Linnaeus University

1DV512 - Operating System
Group Assignment 2
FreeBSD Operating System
(Group 10)

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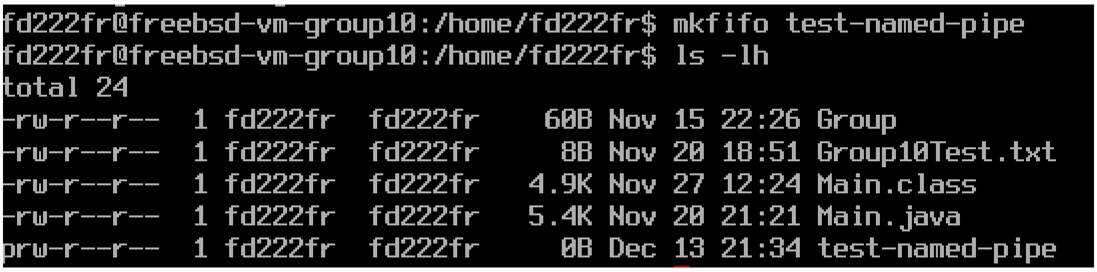
1. Introduction

In this assignment, we will continue to explore the FreeBSD operating system and implementation of Java programs in terms of inter-process communication and file system access aiming to better understand the system behavior. To begin with, the inter-process communication with named pipes will be investigated; furthermore, the FreeBSD file system will be examined in detail typically regarding the virtual disk drive within FreeBSD; the last but not least the interaction of file system will be presented which in order to demonstrate the I/O performance of the respective virtual disk drive. For the sake of consistency and not overcomplicating processes, all group members had a consensus on using a base account to work on so to speak and fd222fr is that account. In case something goes wrong, yd222br and fe222pa are the backup accounts in that order with the root account being the superuser. This is the setup the group members decided to go with on this assignment. Regarding the work distribution in this group assignment, it was distributed as follows: Yuyao Duan worked on the first task, Fredric Sepulveda worked on the second and Fabian Dacic worked on the third. Due to clear communication and determination, the workflow was fluent.

2. Task 1

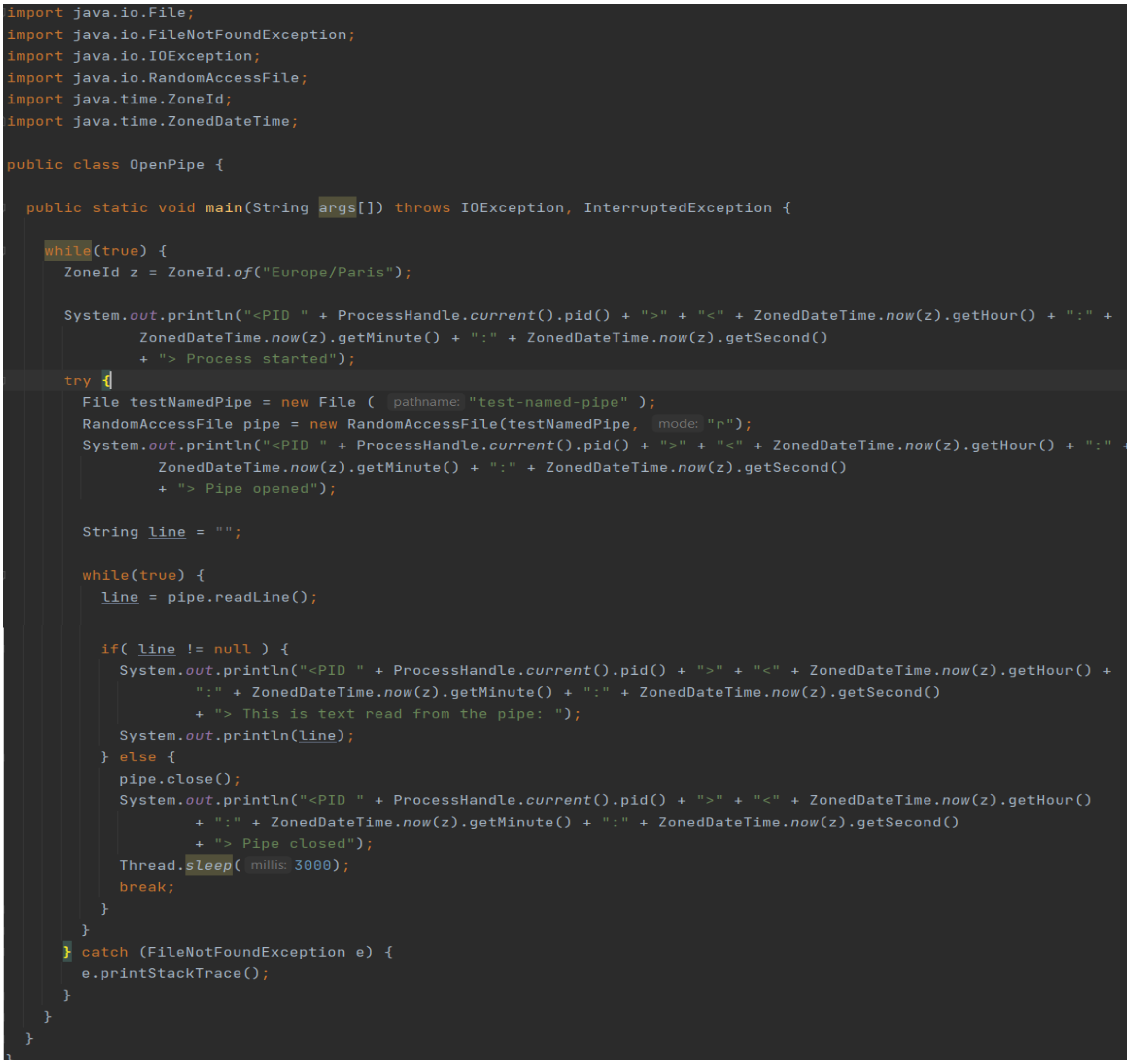
2.1 Creating the pipe for use



```
fd222fr@freebsd-vm-group10:/home/fd222fr$ mkfifo test-named-pipe
fd222fr@freebsd-vm-group10:/home/fd222fr$ ls -lh
total 24
-rw-r--r--  1 fd222fr  fd222fr   60B Nov 15 22:26 Group
-rw-r--r--  1 fd222fr  fd222fr    8B Nov 20 18:51 Group10Test.txt
-rw-r--r--  1 fd222fr  fd222fr  4.9K Nov 27 12:24 Main.class
-rw-r--r--  1 fd222fr  fd222fr  5.4K Nov 20 21:21 Main.java
prw-r--r--  1 fd222fr  fd222fr    0B Dec 13 21:34 test-named-pipe
```

The permissions are slightly different from the other files since it is a pipe and the difference between the others lies in the letter “p” standing in front of the name which implies that it is indeed a named pipe and other than that it has the same permissions as the other files.

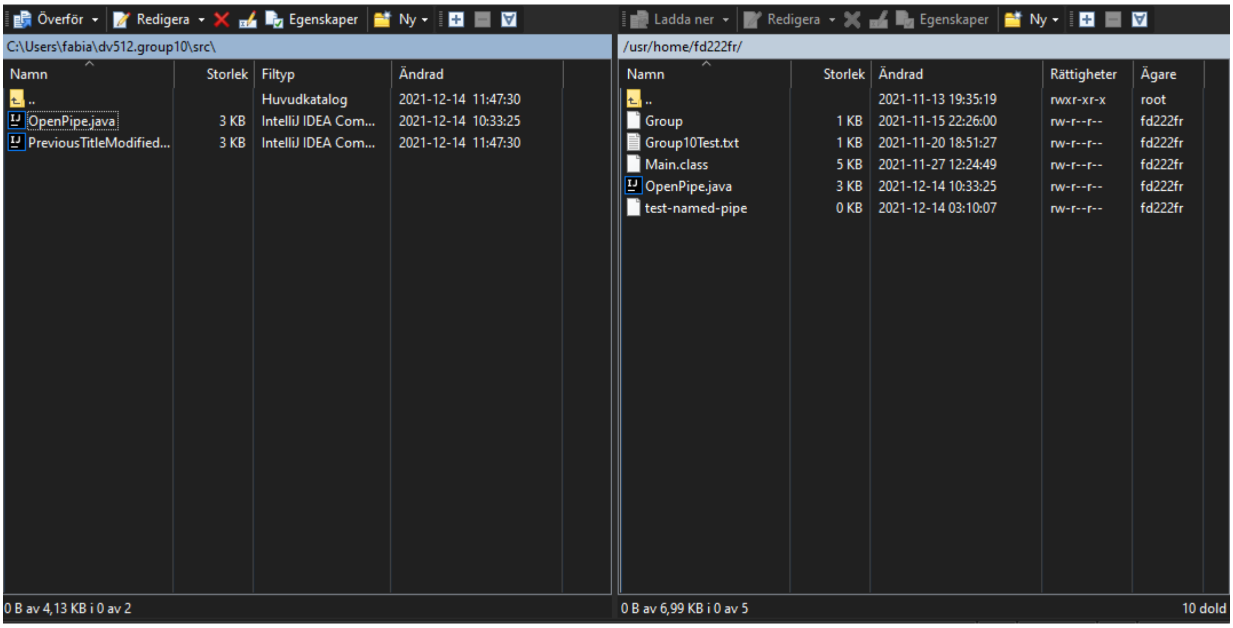
2.2 Implementation of a program to for the pipe



```java
import java.io.File;
import java.io.FileNotFoundException;
import java.io.IOException;
import java.io.RandomAccessFile;
import java.time.ZoneId;
import java.time.ZonedDateTime;

public class OpenPipe {

  public static void main(String args[]) throws IOException, InterruptedException {

    while(true) {
      ZoneId z = ZoneId.of("Europe/Paris");

      System.out.println("<PID " + ProcessHandle.current().pid() + ">" + "<" + ZonedDateTime.now(z).getHour() + ":" +
              ZonedDateTime.now(z).getMinute() + ":" + ZonedDateTime.now(z).getSecond()
              + "> Process started");
      try {
        File testNamedPipe = new File ( pathname: "test-named-pipe" );
        RandomAccessFile pipe = new RandomAccessFile(testNamedPipe,  mode: "r");
        System.out.println("<PID " + ProcessHandle.current().pid() + ">" + "<" + ZonedDateTime.now(z).getHour() + ":" +
                ZonedDateTime.now(z).getMinute() + ":" + ZonedDateTime.now(z).getSecond()
                + "> Pipe opened");

        String line = "";

        while(true) {
          line = pipe.readLine();

          if( line != null ) {
            System.out.println("<PID " + ProcessHandle.current().pid() + ">" + "<" + ZonedDateTime.now(z).getHour() +
                    ":" + ZonedDateTime.now(z).getMinute() + ":" + ZonedDateTime.now(z).getSecond()
                    + "> This is text read from the pipe: ");
            System.out.println(line);
          } else {
            pipe.close();
            System.out.println("<PID " + ProcessHandle.current().pid() + ">" + "<" + ZonedDateTime.now(z).getHour()
                    + ":" + ZonedDateTime.now(z).getMinute() + ":" + ZonedDateTime.now(z).getSecond()
                    + "> Pipe closed");
            Thread.sleep( millis: 3000);
            break;
          }
        }
      } catch (FileNotFoundException e) {
        e.printStackTrace();
      }
    }
  }
```

The code is pretty basic in nature, making use of no external libraries. Starting off with the necessary packages such as the File and RandomAccessFile to create and open the pipe, exception-related packages, and Zone-related packages in order to get the time and print it out. After that, the first loop arrives which initially starts off by printing out that the process has started and then immediately after it tries to open the pipe and at the other end as soon as the command "*cat > test-named-pipe*" is written in the other shell, it prints out that the pipe is indeed open and the user can type in the messages that they want to echo. The task of that is assigned to the second loop which waits until the command to close the pipe (control key + c) is written in the other shell and then it prints out the message telling the user that the pipe has indeed been closed and waits for three seconds before redoing the outer loop. All of the requirements have been fulfilled.

