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Bachelor of Science in I.T. Management

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Storage Virtualisation

Storage virtualisation is the activity of taking physical storage across many different network storage devices, and grouping them together so they appear as one single storage device. Storage virtualisation provides improved scalability and flexibility through the separation of the underlying hardware infrastructure from the storage-management software. Advantages of storage virtualisation include simplified storage management across multiple platforms and a reduction in administrative overhead. Virtualisation also allows for the expansion of storage without the disruption of users or the need to take storage systems offline first, and is a relatively simple operation to carry out. Storage virtualisation is usually implemented using Network Attached Storages (NAS) or Storage Area Networks (SAN).
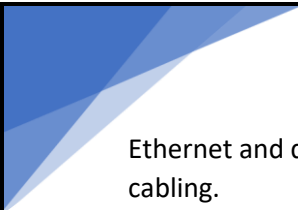
Network Attached Storage

NAS provides users of a LAN with file-based shared storage with the use of a standard Ethernet connection. A NAS is connected to a network and allows users and clients to retrieve and store data from a centralised location. NAS devices are very flexible and easily scale-out meaning that you can add on more storage as it's required. A NAS is designed for use on a TCP/IP network to allow shared access to storage. NAS is relatively easy to operate meaning an IT professional is not required, which benefits SMEs. In business, NAS can prove crucial as a NAS array can be created and used for archive and disaster recovery. Furthermore, if a server mode can be activated on a NAS device, it can be used as an email, database, multimedia or print server. Since data is continuously accessible, activities such as collaboration among employees and the follow up of incidents becomes easier and more efficient. Advantages of a NAS include:

- A NAS is attached as part of the network, not just to one computer or server, which means that many users can access the one storage.
- A NAS supports a high level of redundancy using extra disks and network adapters which can be used as hot spares. Many NAS devices also possess a replication mechanism which will replicate content to a secondary NAS device. This protects against appliance-level failure.

One major disadvantage of NAS is that it shares the network with other computers meaning it will be consuming more network bandwidth. Additionally, NAS performance ultimately depends on the amount of network bandwidth available. Poor bandwidth will lead to poor performance on the NAS. NAS devices generally don't have a display or keyboard but are configured and managed using a browser-based utility program.

Storage Area Network

A SAN is a high-speed special-purpose network which, on behalf of a larger network of users, interlinks different types of data storage devices with associated data servers. A SAN provides block-level access to storage. SANs provide the functionality for a server to access shared storage as if it was a directly attached drive on the server. A SAN may span across multiple sites and typically be made up of switches, hosts, storage elements and storage devices which are interconnected using many different topologies, technologies and protocols. The two most commonly used SAN protocols are Fibre Channel, which is more expensive as it requires the use of fibre optic cabling, a host bus adapter and a layer2 FC switch, and iSCSI, which is a cheaper alternative to FC as it runs on Gigabit

Ethernet and does not require host bus adapters or storage specific network devices or separate cabling.

Storage Attached Networks can be incredibly beneficial when implemented correctly. The benefits of implementing a SAN include:

- A SAN uses a storage arrays which have excellent data protection algorithms to ensure consistency amongst data stored.
- A SAN does not influence bandwidth bottlenecks which can be associated with LAN server storage. The data is stored on the SAN meaning the server processing resources are still available to the systems on the LAN and data transfer doesn't pollute the LAN.

SANs have many advantages, but the one disadvantage can be crucial. SANs are generally quite expensive to implement as opposed to a NAS. There needs to be sufficient budget for the organisation to have the right staff on hand, including an IT expert, and ensure application requirements are present to support it.

Two storage virtualisation products that will be investigated in this report are FreeNAS and OpenFiler.

FreeNAS

FreeNAS is an open source Network Attached Storage software appliance which provides free NAS services.

Installation & Configuration

Installing FreeNAS was not a very complex operation. It was difficult to find an installation guide that went through the entire process, start to finish so I ended up using several different documents and video tutorials to guide me through setup. I used VirtualBox to install FreeNAS as VirtualBox is a free software virtualisation package which can be installed on an operating system as an application. Before installation, I checked the minimum hardware requirements for a FreeNAS installation. The minimum requirements, as listed by FreeNAS, for the most basic FreeNAS implementation were:

- FreeNAS no longer supports 32-bit hardware meaning a multicore 64-bit processor is required.
- An 8GB Boot Drive, a USB Flash Drive will also work fine.
- 4GB of RAM
- At least 1 directly attached disk.
- One physical network port is also required.

My installation process was as follows:

Step 1: First I had to open Oracle VirtualBox and click on the create new virtual machine option. Then I had to provide this VM with a name so that it will be easily identifiable. Once I had given the VM a name, I had to select what the type of VM this was going to be and select which version I want to choose.
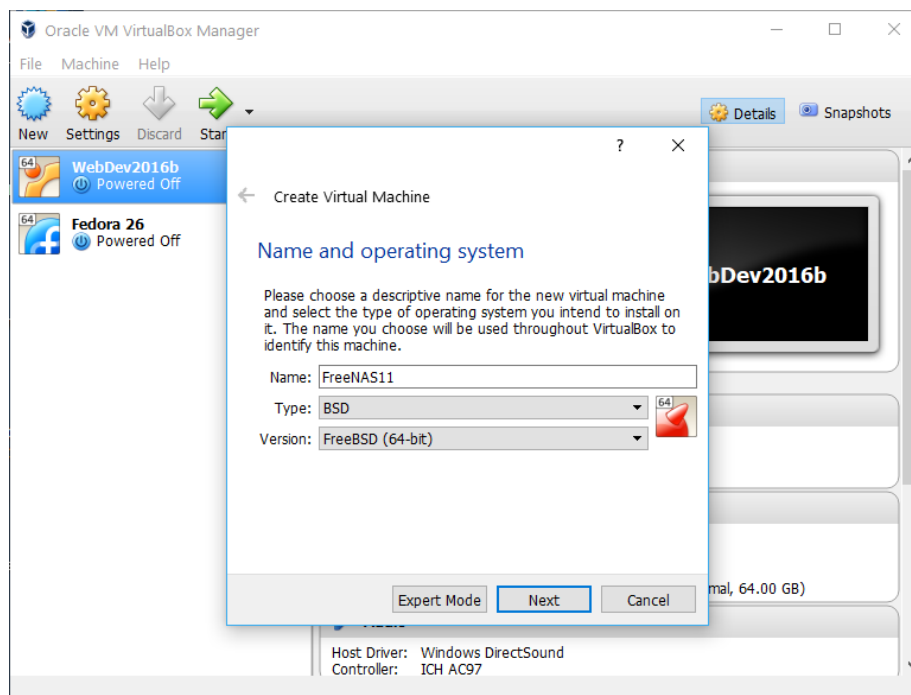
Step 2: After choosing the virtual machine name and type, I had to allocate RAM to the VM. The recommended minimum requirement was 4GB of RAM. However, as I was installing FreeNAS through VirtualBox, I wanted to test if it would work with only 2GB of RAM, before increasing it to 4GB RAM. Through this, I discovered that FreeNAS VM worked completely fine with only 2GB of RAM.
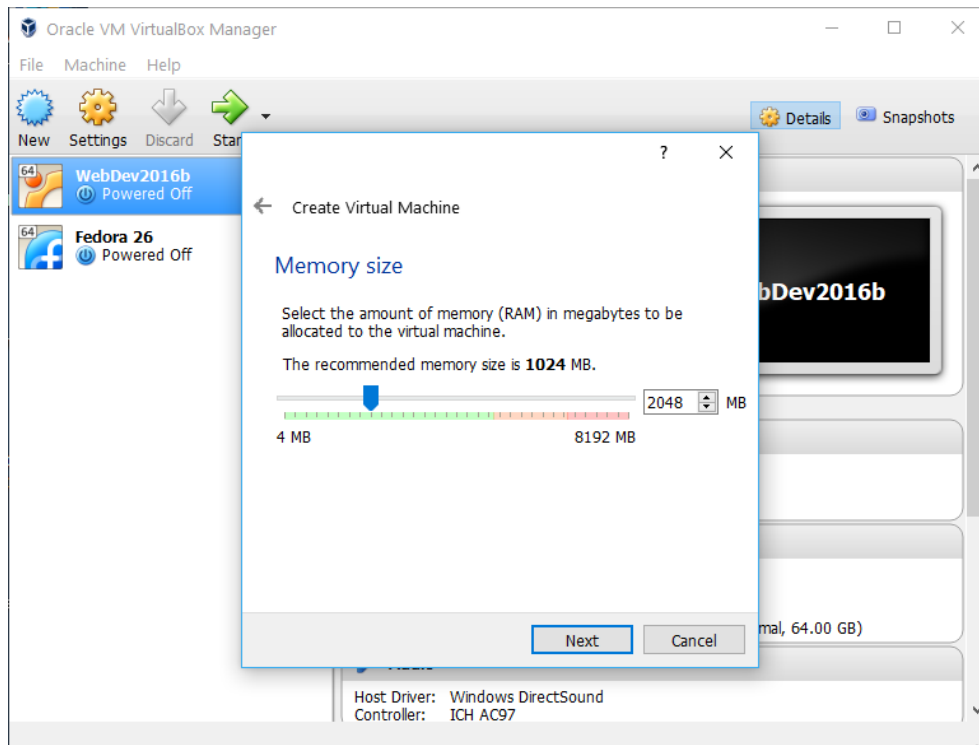

