- Create some datasets:

```
sudo zfs create myZpool/test1
sudo zfs create myZpool/test2
sudo zfs create myZpool/test3
```

- Show the datasets:

```
zfs list
```

```
NAME           USED  AVAIL  REFER  MOUNTPOINT
myZpool        164K   880M    24K  /myZpool
myZpool/test1   24K   880M    24K  /myZpool/test1
myZpool/test2   24K   880M    24K  /myZpool/test2
myZpool/test3   24K   880M    24K  /myZpool/test3
```

Each dataset is automatically mounted to its mount point and has full access to the storage pool.

- Store some data in one of the datasets:

```
sudo chmod 777 /myZpool/test*
```

The following command will 10 data files filled with random data:

```
cd /myZpool/test3
for i in {1..10}; do dd if=/dev/urandom of=file$i.dat bs=1024 count=$RANDOM; done
```

You may use the `ll` command to show the created files.

Now, show the datasets again:

```
zfs list
```

```
NAME           USED  AVAIL  REFER  MOUNTPOINT
myZpool        165M   715M    24K  /myZpool
myZpool/test1   24K   715M    24K  /myZpool/test1
myZpool/test2   24K   715M    24K  /myZpool/test2
myZpool/test3  165M   715M   165M  /myZpool/test3
```

You will see that the `myZpool/tests` dataset occupies about 165MB of the pool and the unused space, about 715MB, is available to all datasets. (The actual values may differ on your VM as they are created with random data of random lengths.)

You do not need to worry how much space to preallocate for each datasets as you would have to do with traditional file systems. ZFS manages the entire pool of disks.

5. **Enable compression on datasets**

- Look at the compression property:

```
zfs get -r compression myZpool
```

```
NAME           PROPERTY     VALUE     SOURCE
myZpool        compression  off       default
myZpool/test1  compression  off       default
myZpool/test2  compression  off       default
myZpool/test3  compression  off       default
```

By default the compression property of all datasets is off.

- Enable compression:

```
sudo zfs set compression=lz4 myZpool/test1
zfs get -r compression myZpool
```

```
NAME           PROPERTY     VALUE     SOURCE
myZpool        compression  off       default
myZpool/test1  compression  lz4       local
myZpool/test2  compression  off       default
myZpool/test3  compression  off       default
```

Now, the LZ4 compression on the dataset `myZpool/test1` is enabled.

- Test compression

  Create a text file with redundancy on compressed and uncompressed datasets:

  ```
  cd /myZpool/test1
  for i in {1..1000000}; do echo "Line $i: This is a line of text." >> textfile.txt; done
  ll
  ```

  ```
  total 5108
  drwxrwxrwx 2 root    root          3 Sep 15 22:39 ./
  drwxr-xr-x 5 root    root          5 Sep 15 21:52 ../
  -rw-rw-r-- 1 csci322 csci322 36888896 Sep 15 22:40 textfile.txt
  ```

  ```
  cd /myZpool/test2
  for i in {1..1000000}; do echo "Line $i: This is a line of text." >> textfile.txt; done
  ll
  ```

  ```
  total 36122
  drwxrwxrwx 2 root    root          3 Sep 15 22:40 ./
  drwxr-xr-x 5 root    root          5 Sep 15 21:52 ../
  -rw-rw-r-- 1 csci322 csci322 36888896 Sep 15 22:41 textfile.txt
  ```

  ```
  zfs list
  ```

  ```
  NAME           USED  AVAIL  REFER  MOUNTPOINT
  myZpool        205M   675M    24K  /myZpool
  myZpool/test1  5.01M  675M  5.01M  /myZpool/test1
  myZpool/test2  35.3M  675M  35.3M  /myZpool/test2
  myZpool/test3   165M  675M   165M  /myZpool/test3
  ```

  These two files created on two different datasets have the same content and size while ocuppy different space on the ZFS pool. The uncompressed copy on `/myZpool/test2` uses 35.3MB, which is the same as shown as the size file while the compressed copy on `/myZpool/test1` uses only 5.01MB.

  You can check the compression ratio:

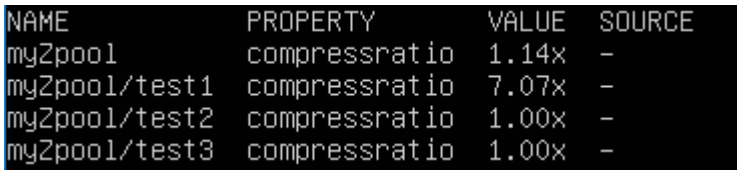
  ```
  zfs get compressratio myZpool/test1
  ```

  ```
  NAME           PROPERTY       VALUE  SOURCE
  myZpool/test1  compressratio  7.07x  -
  ```

  It shows a compression ratio of 7.07x.