2.3 Transferring file to FreeBSD



C:\Users\fabia\dv512.group10\src\

Namn	Storlek	Filtyp	Ändrad
..		Huvudkatalog	2021-12-14 11:47:30
OpenPipe.java	3 KB	IntelliJ IDEA Com...	2021-12-14 10:33:25
PreviousTitleModified...	3 KB	IntelliJ IDEA Com...	2021-12-14 11:47:30

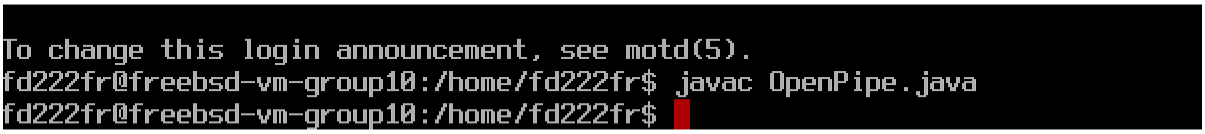
0 B av 4,13 KB i 0 av 2

/usr/home/fd222fr/

Namn	Storlek	Ändrad	Rättigheter	Ägare
..		2021-11-13 19:35:19	rwxr-xr-x	root
Group	1 KB	2021-11-15 22:26:00	rw-r--r--	fd222fr
Group10Test.txt	1 KB	2021-11-20 18:51:27	rw-r--r--	fd222fr
Main.class	5 KB	2021-11-27 12:24:49	rw-r--r--	fd222fr
OpenPipe.java	3 KB	2021-12-14 10:33:25	rw-r--r--	fd222fr
test-named-pipe	0 KB	2021-12-14 03:10:07	rw-r--r--	fd222fr

0 B av 6,99 KB i 0 av 5 10 dold

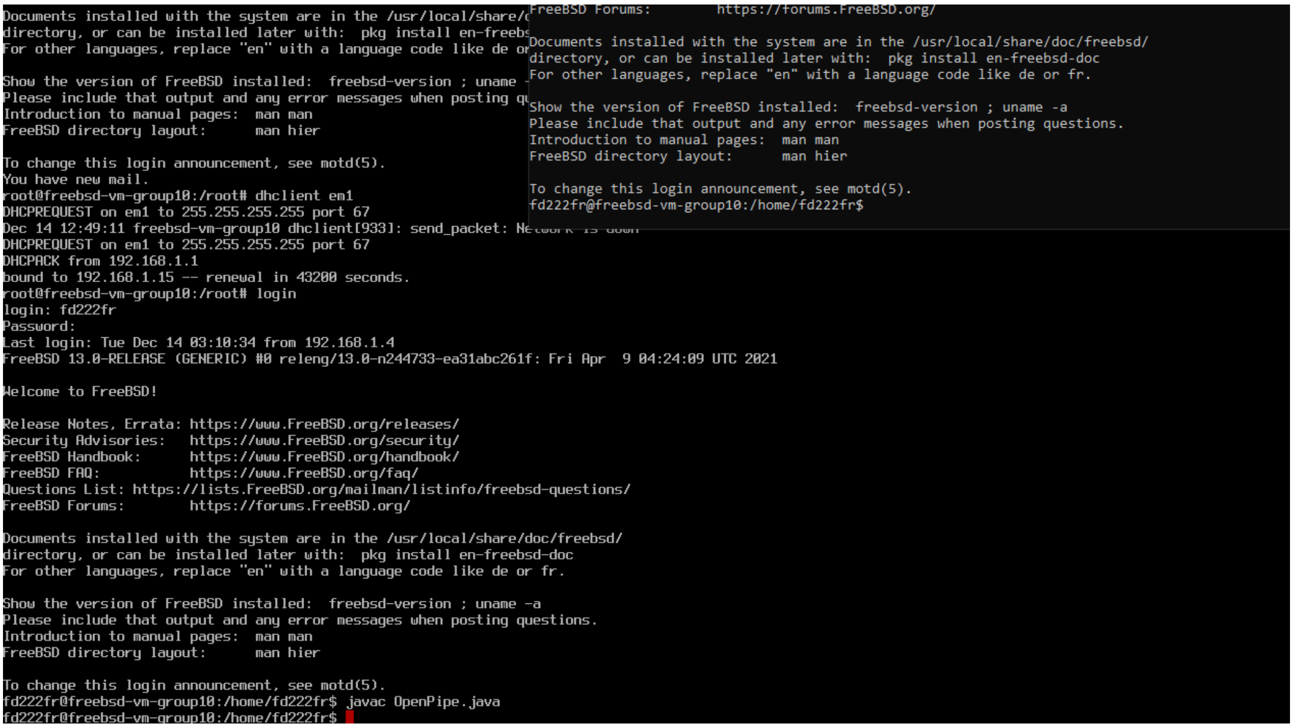
For the sake of simplicity and consistency, WinSCP is used to transfer files from host to guest and as it can be seen here all the previous steps used from assignment 1 moved on to assignment 2 and it works well.



```
To change this login announcement, see motd(5).
fd222fr@freebsd-vm-group10:/home/fd222fr$ javac OpenPipe.java
fd222fr@freebsd-vm-group10:/home/fd222fr$
```

To compile the file the command "*javac…*" is used and then immediately followed by the file of the program.

2.4 Preparing to work with multiple shells

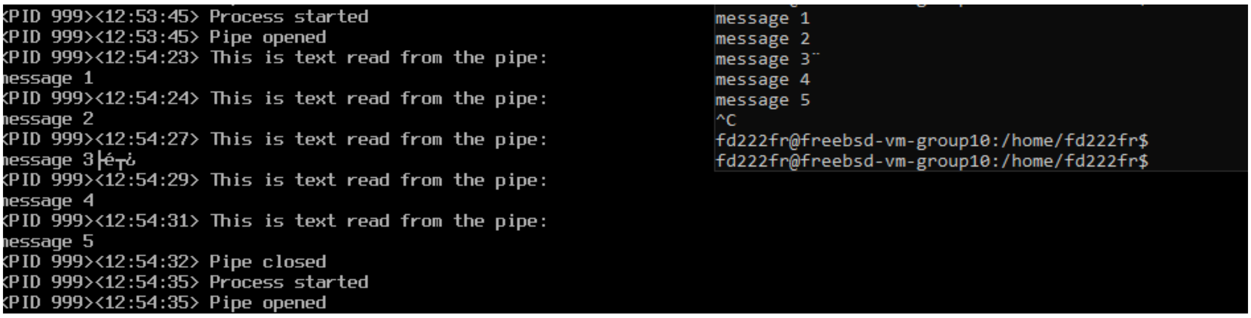


```
Documents installed with the system are in the /usr/local/share/c
directory, or can be installed later with:  pkg install en-freebs
For other languages, replace "en" with a language code like de or

Show the version of FreeBSD installed:  freebsd-version ; uname -
Please include that output and any error messages when posting qu
Introduction to manual pages:  man man
FreeBSD directory layout:      man hier

To change this login announcement, see motd(5).
You have new mail.
root@freebsd-vm-group10:/root# dhclient em1
DHCPREQUEST on em1 to 255.255.255.255 port 67
Dec 14 12:49:11 freebsd-vm-group10 dhclient[933]: send_packet: Ne
DHCPREQUEST on em1 to 255.255.255.255 port 67
DHCPACK from 192.168.1.1
bound to 192.168.1.15 -- renewal in 43200 seconds.
root@freebsd-vm-group10:/root# login
login: fd222fr
Password:
Last login: Tue Dec 14 03:10:34 from 192.168.1.4
FreeBSD 13.0-RELEASE (GENERIC) #0 releng/13.0-n244733-ea31abc261f: Fri Apr  9 04:24:09 UTC 2021

Welcome to FreeBSD!

Release Notes, Errata: https://www.FreeBSD.org/releases/
Security Advisories:   https://www.FreeBSD.org/security/
FreeBSD Handbook:      https://www.FreeBSD.org/handbook/
FreeBSD FAQ:           https://www.FreeBSD.org/faq/
Questions List: https://lists.FreeBSD.org/mailman/listinfo/freebsd-questions/
FreeBSD Forums:        https://forums.FreeBSD.org/

Documents installed with the system are in the /usr/local/share/doc/freebsd/
directory, or can be installed later with:  pkg install en-freebsd-doc
For other languages, replace "en" with a language code like de or fr.

Show the version of FreeBSD installed:  freebsd-version ; uname -a
Please include that output and any error messages when posting questions.
Introduction to manual pages:  man man
FreeBSD directory layout:      man hier

To change this login announcement, see motd(5).
fd222fr@freebsd-vm-group10:/home/fd222fr$ javac OpenPipe.java
fd222fr@freebsd-vm-group10:/home/fd222fr$
```

```
FreeBSD Forums:        https://forums.FreeBSD.org/

Documents installed with the system are in the /usr/local/share/doc/freebsd/
directory, or can be installed later with:  pkg install en-freebsd-doc
For other languages, replace "en" with a language code like de or fr.

Show the version of FreeBSD installed:  freebsd-version ; uname -a
Please include that output and any error messages when posting questions.
Introduction to manual pages:  man man
FreeBSD directory layout:      man hier

To change this login announcement, see motd(5).
fd222fr@freebsd-vm-group10:/home/fd222fr$
```

For this step, to not overcomplicate the process, multiple terminal windows with SSH connection to the virtual machine (VM) were opened as it can be seen in the figure above.

2.5 Running the program and observing the results

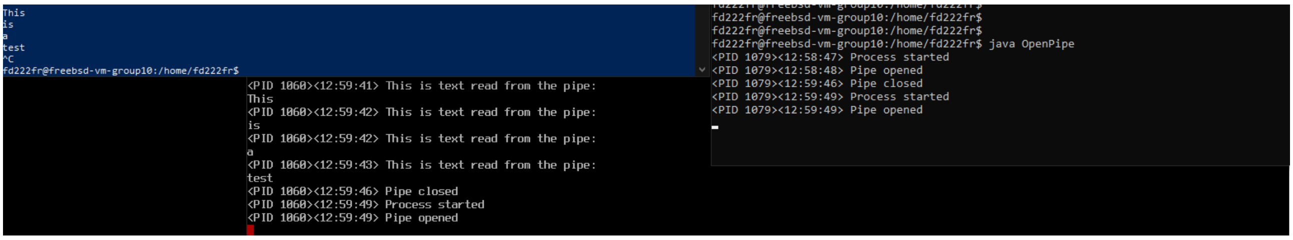


```
<PID 999><12:53:45> Process started
<PID 999><12:53:45> Pipe opened
<PID 999><12:54:23> This is text read from the pipe:
message 1
<PID 999><12:54:24> This is text read from the pipe:
message 2
<PID 999><12:54:27> This is text read from the pipe:
message 3├é┬¿
<PID 999><12:54:29> This is text read from the pipe:
message 4
<PID 999><12:54:31> This is text read from the pipe:
message 5
<PID 999><12:54:32> Pipe closed
<PID 999><12:54:35> Process started
<PID 999><12:54:35> Pipe opened
```

```
message 1
message 2
message 3¨
message 4
message 5
^C
fd222fr@freebsd-vm-group10:/home/fd222fr$
fd222fr@freebsd-vm-group10:/home/fd222fr$
```

After running the program with the command "*java OpenPipe*", immediately we can see that the program prints out that the program has started and then after typing in the second shell "*cat > test-named-pipe*", it will print out that the pipe has indeed been opened and is ready to echo the input from the respective shell. It successfully echoed the five messages and as soon as control key + c was input, the pipe closed and it waited 3 seconds before it started the process once more. Terminating the Java program from the main shell and then re-running it produced us with a new process id.