Step 3: Next, I had to create a Virtual Hard Disk. I allocated roughly 27GB and set it to be dynamically allocated as I only wanted the VM to use space on my physical hard disk as it required, and not take the full 27GB in one go.
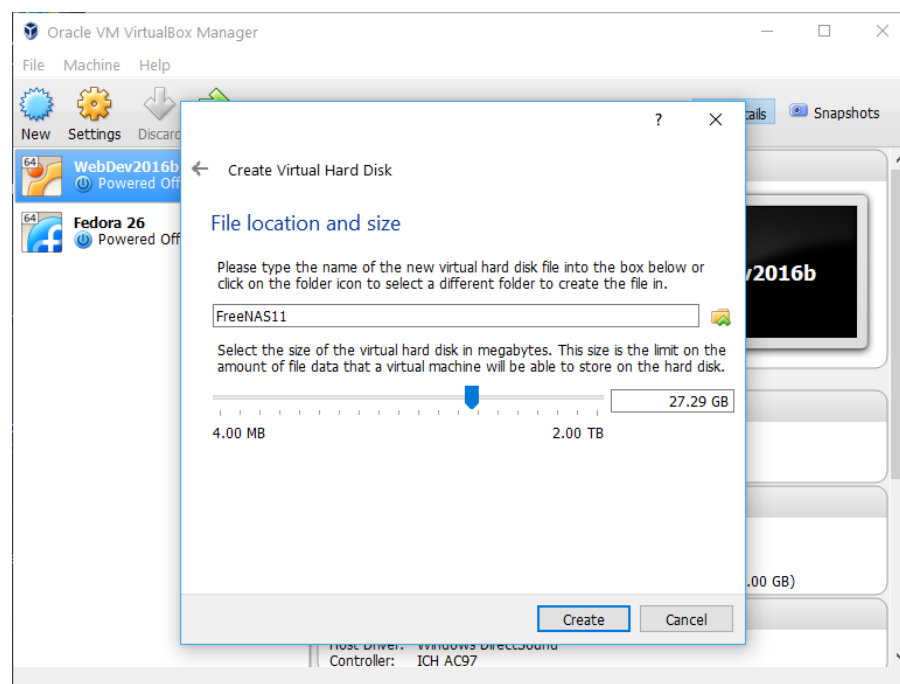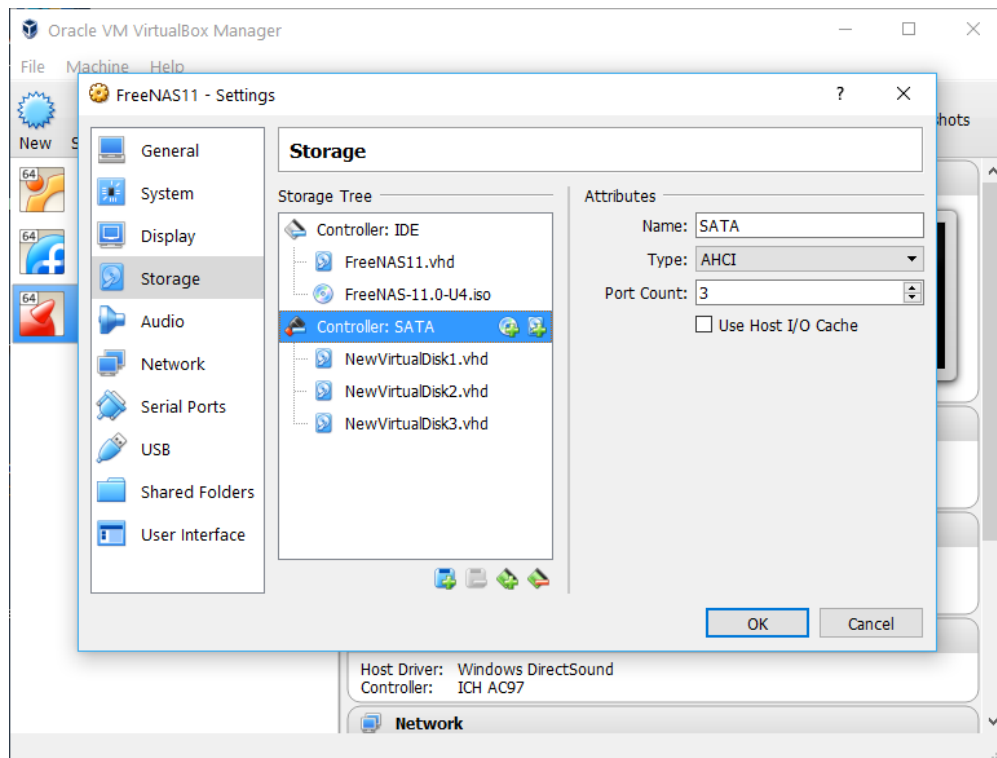
Step 4: Once the creation was complete, I had to edit the settings for the VM. First, I increased the number of CPUs from 1 to 2.
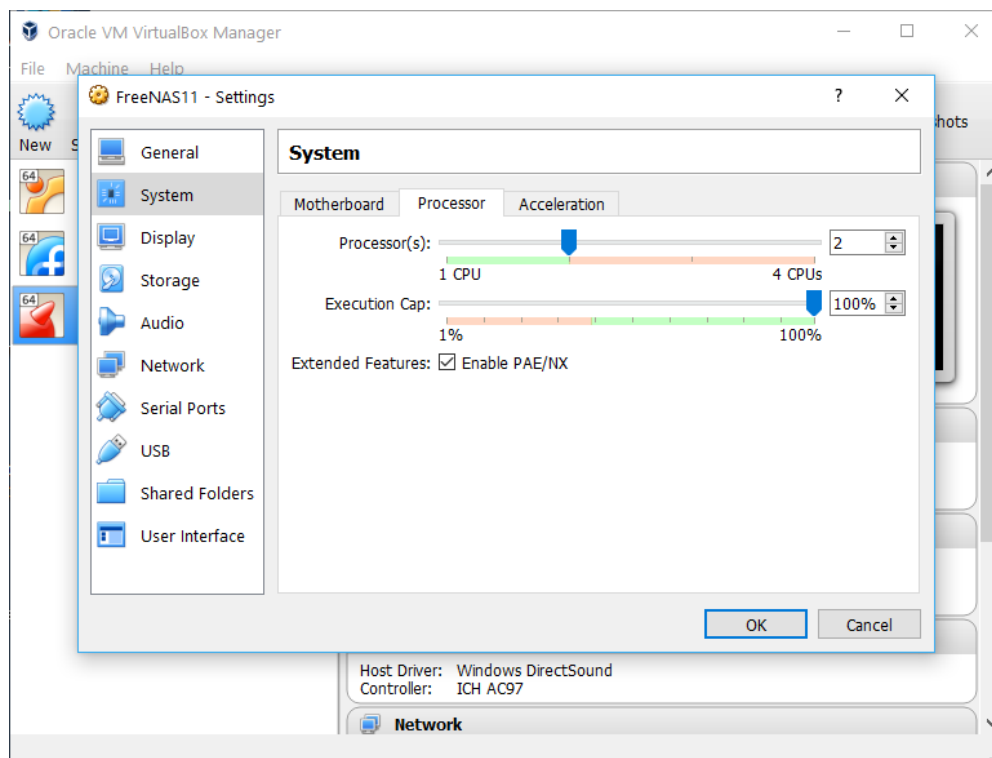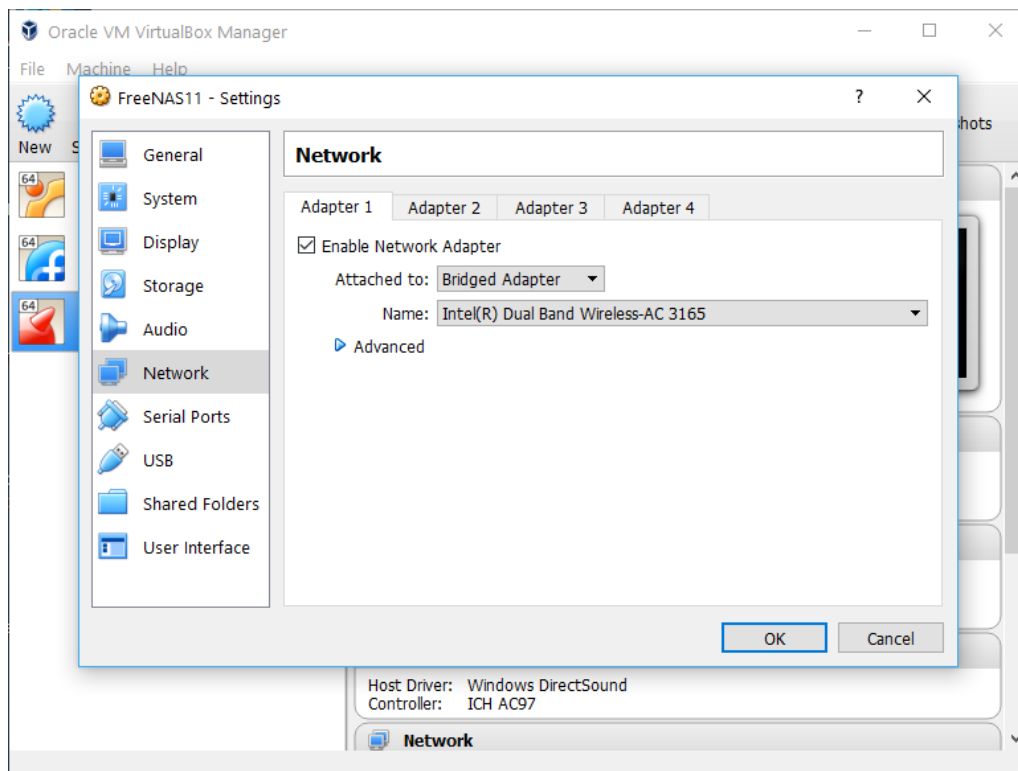