  You can check the compression ratio of the whole pool:

  ```
  zfs get -r compressratio myZpool
  ```



```
NAME           PROPERTY       VALUE  SOURCE
myZpool        compressratio  1.14x  -
myZpool/test1  compressratio  7.07x  -
myZpool/test2  compressratio  1.00x  -
myZpool/test3  compressratio  1.00x  -
```

The other uncompressed datasets have a compression ratio of 1.00x, which means no compression. The pool achieves 1.14x compression with current data on it. Some data will be compressed well to reach a high compression ratios while others will not be easily compressed.

6. **Snapshot a dataset**

A ZFS snapshot is a read-only copy of a dataset or the whole pool. It saves the state of the ZFS file system at a point of time that can be rolled back at a later time. Files can be extracted from a snapshot without performing a complete roll back.

- Create a text file before snapshot:

```
cd /myZpool/test1
echo `date` >> myfile.txt
cat myfile.txt
```

The current time is saved in the `myfile.txt`.

- Take a snapshot of the dataset:

```
sudo zfs snapshot -r myZpool/test1@snapshot1
```

Show the snapshots:

```
zfs list -t snapshot
```

- Now lets "accidentally" delete a file:

```
ll
rm textfile.txt
ll
```

- Extract the deleted file from the snapshot:

```
cp .zfs/snapshot/snapshot1/textfile.txt textfile.txt
ll
```

- Modify an existing file:

```
echo `date` >> myfile.txt
cat myfile.txt
```

Now you have one more line in the `myfile.txt` to show the current time.

- Extract the earlier copy of a file from the snapshot

For some reasons, you may need to get your earlier copy of a file back from the snapshot.

```
cp .zfs/snapshot/snapshot1/myfile.txt myfile.txt
cat myfile.txt
```

- Rollback the whole dataset

  Now lets "accidentally" destroy all files:

  ```
  rm /myZpool/test1/*
  ll
  ```

  Rollback the files from the snapshot:

  ```
  sudo zfs rollback myZpool/test1@snapshot1
  ll
  ```

7. **Expand the capacity of the pool**

   More disks can be added to the pool to expand the capacity.

   Show the current status:

   ```
   zpool status
   zfs list
   ```

   Now add another VDEV of 2 disks in a mirror to the pool:

   ```
   sudo zpool add myZpool mirror /dev/sdg /dev/sdh
   zpool status
   zfs list
   ```

   Now you see that another VDEV `mirror-1` is added to the pool and the available capacity is increased for all datasets.

   We have a 2x2 mirrored pool.

8. **Test reliability**

- Simulate a disk failure by first removing it from the pool:

  ```
  sudo zpool detach myZpool /dev/sde
  zpool status
  ```

```
  pool: myZpool
 state: ONLINE
  scan: resilvered 205M in 0h0m with 0 errors on S
config:

        NAME        STATE     READ WRITE CKSUM
        myZpool     ONLINE       0     0     0
          sdf       ONLINE       0     0     0
          mirror-1  ONLINE       0     0     0
            sdg     ONLINE       0     0     0
            sdh     ONLINE       0     0     0

errors: No known data errors
```

  You will see that the `mirror-0` disappears with only one disk `sdf` in the pool.

  ```
  cat myfile.txt
  ```

  You can still access your file.

- Add the disk back as a new disk to transform the existing disk `sdf` into a new mirror.

  First destroy the disk `/dev/sde` by overwriting it with zeros.

  ```
  sudo dd if=/dev/zero of=/dev/sde bs=1M count=1024
  ```

  Now add it back to the pool to form a mirrored VDEV with `/dev/sdf`.

  ```
  sudo zpool attach myZpool /dev/sdf /dev/sde
  zpool status
  ```

  Now you will see the two disks form a new mirrored VDEV, stilled called `mirror-0`.

Submission and mark

Show your work to the lab tutor.

Of 3 marks, you can get

- 1 for showing datasets on the pool;
- 0.5 for showing the compression ratio of all datasets;
- 1 for showing the snapshot;
- 0.5 for showing the pool with two mirrored VDEVs.

You should be ready to answer any questions to demonstrate that all work is done by yourself otherwise you may receive 0 mark.

IMPORTANT NOTE: You will need to document all of your lab work in CSCI322 in your wiki.