2.6 Running the program and observing the result from two outputs



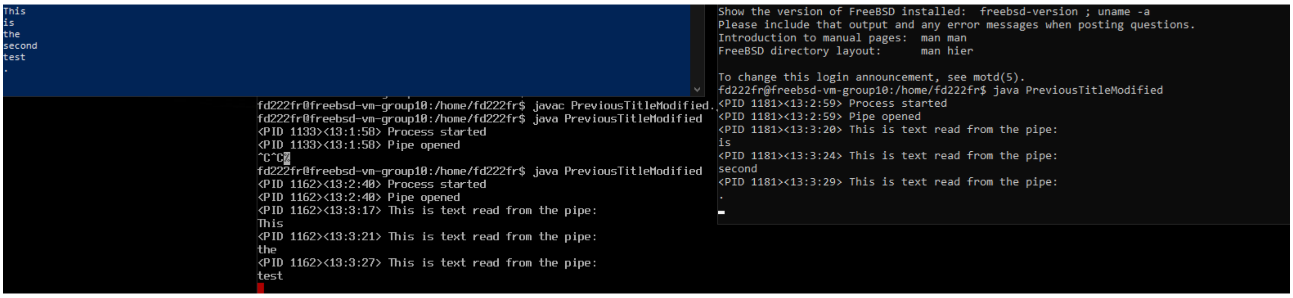
```
This
is
a
test
^C
fd222fr@freebsd-vm-group10:/home/fd222fr$
```

```
<PID 1060><12:59:41> This is text read from the pipe:
This
<PID 1060><12:59:42> This is text read from the pipe:
is
<PID 1060><12:59:42> This is text read from the pipe:
a
<PID 1060><12:59:43> This is text read from the pipe:
test
<PID 1060><12:59:46> Pipe closed
<PID 1060><12:59:49> Process started
<PID 1060><12:59:49> Pipe opened
```

```
fd222fr@freebsd-vm-group10:/home/fd222fr$
fd222fr@freebsd-vm-group10:/home/fd222fr$
fd222fr@freebsd-vm-group10:/home/fd222fr$ java OpenPipe
<PID 1079><12:58:47> Process started
<PID 1079><12:58:48> Pipe opened
<PID 1079><12:59:46> Pipe closed
<PID 1079><12:59:49> Process started
<PID 1079><12:59:49> Pipe opened
```

For this sub-task, another shell was opened and as it can be seen from the figure above, it has a different colour from the other two to help it differentiate since it is our "input shell" so to speak. Observing the results it can be noted that only one of the shells is actually echoing messages whereas the other is remaining dormant for an unknown reason. Different strategies have been applied such as writing multiple messages repeatedly however proved to no fruitition.

2.7 Running the modified program and observing the result from two outputs



```
This
is
the
second
test
.
```

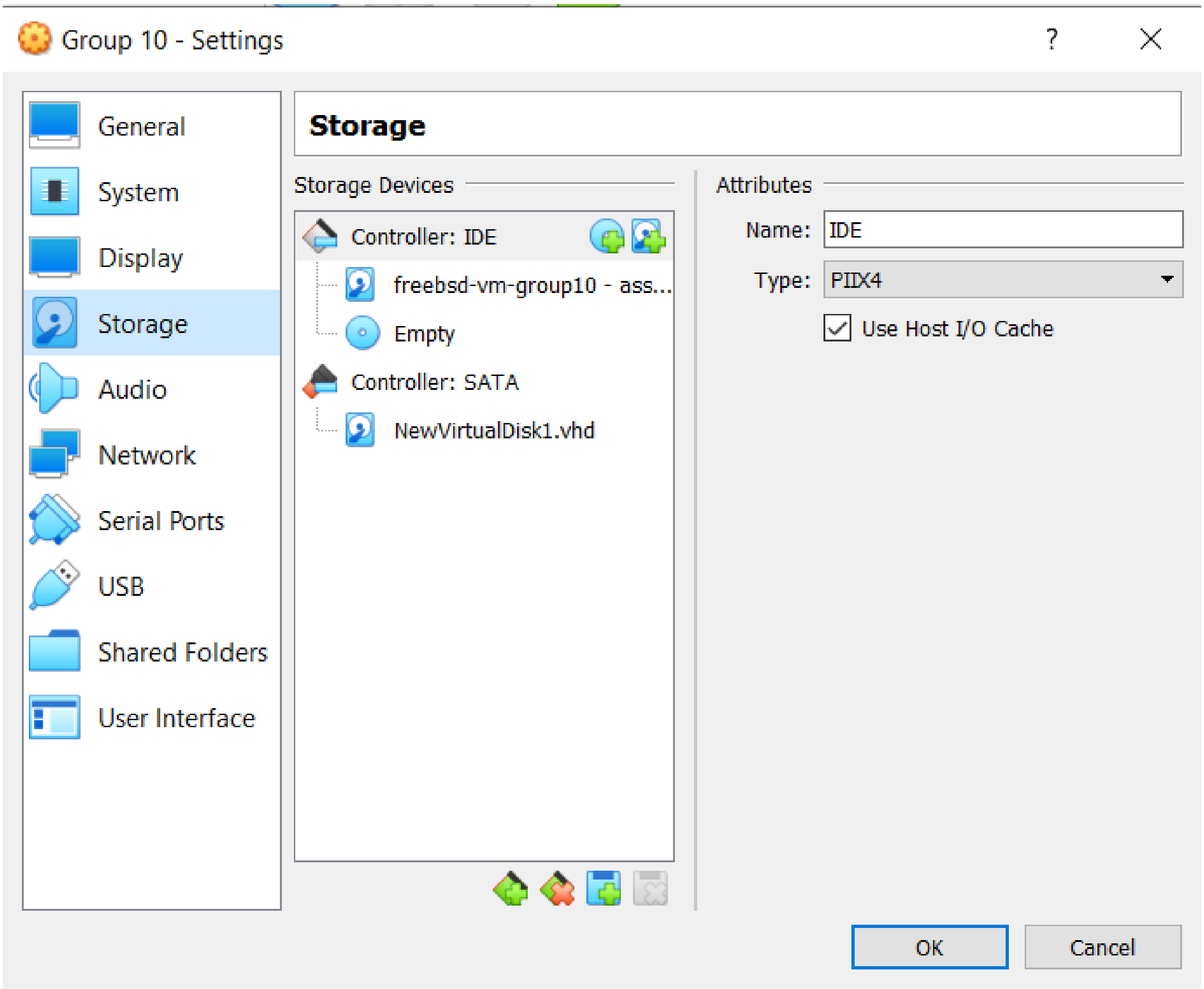
```
fd222fr@freebsd-vm-group10:/home/fd222fr$ javac PreviousTitleModified.
fd222fr@freebsd-vm-group10:/home/fd222fr$ java PreviousTitleModified
<PID 1133><13:1:58> Process started
<PID 1133><13:1:58> Pipe opened
^C^C
fd222fr@freebsd-vm-group10:/home/fd222fr$ java PreviousTitleModified
<PID 1162><13:2:40> Process started
<PID 1162><13:2:40> Pipe opened
<PID 1162><13:3:17> This is text read from the pipe:
This
<PID 1162><13:3:21> This is text read from the pipe:
the
<PID 1162><13:3:27> This is text read from the pipe:
test
```

```
Show the version of FreeBSD installed:  freebsd-version ; uname -a
Please include that output and any error messages when posting questions.
Introduction to manual pages:  man man
FreeBSD directory layout:      man hier

To change this login announcement, see motd(5).
fd222fr@freebsd-vm-group10:/home/fd222fr$ java PreviousTitleModified
<PID 1181><13:2:59> Process started
<PID 1181><13:2:59> Pipe opened
<PID 1181><13:3:20> This is text read from the pipe:
is
<PID 1181><13:3:24> This is text read from the pipe:
second
<PID 1181><13:3:29> This is text read from the pipe:
.
```

The result does indeed differ from the last run and as it can be seen from the figure above, each shell prints out every second message that the main shell inputs. This could be indeed because of the delay added in the program once a message has been input which for the first shell means that it has to wait for 3 seconds while the other is in stand-by mode and vice-versa.

3. Task 2

3.1 Creating a secondary storage



Group 10 - Settings

Storage

Storage Devices

- Controller: IDE
  - freebsd-vm-group10 - ass...
  - Empty
- Controller: SATA
  - NewVirtualDisk1.vhd

Attributes

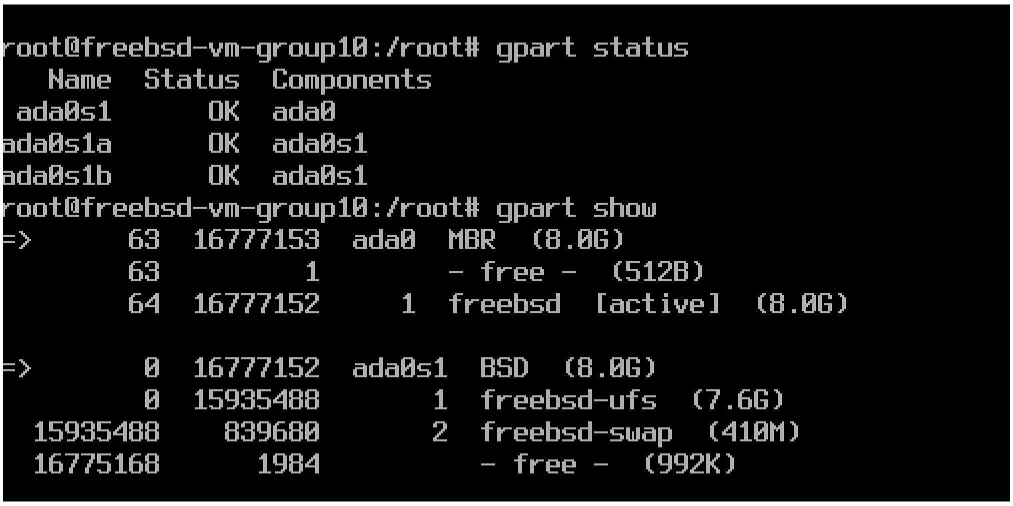
Name: IDE

Type: PIIX4

☑ Use Host I/O Cache

As it can be seen here new storage was created for the VM and it was added to it and right after this step, the VM was started.