Step 5: After increasing the CPU, I had to mount the FreeNAS ISO file in the IDE controller section of the storage tab.
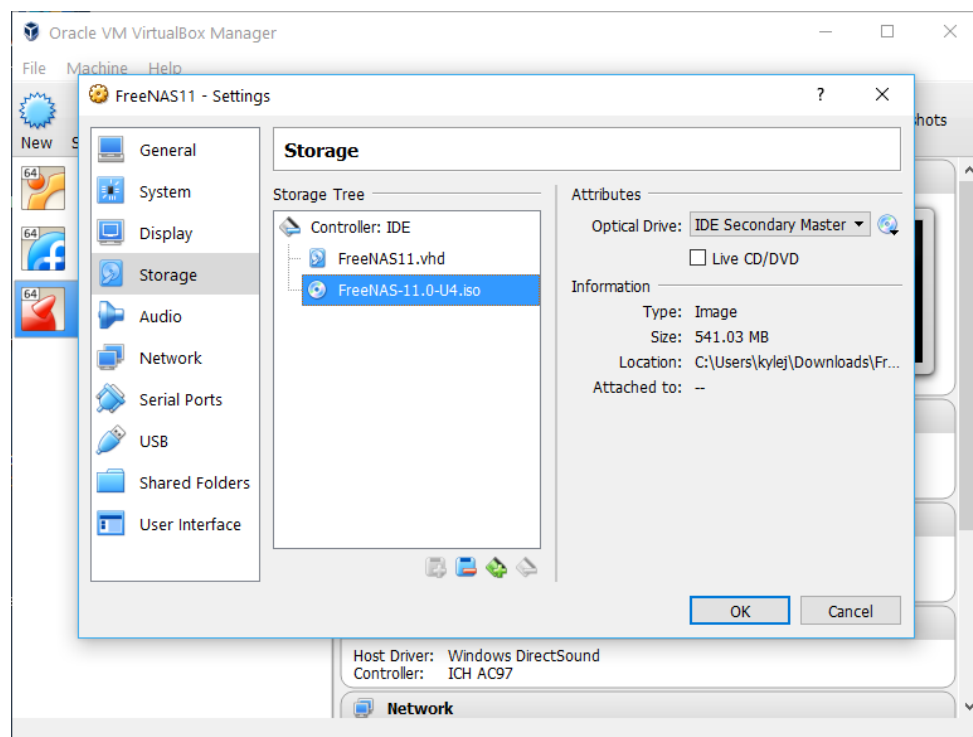
Step 6: Once the ISO was mounted, I added a SATA controller and created three virtual hard disks under it.


Step 7: The final step of the VirtualBox setup was to attach a bridged network adapter to the VM.
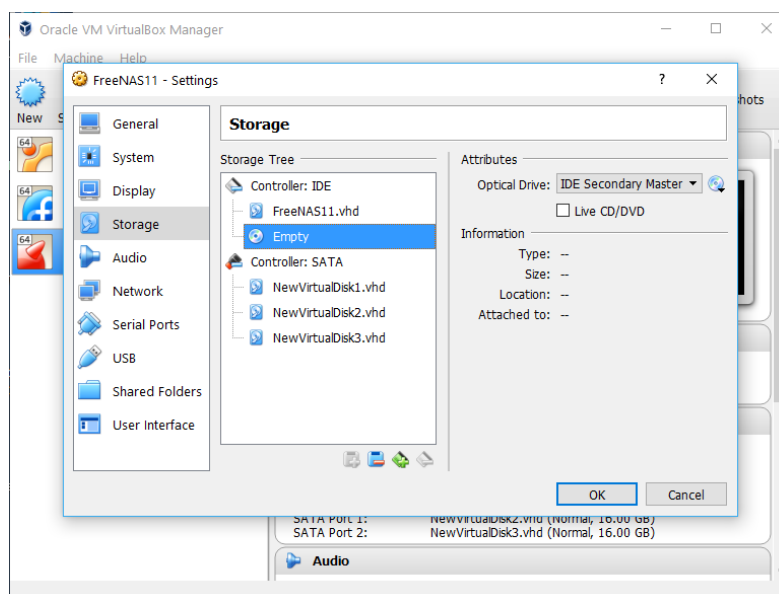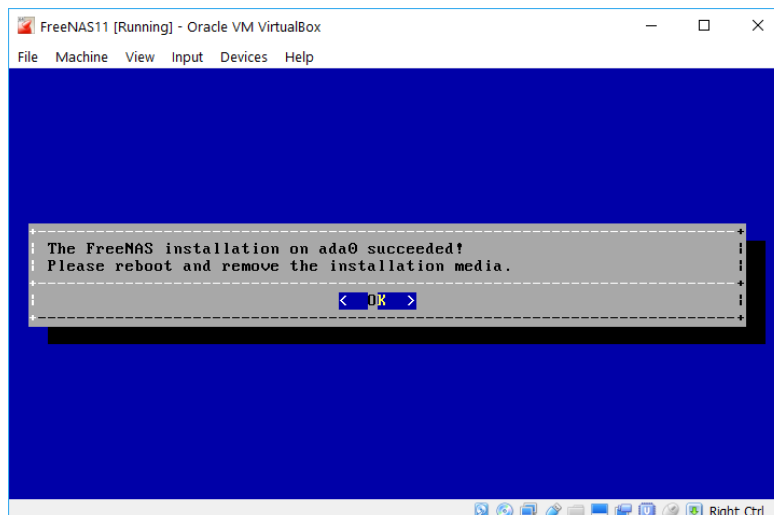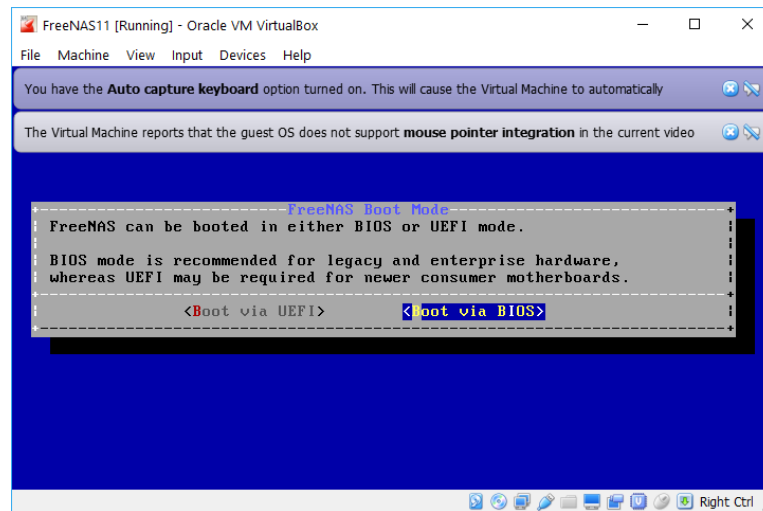
Step 8: It was now time to run the FreeNAS VM for the first time and begin the ISO installation. Firstly, I selected the regular FreeNAS Installer option, and chose option 1, Install/Upgrade, at the console setup menu.
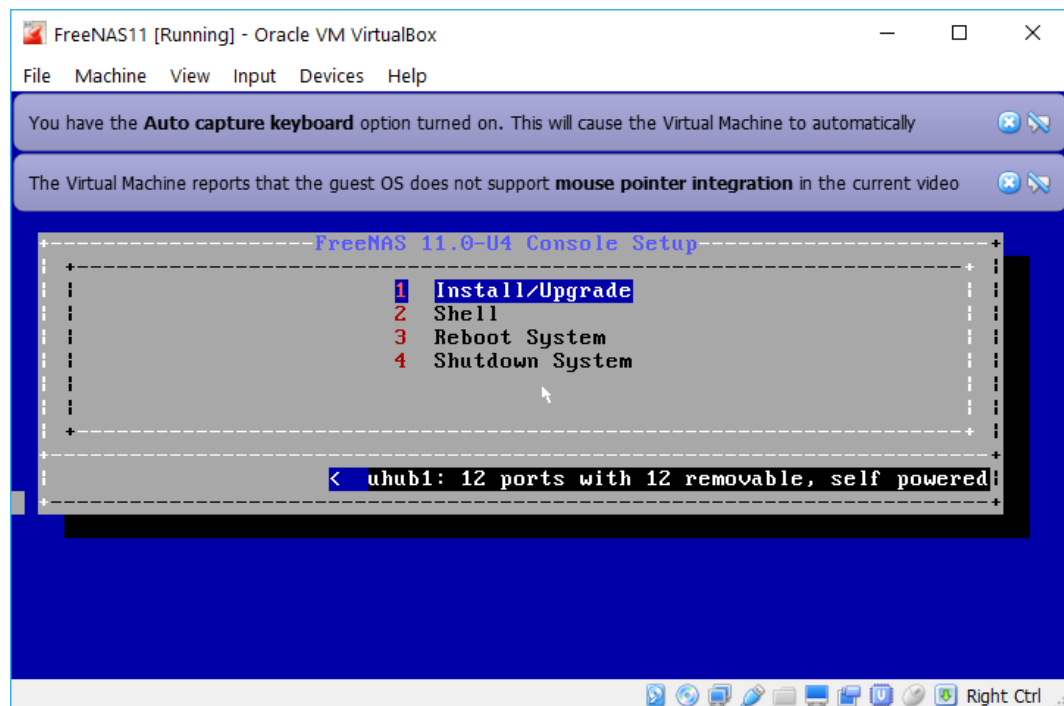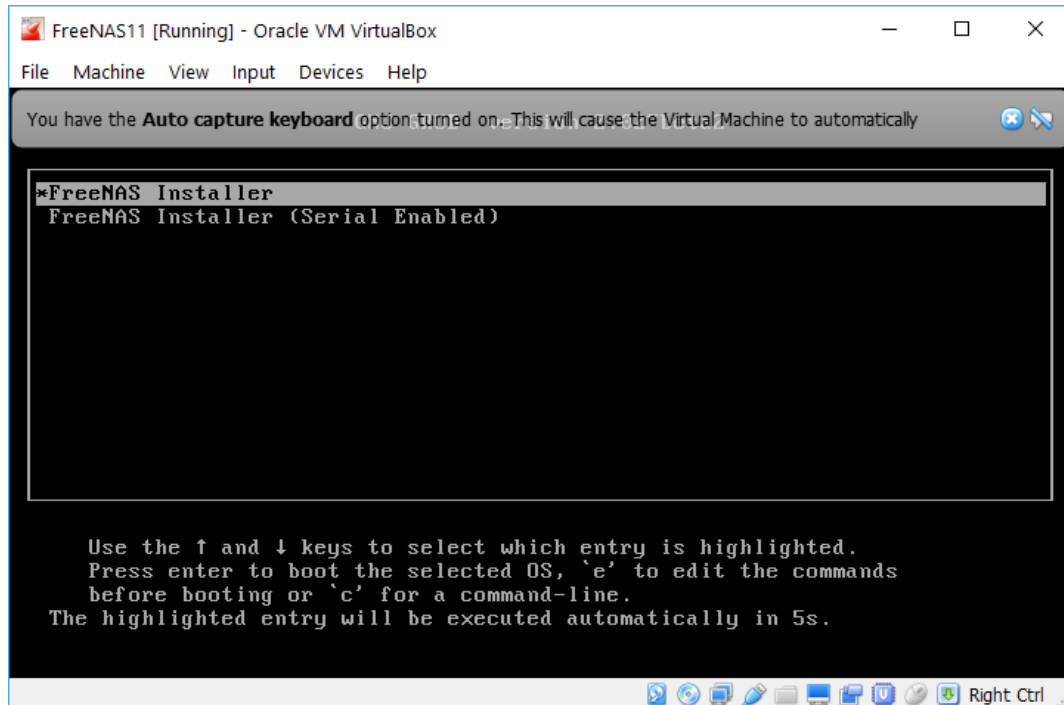
Step 9: Next, I had to select which drive FreeNAS will be installed on and then choose a password for log in.
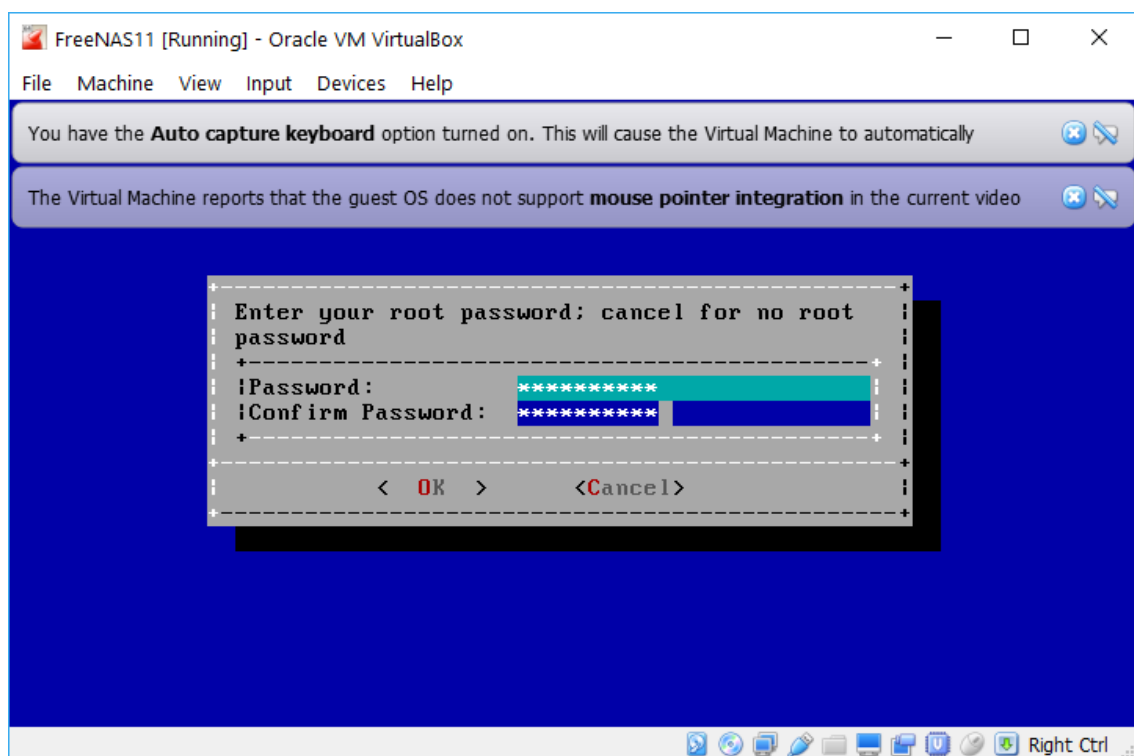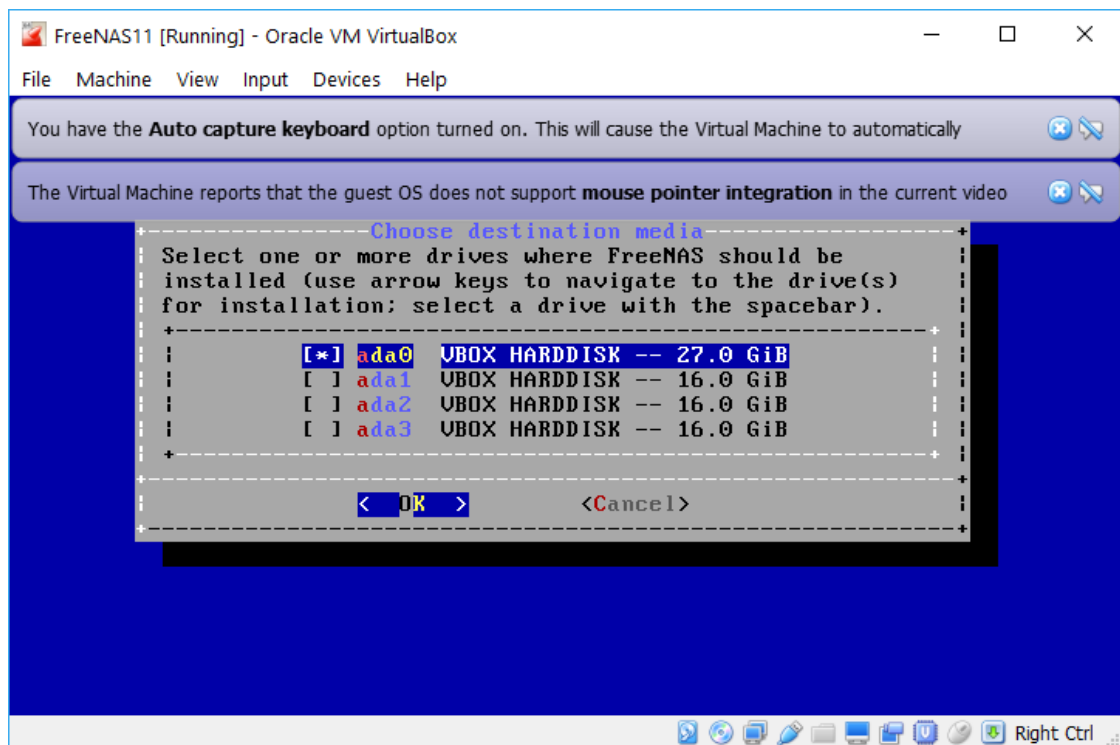
Step 10: I then choose to boot from BIOS and then, as instructed by the installation wizard, I had to reboot and remove the ISO file.