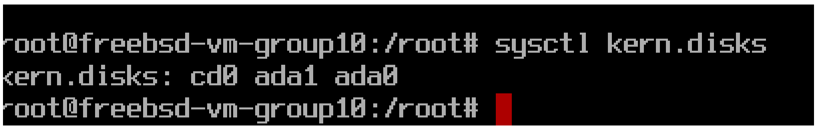
3.2 Using gpart to check storage devices



```
root@freebsd-vm-group10:/root# gpart status
   Name  Status  Components
 ada0s1      OK  ada0
ada0s1a      OK  ada0s1
ada0s1b      OK  ada0s1
root@freebsd-vm-group10:/root# gpart show
=>      63  16777153  ada0  MBR  (8.0G)
        63         1        - free -  (512B)
        64  16777152     1  freebsd  [active]  (8.0G)

=>       0  16777152  ada0s1  BSD  (8.0G)
         0  15935488       1  freebsd-ufs  (7.6G)
  15935488    839680       2  freebsd-swap  (410M)
  16775168      1984          - free -  (992K)
```

The name of the disk or the geom is **ada0** and its slice is **ada0s1** with the partitions **a** and **b**. The "ada" prefix indicates the storage device that is a drive type of SATA and IDE hard-drive. Continuing with the zero attached to it or shortly said; the geom **ada0** means that it is the first disk. Proceeding with the first slice of it which is **ada0s1** in our group's case means that the **s1** implies it's indeed the first slice of the first disk. The letter **a** and **b** are the partitions of our slice, and the **a** indicates that in that partition the root file system is contained whereas in **b** the so-called swap space is contained. The partitioning scheme that is used is **MBR** as it can be seen in the part where the command "*gpart show*" is run and the partition types used are **freebsd-ufs** and **freebsd-swap** [1].

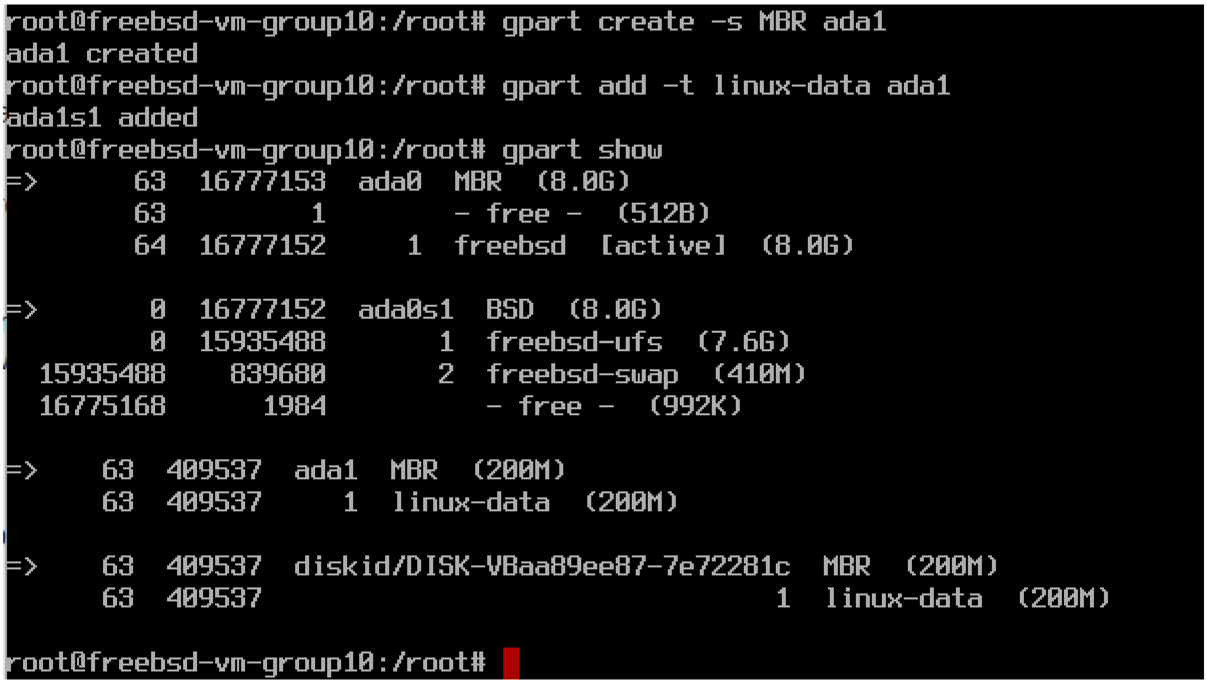
3.3 Using sysctl to check storage devices



```
root@freebsd-vm-group10:/root# sysctl kern.disks
kern.disks: cd0 ada1 ada0
root@freebsd-vm-group10:/root#
```

After running the command as it can be seen in the figure above, a new disk appears and its named **ada1** which is probably the secondary disk that is attached to the storage of the VM.

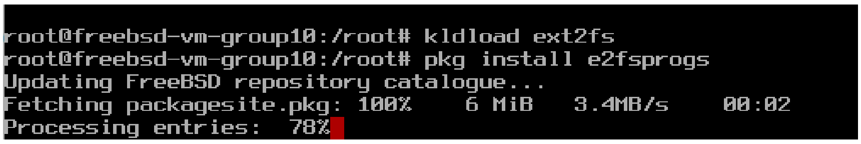
3.4 Creating a new partition on the secondary disk



```
root@freebsd-vm-group10:/root# gpart create -s MBR ada1
ada1 created
root@freebsd-vm-group10:/root# gpart add -t linux-data ada1
ada1s1 added
root@freebsd-vm-group10:/root# gpart show
=>       63  16777153  ada0  MBR  (8.0G)
         63         1        - free -  (512B)
         64  16777152     1  freebsd  [active]  (8.0G)

=>        0  16777152  ada0s1  BSD  (8.0G)
          0  15935488       1  freebsd-ufs  (7.6G)
   15935488    839680       2  freebsd-swap  (410M)
   16775168      1984          - free -  (992K)

=>     63  409537  ada1  MBR  (200M)
       63  409537     1  linux-data  (200M)

=>     63  409537  diskid/DISK-VBaa89ee87-7e72281c  MBR  (200M)
       63  409537                                1  linux-data  (200M)

root@freebsd-vm-group10:/root#
```

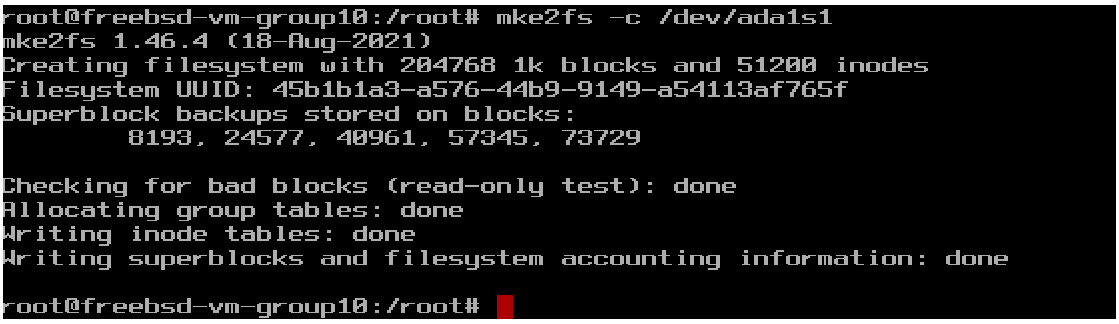
As it can be seen in the figure above the first partition was created and it is displayed in the output after running the commands to do so.

3.5 Loading kernel module and creating new file system



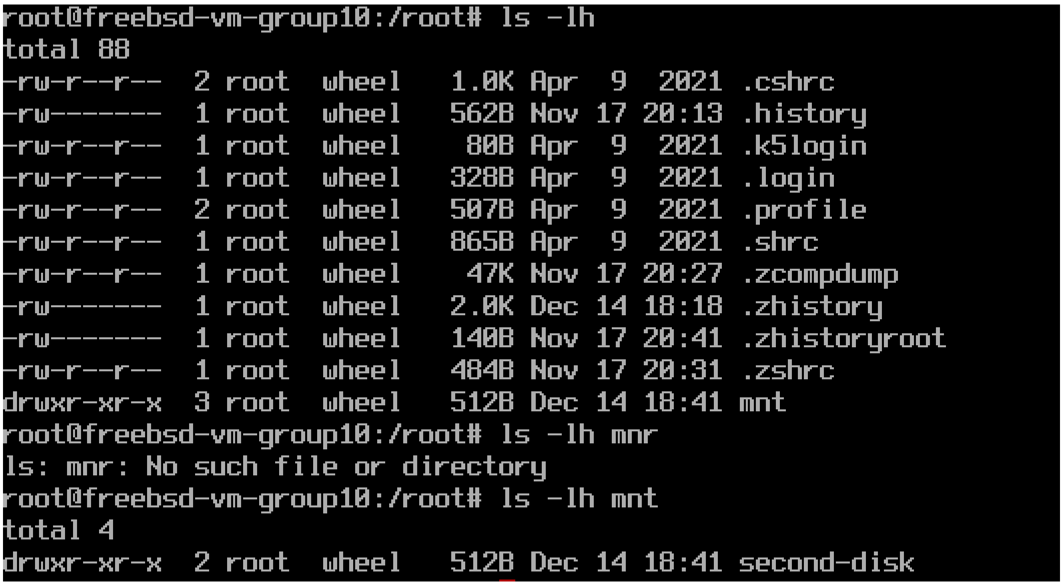
```
root@freebsd-vm-group10:/root# kldload ext2fs
root@freebsd-vm-group10:/root# pkg install e2fsprogs
Updating FreeBSD repository catalogue...
Fetching packagesite.pkg: 100%    6 MiB   3.4MB/s    00:02
Processing entries:  78%
```

In the figure above the kernel module that supports the EXT2 file system is loaded and ready to go and right after the command to load it, the command to install the e2fsprogs package is run and installed. The figure below shows the running of the command for creating an EXT2 file system to the previously created partition.