Step 11: It was now time to run the FreeNAS again. I booted the default FreeNAS option and waited for the VM to finish booting up. All that was left to do then, was to go to the IP address which the web user interface resides.
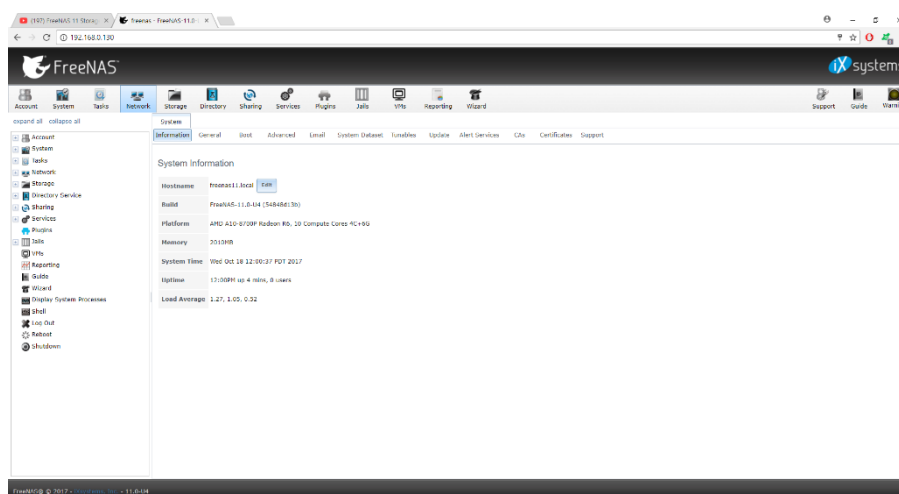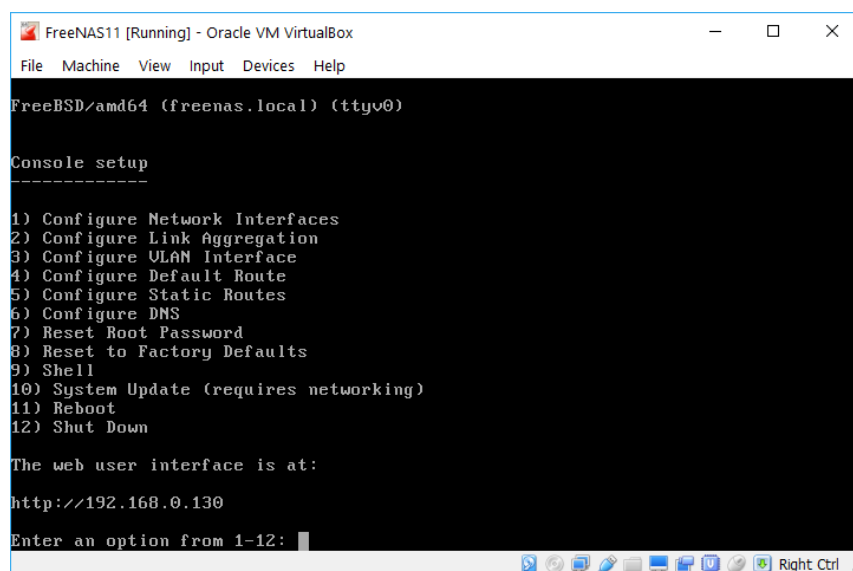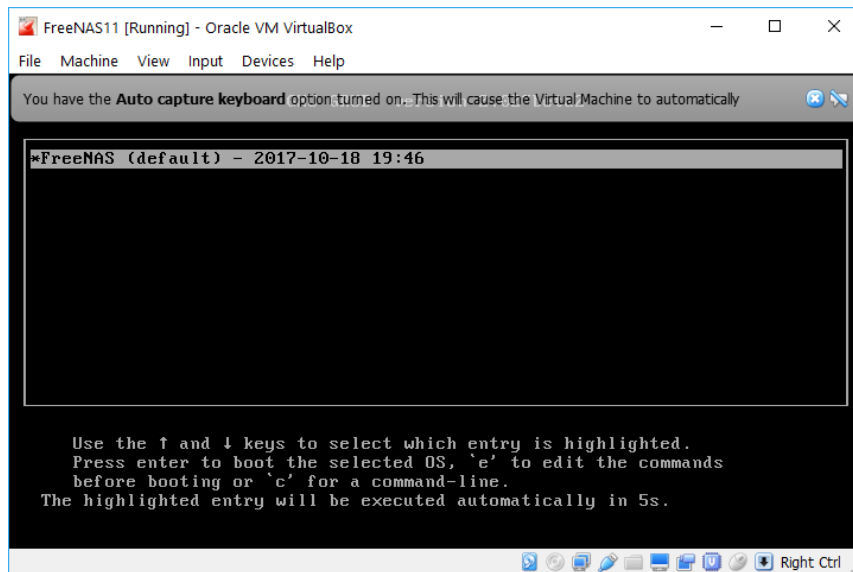
The entire installation process took me exactly 15 minutes and 46 seconds. One noticeable thing about FreeNAS is that configuration is relatively easy thanks to a well-designed GUI. There is a lot of help and support provided to help you take full advantage of FreeNAS. When you first log in, you are greeted by a helpful wizard which helps set time zones, create a volumes and more. FreeNAS also has a support page in which you can report bugs, request features or raise any issue directly with their support team. Beside the support page, there is also a Guide page. On the guide page, there is a user guide for FreeNAS which is very helpful when troubleshooting or carrying out tasks such as creating groups or shares on the NAS.
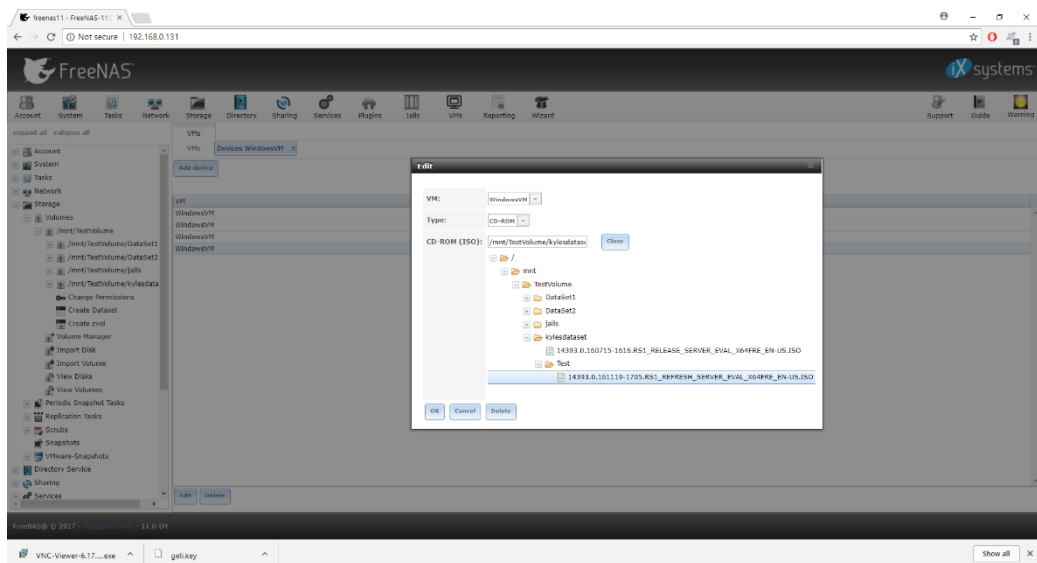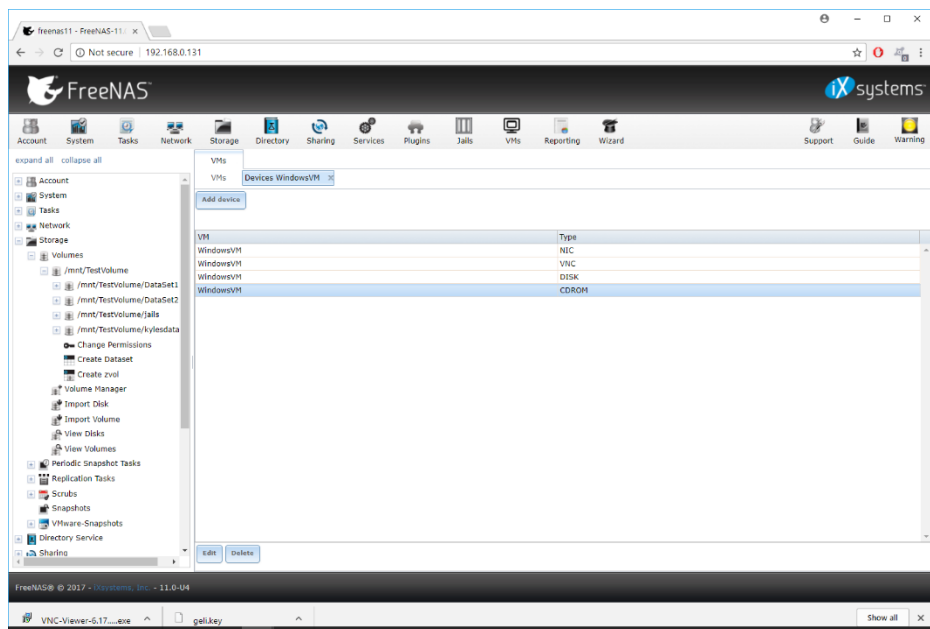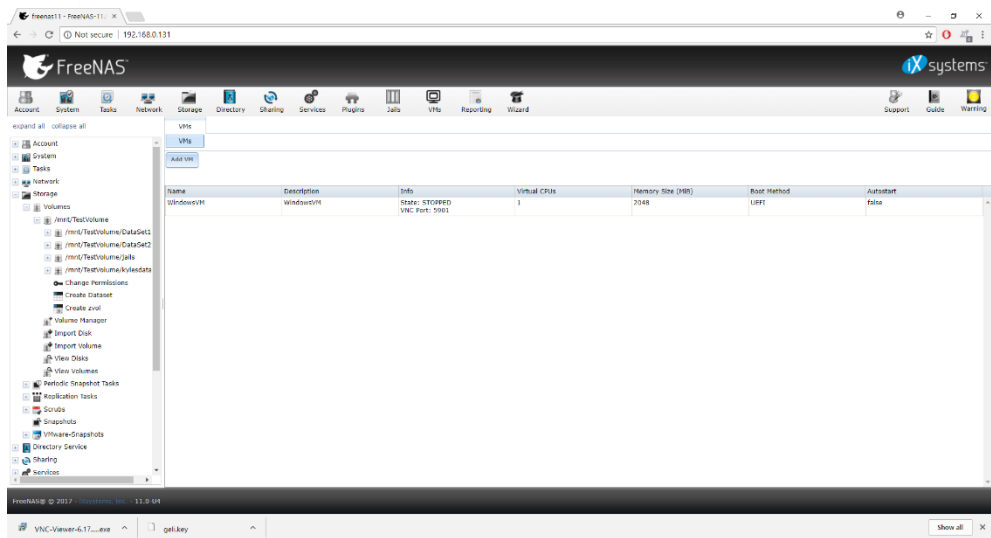
Features

FreeNAS is packed with a range of different features. Some features which I found useful were:

- A user-friendly GUI. FreeNAS provides a very easy to use and attractive looking web-based GUI. I found this very helpful when testing FreeNAS as navigation was made easy through both a navigation bar and a side bar, both which were clearly labelled and appropriately named. Furthermore, the individual pages themselves were also easy to use and to navigate around.
- FreeNAS allows for the creation of users and volumes. Within these volumes, datasets can be created. Users can then be assigned a dataset volume, or, share groups can be created which give multiple users in a group access to a dataset. I tested the share volume creation functionality and found it very easy to use. I created a user named Kyle along with a dataset called 'kylesdataset'. I then could change the permissions of the dataset so that Kyle would be the owner and set it to be password protected. I navigated to the sharing section of FreeNAS, and created a Windows, SMB share and selected 'kylesdataset' as the directory. I now had access to this folder through my physical PCs file explorer. I entered the password and then could create folders and add files within kylesdataset, and it was all being stored on FreeNAS.
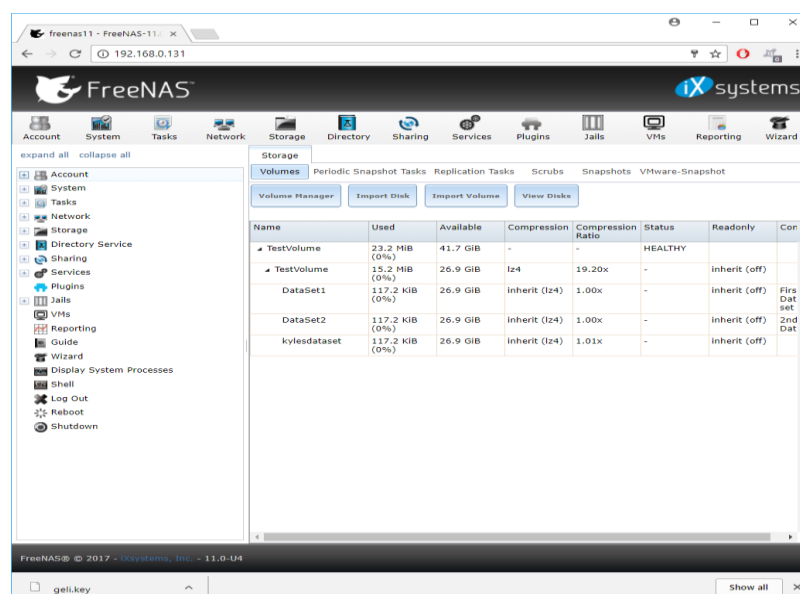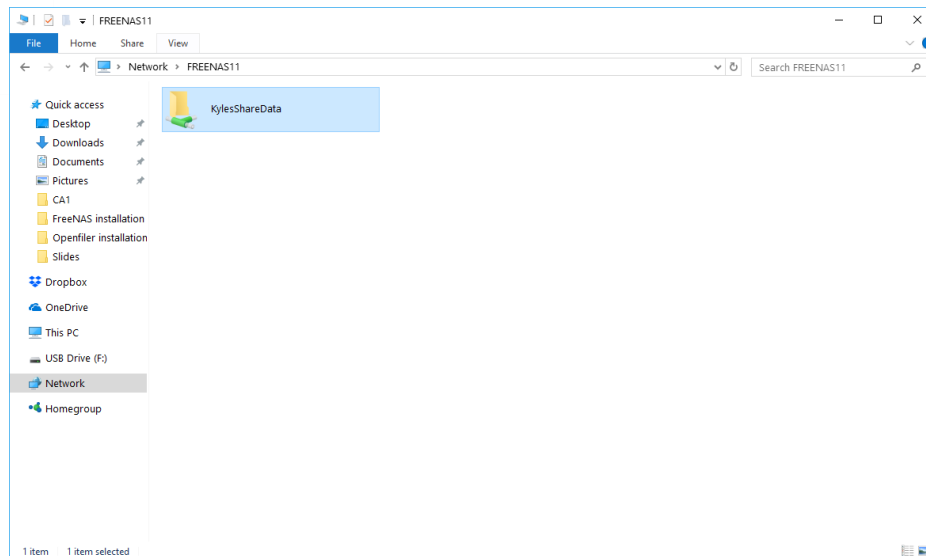
- FreeNAS also provides disaster recovery in the form of a geli.key file. This is a key which, when downloaded, allows for the recovery of the storage volume which it belongs in the event of a crash or a corruption of data. Without this key, it's not be possible to recover data so it is important to store it somewhere safe. Snapshots can also be taken through FreeNAS in case an error arises so that the user can use the snapshot to go back to when the error was not present.

- FreeNAS also provides other helpful features such as an installation wizard, which OpenFiler does not, as well as reporting which was helpful when I was attempting to assess the performance of FreeNAS.

- FreeNAS also allows the installation of plugins. This can be extremely useful for different users as plugins include bacula-sd, which is a network backup solution server, MineOS which is a web interface that allows for the creation and managing of server instances of the hugely popular video game Minecraft, and Transmission, a powerful BitTorrent client.