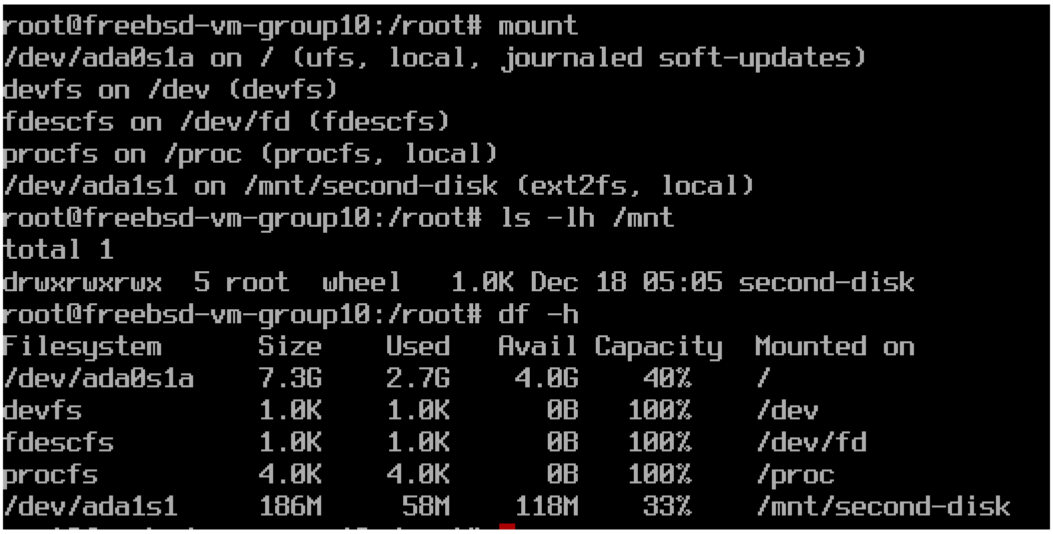
```
root@freebsd-vm-group10:/root# mke2fs -c /dev/ada1s1
mke2fs 1.46.4 (18-Aug-2021)
Creating filesystem with 204768 1k blocks and 51200 inodes
Filesystem UUID: 45b1b1a3-a576-44b9-9149-a54113af765f
Superblock backups stored on blocks:
        8193, 24577, 40961, 57345, 73729

Checking for bad blocks (read-only test): done
Allocating group tables: done
Writing inode tables: done
Writing superblocks and filesystem accounting information: done

root@freebsd-vm-group10:/root#
```

3.6 Creating a mount point for the secondary disk



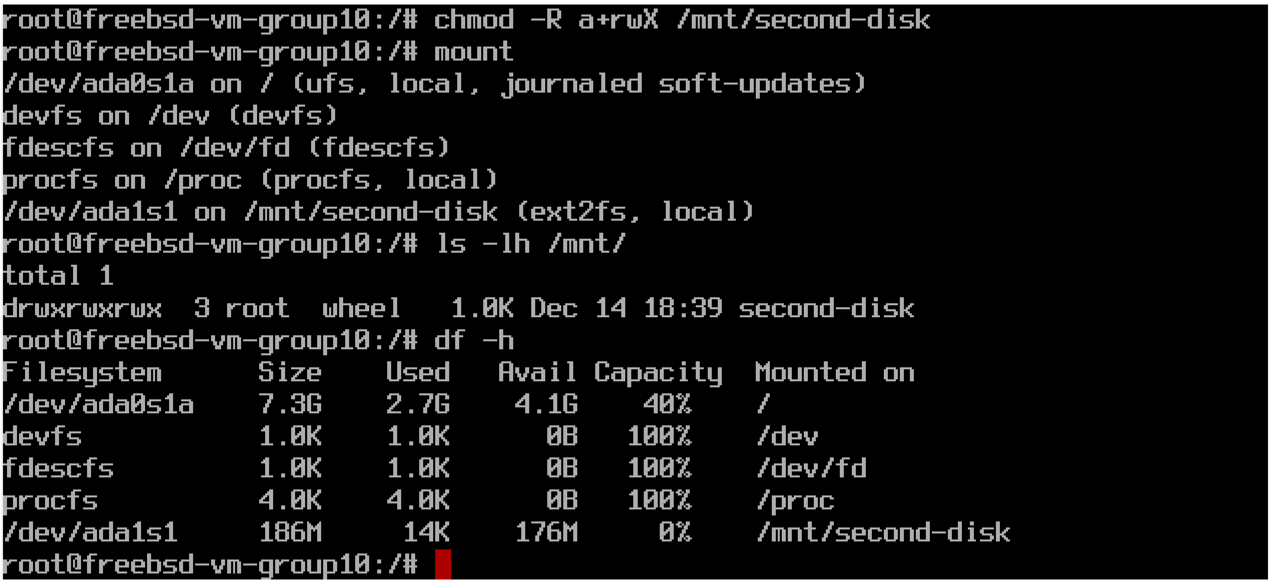
```
root@freebsd-vm-group10:/root# ls -lh
total 88
-rw-r--r--  2 root  wheel   1.0K Apr  9  2021 .cshrc
-rw-------  1 root  wheel   562B Nov 17 20:13 .history
-rw-r--r--  1 root  wheel    80B Apr  9  2021 .k5login
-rw-r--r--  1 root  wheel   328B Apr  9  2021 .login
-rw-r--r--  2 root  wheel   507B Apr  9  2021 .profile
-rw-r--r--  1 root  wheel   865B Apr  9  2021 .shrc
-rw-r--r--  1 root  wheel    47K Nov 17 20:27 .zcompdump
-rw-------  1 root  wheel   2.0K Dec 14 18:18 .zhistory
-rw-------  1 root  wheel   140B Nov 17 20:41 .zhistoryroot
-rw-r--r--  1 root  wheel   484B Nov 17 20:31 .zshrc
drwxr-xr-x  3 root  wheel   512B Dec 14 18:41 mnt
root@freebsd-vm-group10:/root# ls -lh mnr
ls: mnr: No such file or directory
root@freebsd-vm-group10:/root# ls -lh mnt
total 4
drwxr-xr-x  2 root  wheel   512B Dec 14 18:41 second-disk
```

After creating the mount point for the secondary disk, the "wildcard" of a command which is "*chmod -R a+rwX*" [2] followed by the mount point for the secondary disk, the permissions for all users are changed as well. It is to be noted that the aforementioned command is not entirely recommended to run.



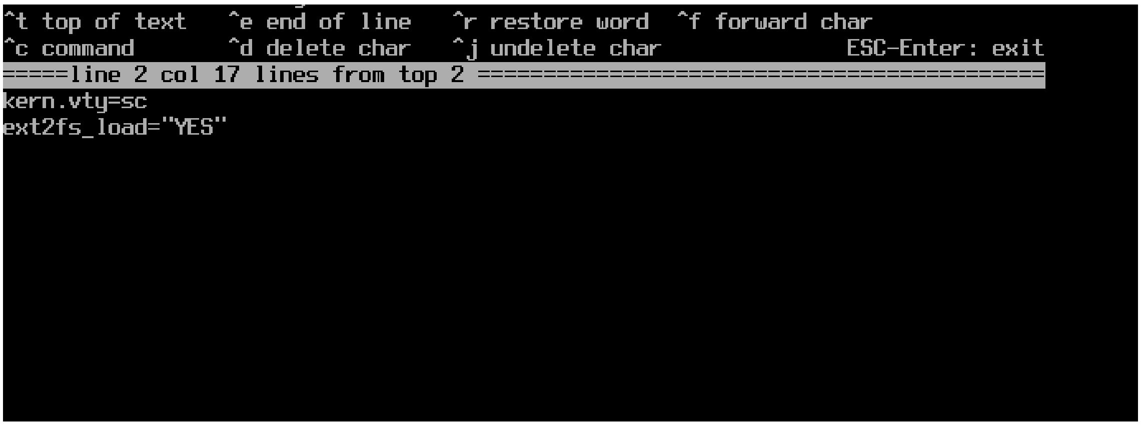
```
root@freebsd-vm-group10:/root# mount
/dev/ada0s1a on / (ufs, local, journaled soft-updates)
devfs on /dev (devfs)
fdescfs on /dev/fd (fdescfs)
procfs on /proc (procfs, local)
/dev/ada1s1 on /mnt/second-disk (ext2fs, local)
root@freebsd-vm-group10:/root# ls -lh /mnt
total 1
drwxrwxrwx  5 root  wheel   1.0K Dec 18 05:05 second-disk
root@freebsd-vm-group10:/root# df -h
Filesystem      Size    Used   Avail Capacity  Mounted on
/dev/ada0s1a    7.3G    2.7G    4.0G    40%    /
devfs           1.0K    1.0K      0B   100%    /dev
fdescfs         1.0K    1.0K      0B   100%    /dev/fd
procfs          4.0K    4.0K      0B   100%    /proc
/dev/ada1s1     186M     58M    118M    33%    /mnt/second-disk
```

Everything seems to be working after running the commands seen in the figure above.

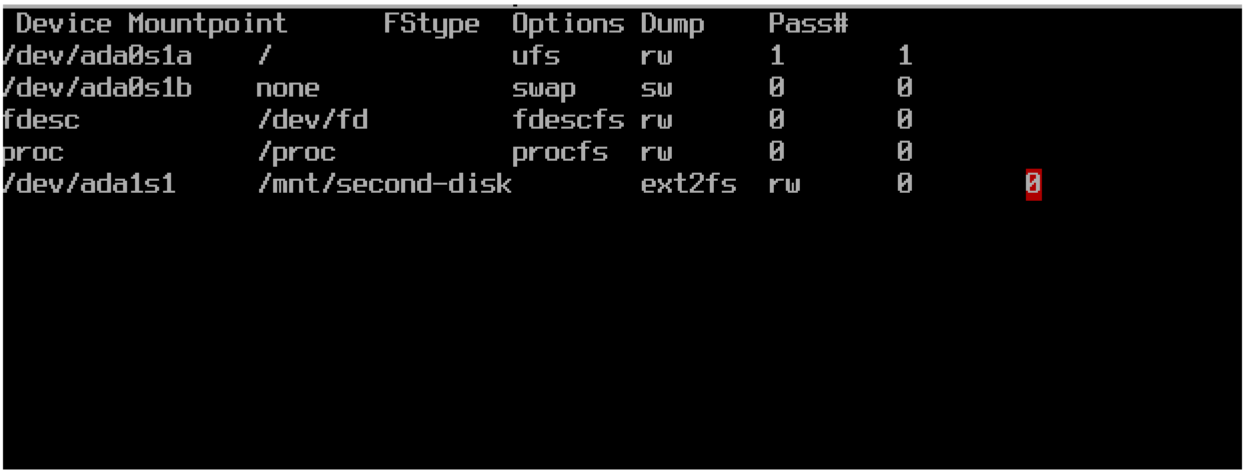


```
root@freebsd-vm-group10:/# chmod -R a+rwX /mnt/second-disk
root@freebsd-vm-group10:/# mount
/dev/ada0s1a on / (ufs, local, journaled soft-updates)
devfs on /dev (devfs)
fdescfs on /dev/fd (fdescfs)
procfs on /proc (procfs, local)
/dev/ada1s1 on /mnt/second-disk (ext2fs, local)
root@freebsd-vm-group10:/# ls -lh /mnt/
total 1
drwxrwxrwx  3 root  wheel   1.0K Dec 14 18:39 second-disk
root@freebsd-vm-group10:/# df -h
Filesystem      Size    Used   Avail Capacity  Mounted on
/dev/ada0s1a    7.3G    2.7G    4.1G    40%    /
devfs           1.0K    1.0K      0B   100%    /dev
fdescfs         1.0K    1.0K      0B   100%    /dev/fd
procfs          4.0K    4.0K      0B   100%    /proc
/dev/ada1s1     186M     14K    176M     0%    /mnt/second-disk
root@freebsd-vm-group10:/#
```