- Another big feature that FreeNAS provides which I was impressed with is the ability to deploy Virtual Machines on it. VMs in FreeNAS are supported by a bhyve hypervisor. I wanted to test this feature and try setting up and running a VM through FreeNAS. I downloaded a software called VNC Viewer which would allow me to connect to the VM on my physical machine once it was running. I created a zvol file in FreeNAS and copied a Windows Server ISO file into my KylesShareData folder. I then added a VM in FreeNAS, allocated it storage and memory, and then added devices such as a disk and a CD-ROM, which was the ISO located in my share folder. I created a new connection in VNC Viewer to allow me to connect to my new VM, inputting my FreeNAS IP address as well as the VNC port number, and I started the VM in FreeNAS. Unfortunately, my computer was not powerful enough to successfully implement this feature, as I kept receiving a 'connection refused' message in VNC. However, I believe that with a slightly more powerful PC, I would easily be able to set up and run a VM from FreeNAS.
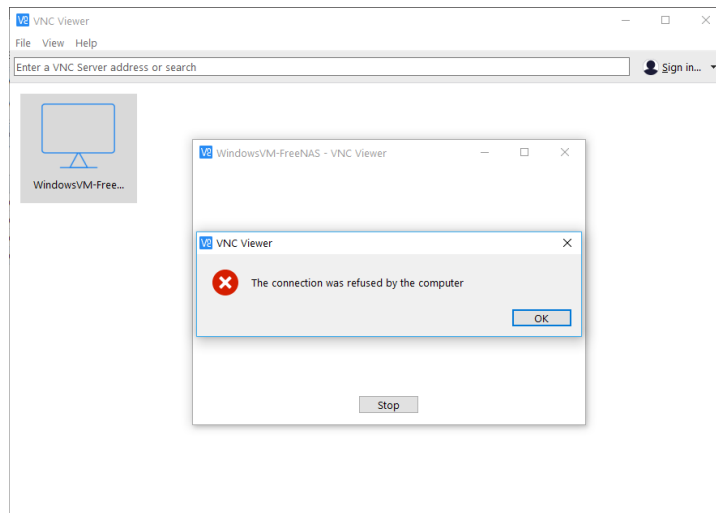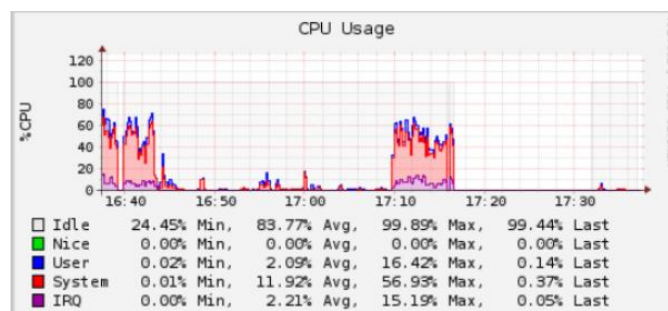
Performance

I found that FreeNAS ran quite smoothly while I was testing different features within it. I wanted to use the Reporting feature to help me garner a more in-depth understanding of how it was performing.

Memory – One thing I noticed about FreeNAS is that it uses all RAM which is allocated. FreeNAS populates memory with caching information meaning if I was to allocate it 65GB RAM for example, it would use all 65GB and fill it with caching information. My FreeNAS was utilising all RAM I allocated and pushing it to its limits, however I never noticed any decline in performance while I was using it.
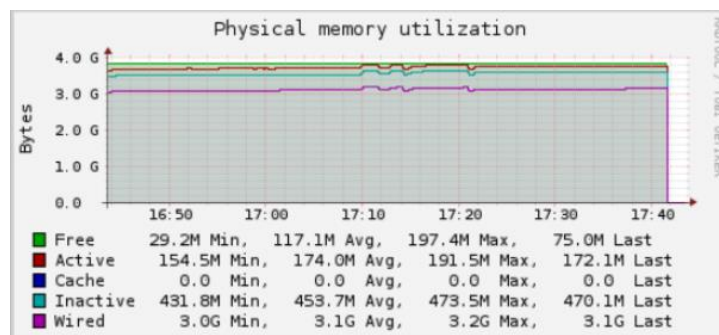
CPU – As expected, the OS was consuming the most CPU power while I was testing FreeNAS. It had an average CPU usage of 11.92%. User applications used an average of 2.09% CPU. These are interesting metrics as it shows that I wasn't stressing the CPU too much while I was performing tasks such as creating shares and VMs.

Overall FreeNAS ran well. I didn't notice any dip in speeds, however, I'm sure if I upped the RAM to 8GB, I would notice an improvement in the performance I had with 4GB.

Licensing & Costing

FreeNAS is an embedded open source Network Attached Storage operating system based on FreeBSD (Berkeley Software Distribution). FreeBSD is an OS which heavily focuses on speed, features and stability. FreeNAS is released under a 2-clause BSD license meaning that it adheres to the rule that it can be redistributed with or without modification in source and binary forms, providing that source redistributions retain the same copyright notice, list of conditions and disclaimer, and, that binary redistributions retain the copyright notice, list of conditions, and include the disclaimer in any documentation and other materials provided with it.

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NAS is perfect for small to medium sized enterprises as it has a relatively low cost and there are many options available to choose from. For a small office a FreeNAS Mini could be purchased for roughly €1000. The Mini can contain four storage drives and provide capacities up to 24TB. It is regarded as one of, if not the best software-defined storage platform available today. In the case of a larger business, a FreeNAS Certified Server can be purchased. There are 5 types of servers available which are a 1U, 2U, 4U, 1U (all flash) and a 2U (all flash). These servers all come with different specs and differen prices. I have seen them listed in the price range of roughly €2000 for an excellent server that will support your business no problem, to €10000 for the top of the range all-flash servers.

Support

As I mentioned previously there is a support page to contact support, as well as a user guide included in the FreeNAS GUI. Furthermore to this, FreeNAS is currently the most popular open source storage OS in the world today. There are tonnes of video tutorials you can find on the web to help you. There is aslo the FreeNAS forums which are incredibly active and consists of a helpul community if you ever need to seek help for specific reasons. With regards to the product itself, FreeNAS are continuing to support the platform through the release of patches and updates. As of right now, you can even test a beta of the new GUI layout from the next update by clicking the option when logging in.

Project Community

Along with a helpful problem-solving community, FreeNAS also boasts an extremely active project community that work regularly to help improve the product. There is a FreeNAS open source GitHub repository with over 20,000 project commits. FreeNAS also have 49 core developers working on the program. There are over 27000 forum members who have generated over 170000 posts with solutions and ways to improve FreeNAS. Over 38000 videos have been posted on YouTube and their social platforms have approximately 30000 followers in total. FreeNAS is an ever-growing community and anyone can help improve it as the development team are easily reachable.

OpenFiler

OpenFiler is an open source storage management OS based on rPath Linux. It is powered by the Linux kernel and provides file-based NAS and block-based SAN.

## Installation & Configuration

Installing OpenFiler in VirtualBox was much more complicated than FreeNAS. Like FreeNAS, I had to use multiple video and text-based tutorials on websites to get it up and running. The minimum requirements of implementing OpenFiler on VirtualBox are listed as being:

- 500 MHz CPU
- 256 MB of RAM
- 10GB Hard disk (8 for OS installation and 2GB for swap space)
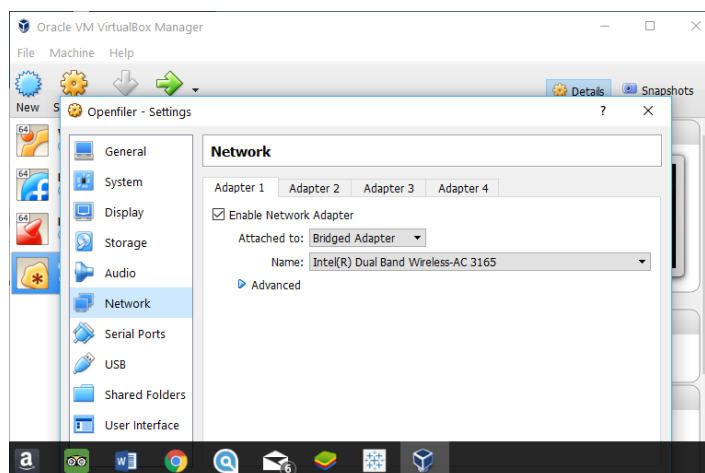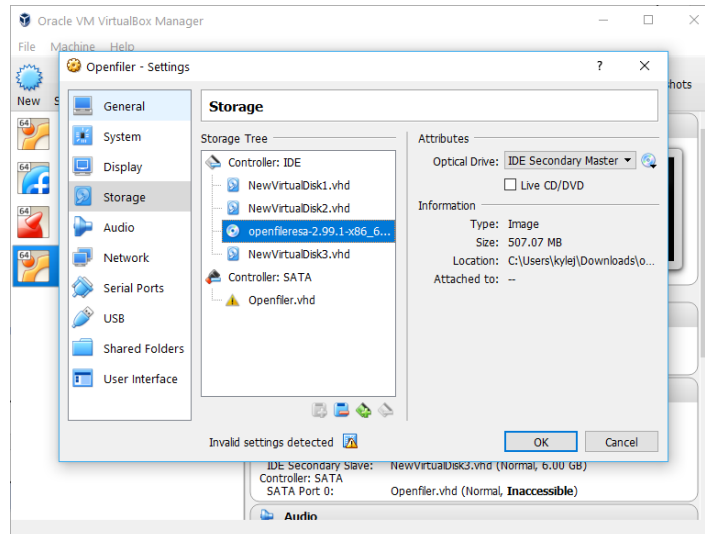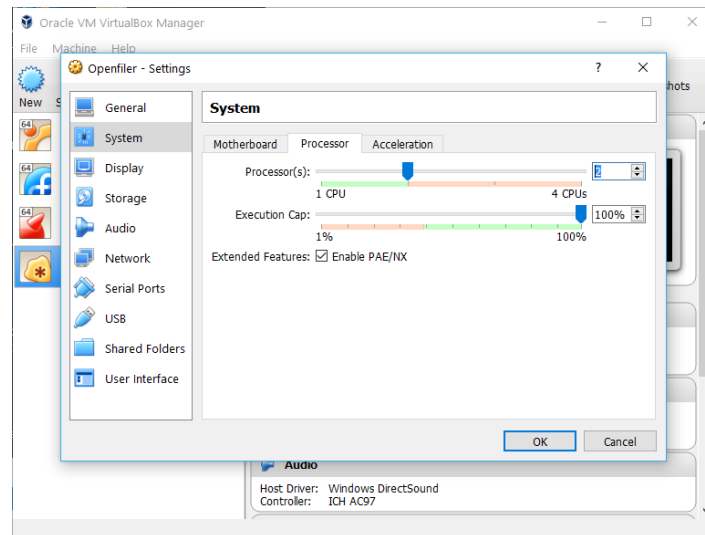- Optical drive
- Ethernet-like network interface