3.7 Configuring the disk to be mounted automatically at start-up

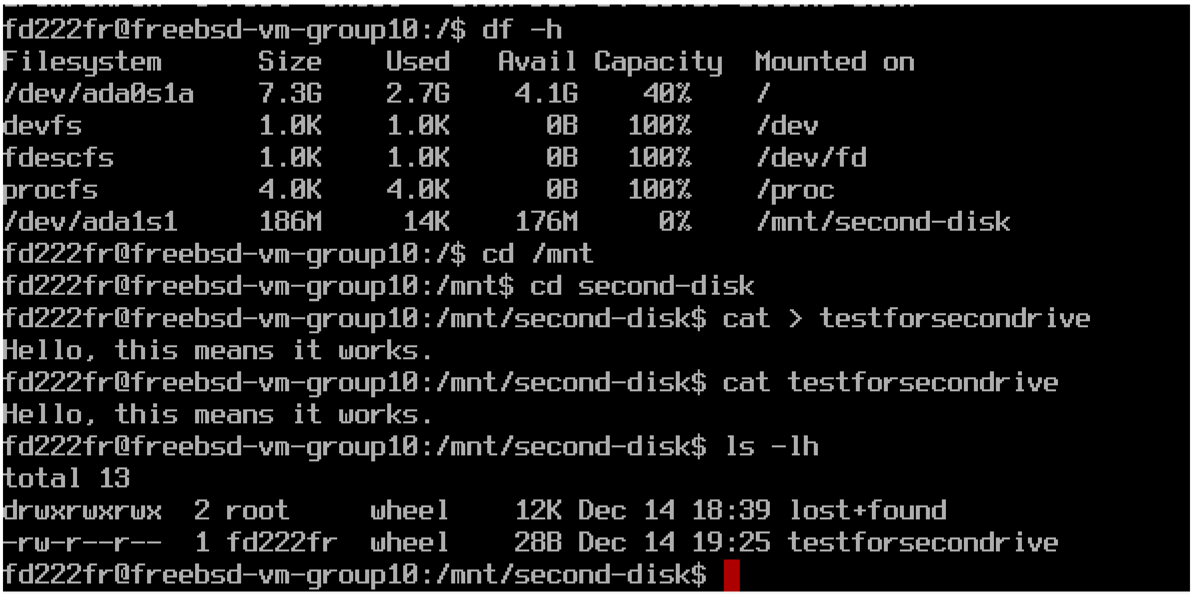


```
^t top of text    ^e end of line    ^r restore word   ^f forward char
^c command        ^d delete char    ^j undelete char               ESC-Enter: exit
=====line 2 col 17 lines from top 2 =========================================
kern.vty=sc
ext2fs_load="YES"
```



```
 Device Mountpoint       FStype  Options Dump    Pass#
/dev/ada0s1a     /               ufs     rw      1       1
/dev/ada0s1b     none            swap    sw      0       0
fdesc            /dev/fd         fdescfs rw      0       0
proc             /proc           procfs  rw      0       0
/dev/ada1s1      /mnt/second-disk        ext2fs  rw      0       0
```

3.8 Testing out the new changes

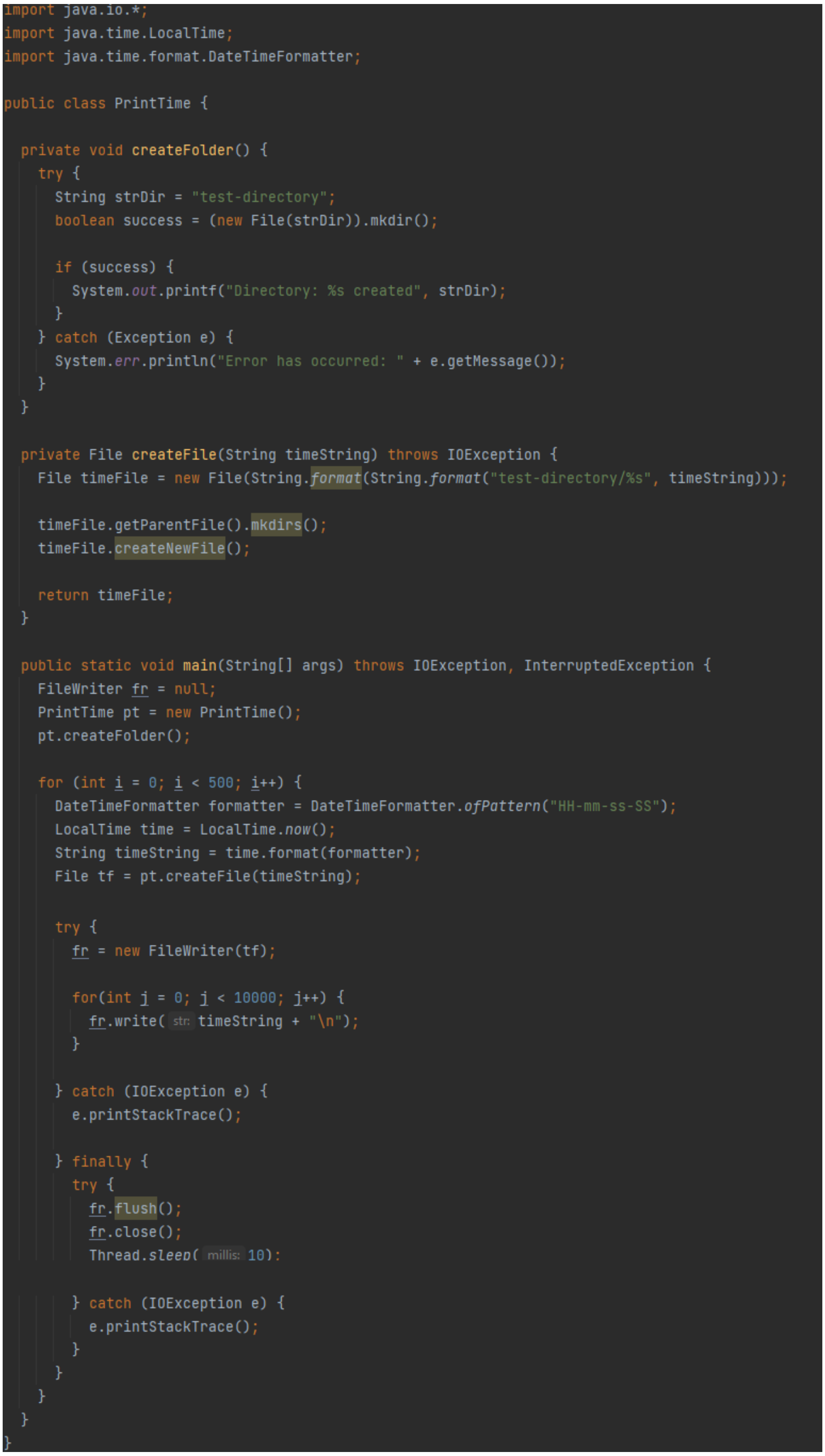


```
fd222fr@freebsd-vm-group10:/$ df -h
Filesystem      Size    Used   Avail Capacity  Mounted on
/dev/ada0s1a    7.3G    2.7G    4.1G    40%    /
devfs           1.0K    1.0K      0B   100%    /dev
fdescfs         1.0K    1.0K      0B   100%    /dev/fd
procfs          4.0K    4.0K      0B   100%    /proc
/dev/ada1s1     186M     14K    176M     0%    /mnt/second-disk
fd222fr@freebsd-vm-group10:/$ cd /mnt
fd222fr@freebsd-vm-group10:/mnt$ cd second-disk
fd222fr@freebsd-vm-group10:/mnt/second-disk$ cat > testforsecondrive
Hello, this means it works.
fd222fr@freebsd-vm-group10:/mnt/second-disk$ cat testforsecondrive
Hello, this means it works.
fd222fr@freebsd-vm-group10:/mnt/second-disk$ ls -lh
total 13
drwxrwxrwx  2 root     wheel    12K Dec 14 18:39 lost+found
-rw-r--r--  1 fd222fr  wheel    28B Dec 14 19:25 testforsecondrive
fd222fr@freebsd-vm-group10:/mnt/second-disk$
```

No sudo or superuser privileges were used after running the commands seen in the figure above.

4. Task 3

4.1 Implementation of the program to print out time



```
import java.io.*;
import java.time.LocalTime;
import java.time.format.DateTimeFormatter;

public class PrintTime {

  private void createFolder() {
    try {
      String strDir = "test-directory";
      boolean success = (new File(strDir)).mkdir();

      if (success) {
        System.out.printf("Directory: %s created", strDir);
      }
    } catch (Exception e) {
      System.err.println("Error has occurred: " + e.getMessage());
    }
  }

  private File createFile(String timeString) throws IOException {
    File timeFile = new File(String.format(String.format("test-directory/%s", timeString)));

    timeFile.getParentFile().mkdirs();
    timeFile.createNewFile();

    return timeFile;
  }

  public static void main(String[] args) throws IOException, InterruptedException {
    FileWriter fr = null;
    PrintTime pt = new PrintTime();
    pt.createFolder();

    for (int i = 0; i < 500; i++) {
      DateTimeFormatter formatter = DateTimeFormatter.ofPattern("HH-mm-ss-SS");
      LocalTime time = LocalTime.now();
      String timeString = time.format(formatter);
      File tf = pt.createFile(timeString);

      try {
        fr = new FileWriter(tf);

        for(int j = 0; j < 10000; j++) {
          fr.write( str: timeString + "\n");
        }

      } catch (IOException e) {
        e.printStackTrace();

      } finally {
        try {
          fr.flush();
          fr.close();
          Thread.sleep( millis: 10);

        } catch (IOException e) {
          e.printStackTrace();
        }
      }
    }
  }
}
```

This program is quite easy to work with as well and simple in nature. First, the methods to create the directory “test-directory” is used then for the outer loop, time is checked using the DateFormatter and LocalTime packages (a slightly different approach from the first few programs from the previous tasks) and then in this outer loop, the file with the timestamp as its name is created. After the file has been created, it is then opened for writing and the timestamp is written 10000 times in it. Afterward, it is flushed and then closed and the program waits 10 milliseconds before continuing again. All of the requirements have been fulfilled.

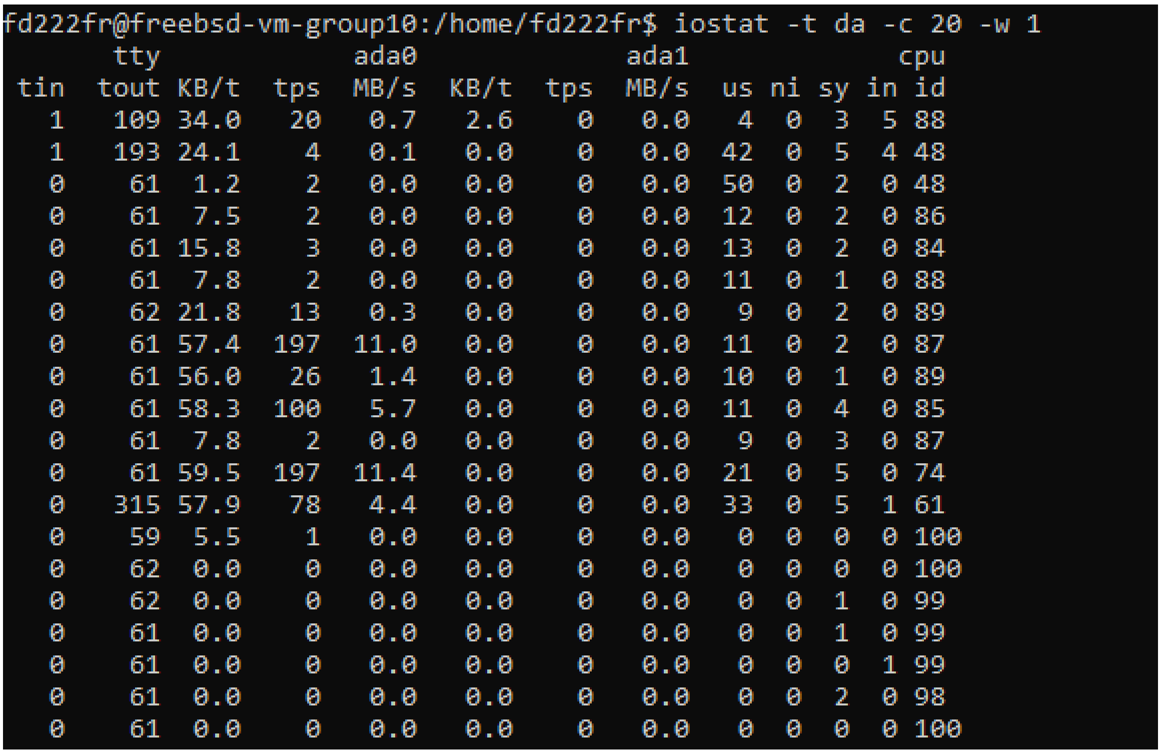
4.2 Transferring the program file to FreeBSD

The same method as in the previous task was used; WinSCP to create the SSH connection from host to guest then the command “*javac PrintTime.java*” was run and the program was compiled.

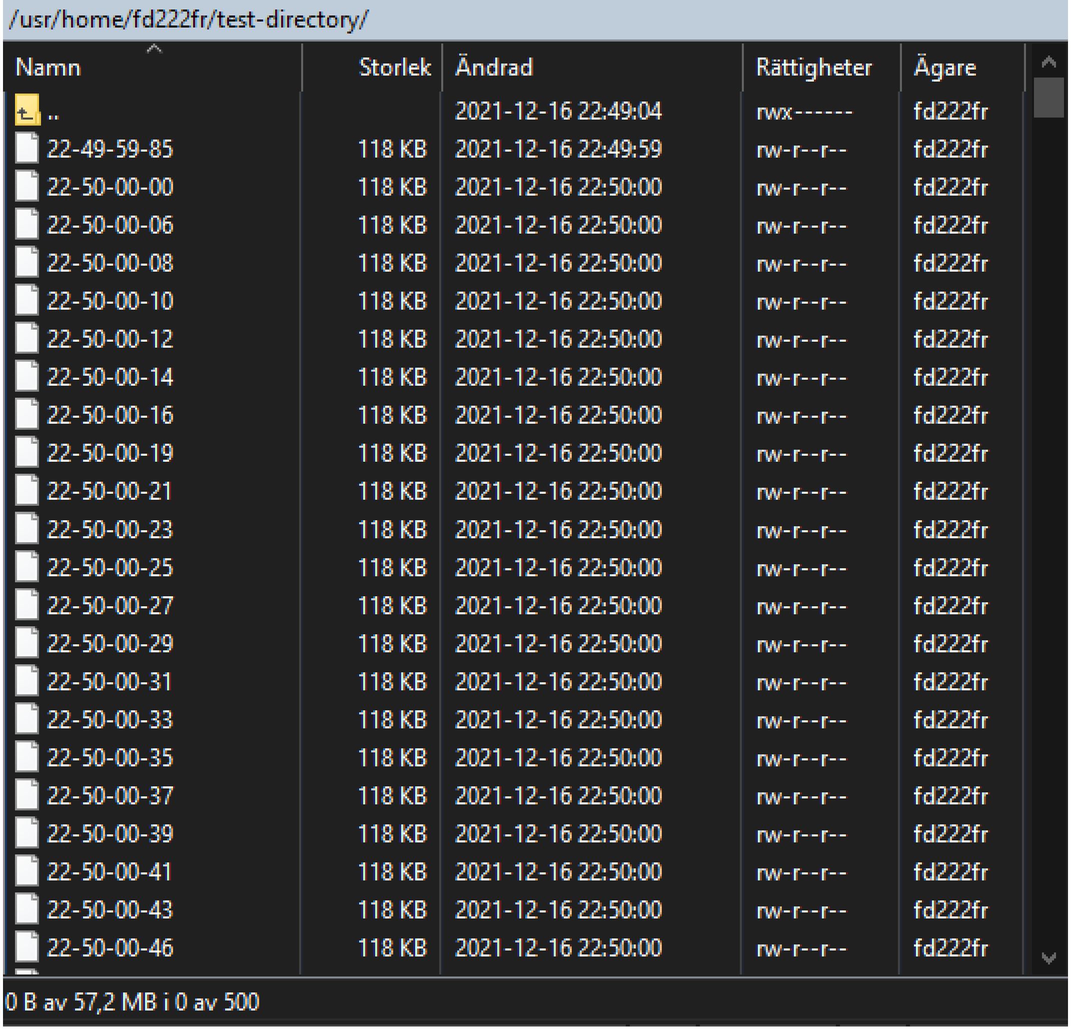
4.3 Preparing to run the program with multiple shells involved

For this task, multiple terminal windows with SSH connection to the VM were used.

4.4 Launching the iostat command and the program simultaneously



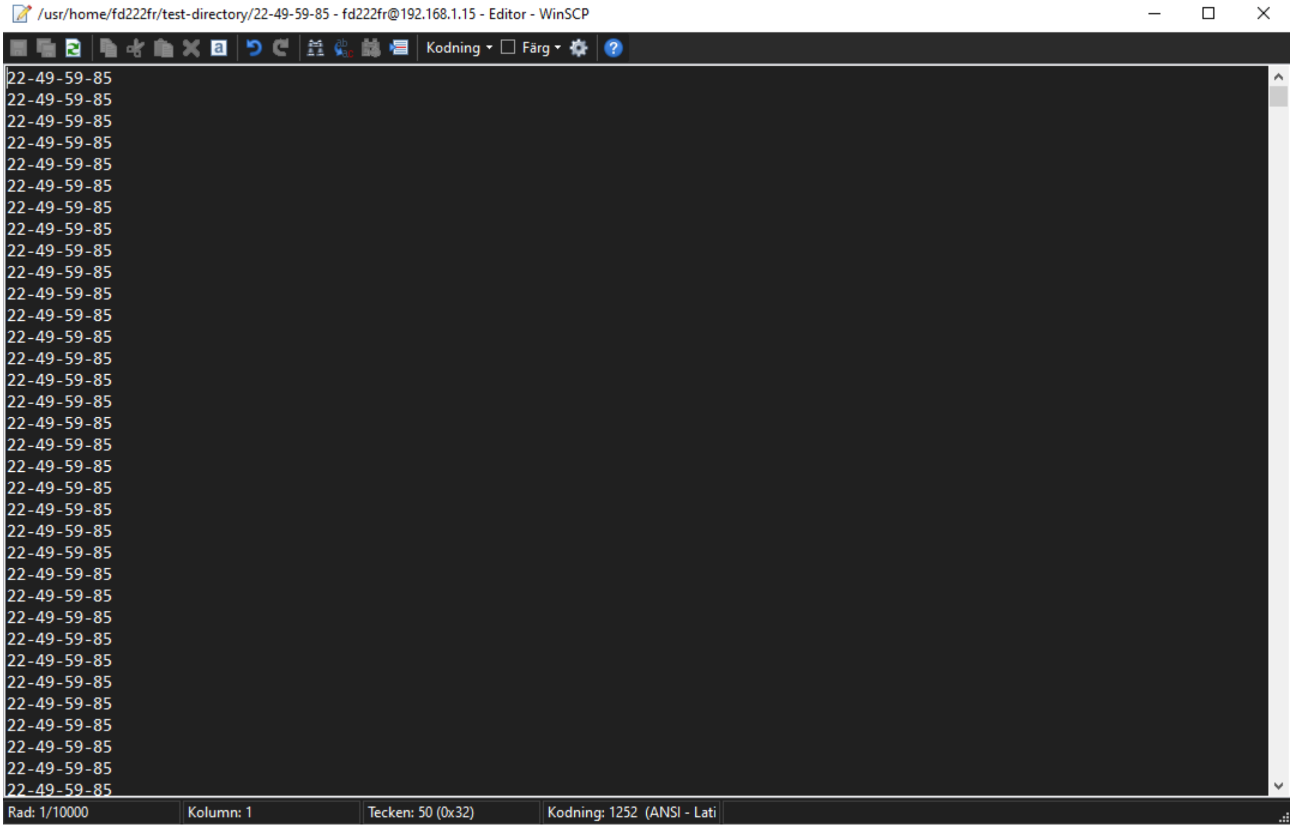
```
fd222fr@freebsd-vm-group10:/home/fd222fr$ iostat -t da -c 20 -w 1
       tty            ada0              ada1             cpu
 tin  tout KB/t  tps  MB/s  KB/t  tps  MB/s  us ni sy in id
   1   109 34.0   20   0.7   2.6    0   0.0   4  0  3  5 88
   1   193 24.1    4   0.1   0.0    0   0.0  42  0  5  4 48
   0    61  1.2    2   0.0   0.0    0   0.0  50  0  2  0 48
   0    61  7.5    2   0.0   0.0    0   0.0  12  0  2  0 86
   0    61 15.8    3   0.0   0.0    0   0.0  13  0  2  0 84
   0    61  7.8    2   0.0   0.0    0   0.0  11  0  1  0 88
   0    62 21.8   13   0.3   0.0    0   0.0   9  0  2  0 89
   0    61 57.4  197  11.0   0.0    0   0.0  11  0  2  0 87
   0    61 56.0   26   1.4   0.0    0   0.0  10  0  1  0 89
   0    61 58.3  100   5.7   0.0    0   0.0  11  0  4  0 85
   0    61  7.8    2   0.0   0.0    0   0.0   9  0  3  0 87
   0    61 59.5  197  11.4   0.0    0   0.0  21  0  5  0 74
   0   315 57.9   78   4.4   0.0    0   0.0  33  0  5  1 61
   0    59  5.5    1   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  1  0 99
   0    61  0.0    0   0.0   0.0    0   0.0   0  0  1  0 99
   0    61  0.0    0   0.0   0.0    0   0.0   0  0  0  1 99
   0    61  0.0    0   0.0   0.0    0   0.0   0  0  2  0 98
   0    61  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
```



/usr/home/fd222fr/test-directory/

Namn	Storlek	Ändrad	Rättigheter	Ägare
..		2021-12-16 22:49:04	rwx------	fd222fr
22-49-59-85	118 KB	2021-12-16 22:49:59	rw-r--r--	fd222fr
22-50-00-00	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-06	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-08	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-10	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-12	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-14	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-16	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-19	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-21	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-23	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-25	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-27	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-29	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-31	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-33	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-35	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-37	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-39	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-41	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-43	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr
22-50-00-46	118 KB	2021-12-16 22:50:00	rw-r--r--	fd222fr

0 B av 57,2 MB i 0 av 500



/usr/home/fd222fr/test-directory/22-49-59-85 - fd222fr@192.168.1.15 - Editor - WinSCP

```
22-49-59-85
22-49-59-85
22-49-59-85
22-49-59-85
22-49-59-85
22-49-59-85
22-49-59-85
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22-49-59-85
```
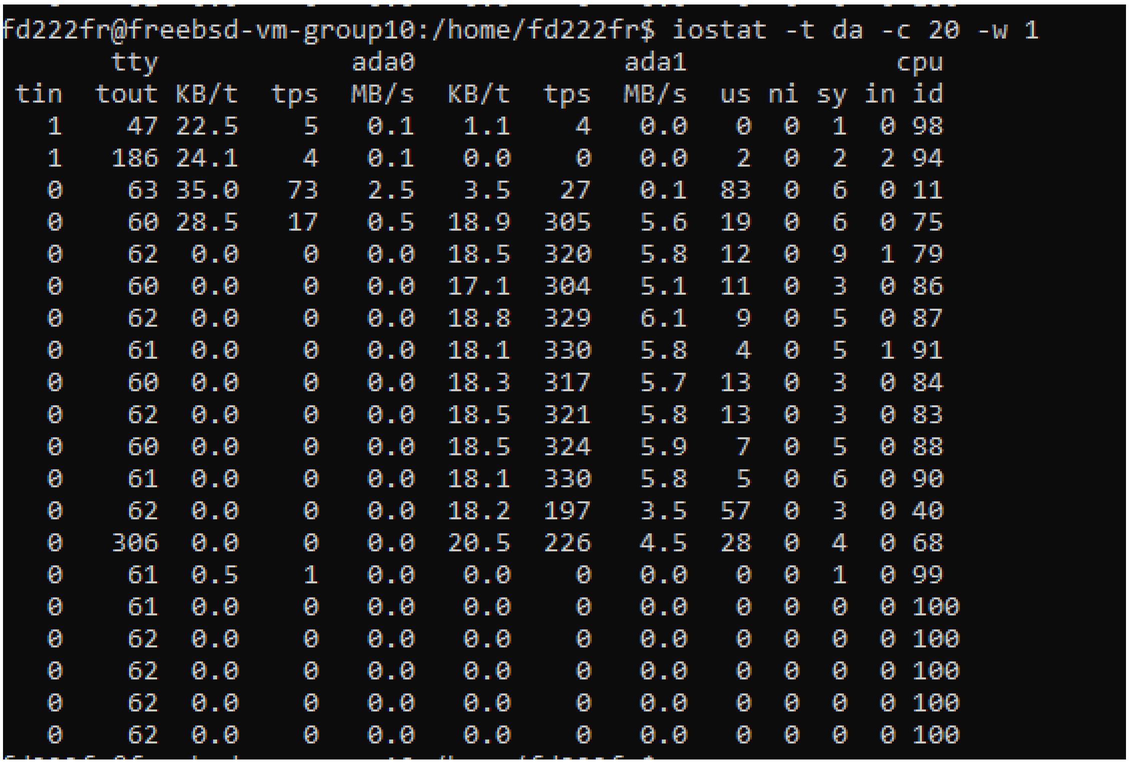
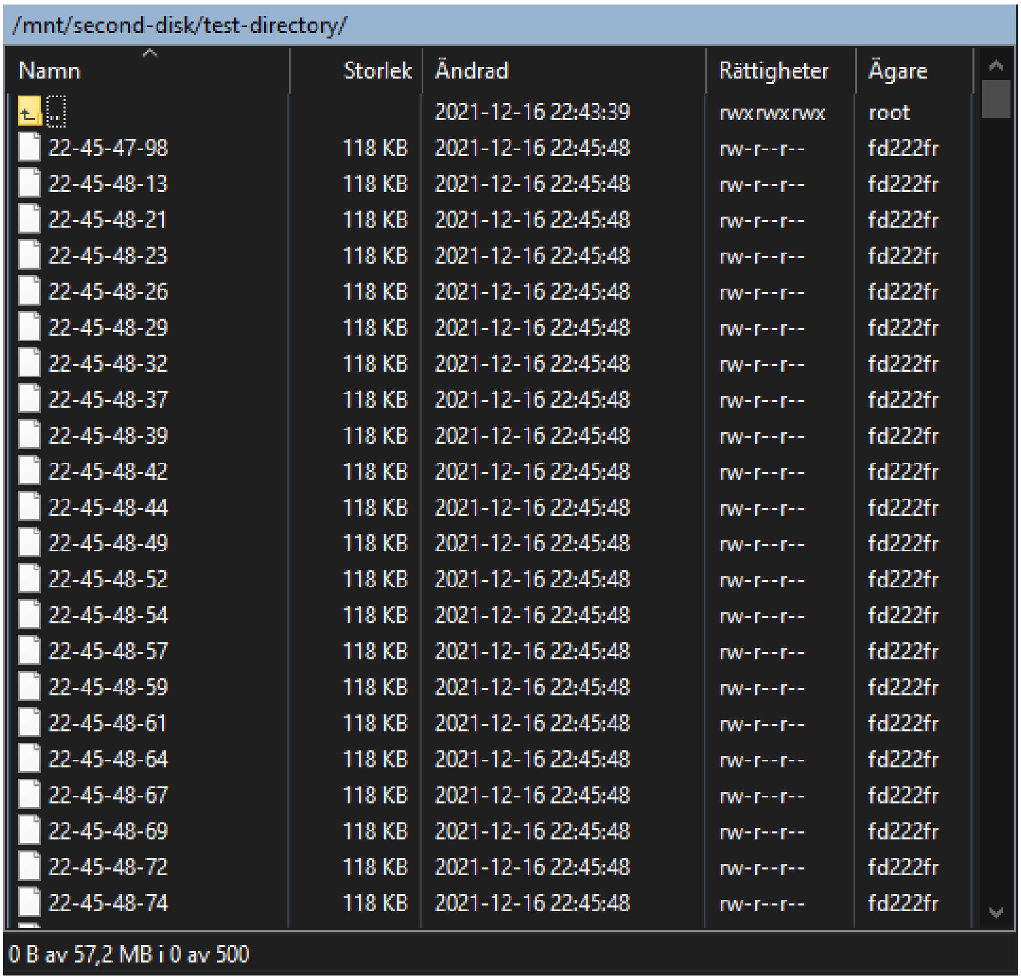

Rad: 1/10000 Kolumn: 1 Tecken: 50 (0x32) Kodning: 1252 (ANSI - Lati

The total size of the directory is 57,2 megabytes (MB). The iostat command displays kernel input and output (I/O) statistics. To take a closer look at the command, in reference to the manual [3] "*iostat -t da -c 20 -w 1*" is included with a few options as it can be seen. The **-t** stands for specifying a device to display and the **da** stands for direct access devices. The **-c** repeats the display a specific number of times which in this case is 20. The **-w** specifies to pause for an amount of time between each display and in this case, it pauses for a second. The output indicates that the average characters written to the terminal are 82, the average kilobytes per transfer are 29, average transfers per second are 46, and on average 4,4 MB/s. Regarding CPU statistics, 18% is the average amount where the CPU stayed in user mode, and the average time it spent on system mode is 2% whereas it spent 3% on interrupt mode and on average it spent about 85% of its time in idle mode. It is really difficult to make any assumptions since no benchmark was provided with the instructions, however, it is to be noted that it is quite remarkable that the average of the CPU's time spent on idle mode is so high and that according to the transfers per second which it has, it performs worse than a single 5400 RPM drive which should be able to do more than 80 transfers per second [4]. The total size of the test directory was 500 with 10000 lines of input on each of the files.

4.5 Launching the iostat command and the program simultaneously on the secondary disk



```
fd222fr@freebsd-vm-group10:/home/fd222fr$ iostat -t da -c 20 -w 1
       tty             ada0             ada1             cpu
 tin  tout KB/t  tps  MB/s  KB/t  tps  MB/s  us ni sy in id
   1    47 22.5    5   0.1   1.1    4   0.0   0  0  1  0 98
   1   186 24.1    4   0.1   0.0    0   0.0   2  0  2  2 94
   0    63 35.0   73   2.5   3.5   27   0.1  83  0  6  0 11
   0    60 28.5   17   0.5  18.9  305   5.6  19  0  6  0 75
   0    62  0.0    0   0.0  18.5  320   5.8  12  0  9  1 79
   0    60  0.0    0   0.0  17.1  304   5.1  11  0  3  0 86
   0    62  0.0    0   0.0  18.8  329   6.1   9  0  5  0 87
   0    61  0.0    0   0.0  18.1  330   5.8   4  0  5  1 91
   0    60  0.0    0   0.0  18.3  317   5.7  13  0  3  0 84
   0    62  0.0    0   0.0  18.5  321   5.8  13  0  3  0 83
   0    60  0.0    0   0.0  18.5  324   5.9   7  0  5  0 88
   0    61  0.0    0   0.0  18.1  330   5.8   5  0  6  0 90
   0    62  0.0    0   0.0  18.2  197   3.5  57  0  3  0 40
   0   306  0.0    0   0.0  20.5  226   4.5  28  0  4  0 68
   0    61  0.5    1   0.0   0.0    0   0.0   0  0  1  0 99
   0    61  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
   0    62  0.0    0   0.0   0.0    0   0.0   0  0  0  0 100
```



/mnt/second-disk/test-directory/

Namn	Storlek	Ändrad	Rättigheter	Ägare
..		2021-12-16 22:43:39	rwxrwxrwx	root
22-45-47-98	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-13	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-21	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-23	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-26	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-29	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-32	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-37	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-39	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-42	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-44	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-49	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-52	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-54	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-57	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-59	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-61	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-64	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-67	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-69	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-72	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr
22-45-48-74	118 KB	2021-12-16 22:45:48	rw-r--r--	fd222fr

0 B av 57,2 MB i 0 av 500

The average kilobytes per transfer on the secondary device is 15, on average there are 280 transfers per second, and 5,4 MB/s on average. Regarding the CPU statistics, 19% on average of the CPU's time was spent on user mode, 4% on system mode, 1% on interrupt mode, and 84% on idle mode. Taking a look at the transfers per second the second drive makes it significantly more than its counterpart which only had 46 and perhaps performs even better than a 5400 RPM spindle → a far fetch however this speculation is made due to the constraints present and lack of material and/or benchmarks. The average kilobytes per transfer on the secondary device is only half of the first device in comparison, however, its MB/s rate is higher than the first device's which was 4,4 instead. Both devices spent a similar time on user, system, interrupt, and idle mode with only a few percentages making the difference which at most was 2%. The secondary device also had the same number of files in the test directory created and the number of files was also the same along with the number of lines inside of them.

5. Reflection

It was quite interesting to have worked with FreeBSD and especially investigating different aspects of it and what makes it unique so to say from the other operating systems. It is quite simple in nature and allows for large quantities of freedom to promote creativity however that is a double-edged sword since it also gives way to fatal errors being made. Regarding this assignment, the instructions were clear however when it comes to tasks that are required for programs to be implemented, it would have been beneficial if a benchmark had been provided so the results can be compared to a baseline so to speak and what should be expected. To be more technical regarding what could have been done differently, although mentioned in the instructions, it is important to keep in mind to make backups of the drives since in case they are corrupted or somehow fiddled within a way that compromises what was written in the fstab configuration file, the system will boot in single-user mode. Other than that, the instructions were easy to follow and to implement too.

References

[1] The FreeBSD Project. n.d. *Chapter 3. FreeBSD basics*. [online] Available at: <https://www.freebsd.org/doc/handbook/disk-organization.html> [Accessed 18 December 2021].

[2] Stack Overflow. 2011. *Changing the file permissions of multiple files through Unix terminal*. [online] Available at: <https://stackoverflow.com/questions/6874618/changing-the-file-permissions-of-multiple-files-through-unix-terminal> [Accessed 18 December 2021].

[3] Freebsd.org. 2021. *iostat*. [online] Available at: <https://www.freebsd.org/cgi/man.cgi?iostat> [Accessed 18 December 2021].

[4] Huffman, C. and Tiwari, M., 2010. *PerfGuide: Analyzing Poor Disk Response Times - TechNet Articles - United States (English) - TechNet Wiki*. [online] Social.technet.microsoft.com. Available at: <https://social.technet.microsoft.com/wiki/contents/articles/1516.perfguide-analyzing-poor-disk-response-times.aspx> [Accessed 18 December 2021].