I adhered to these guidelines for my setup, however, I initially encountered a progress halting error which I will explain further on.

Step 1: First, I created the OpenFiler VM. I made it a Linux, Ubuntu 6f-bit machine and gave it 2GB RAM to be safe. I allocated a 16GB VHD for the OS run on and clicked create.
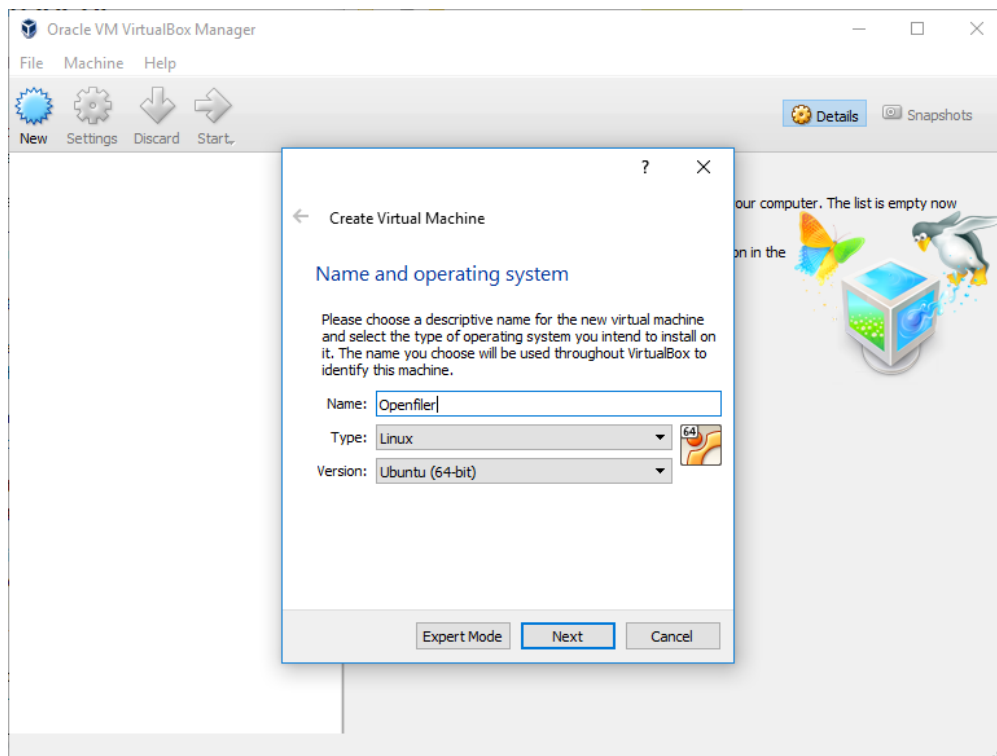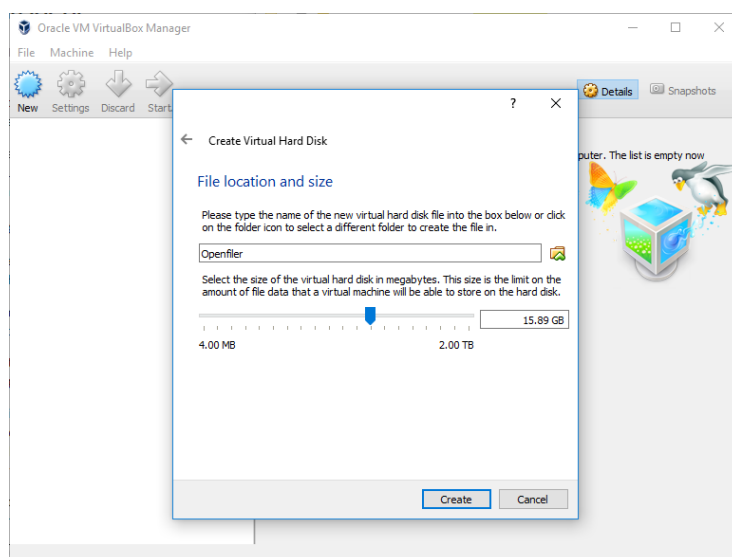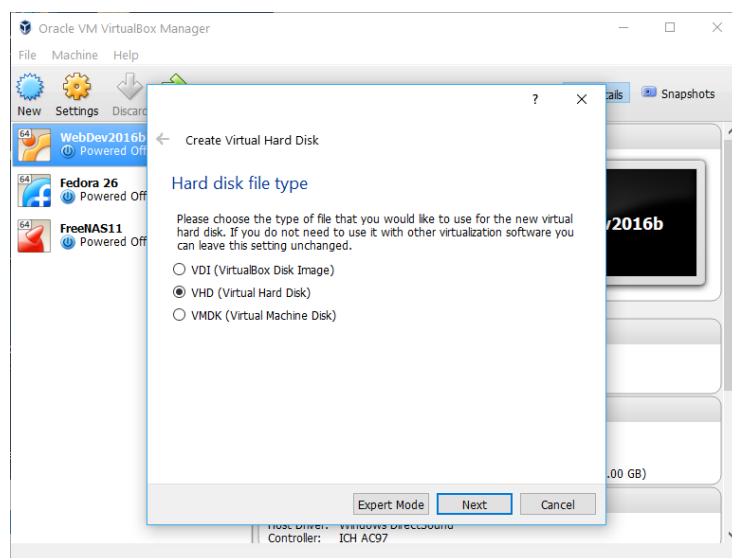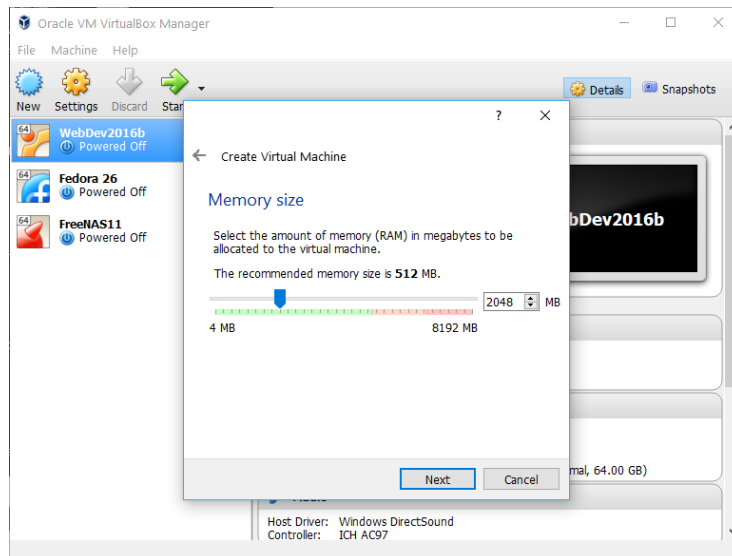
Step 2: I gave the VM 2 processors, mounted the ISO and created 3 virtual hard disks for OpenFiler to use, and attached a bridged network adapter. I then started the VM. Once the VM started it would run the installation process for about a minute and then freeze at the same point every time. I tried to troubleshoot it by increasing the RAM to 4GB to no avail. Eventually, I discovered that it would only work if I increased the processors to 4. My computer can only allocate 2 so I needed to get a new PC and try the set up again. Once I did this, I was ready to continue with the installation.

Step 3: I started the installation process. I selected a keyboard layout, chose what drives to use for the installation and which drive to boot the OS from, set it to get its IP address from DHCP, chose a time zone, set a root password and then rebooted the system. I then went to the IP address that OpenFiler resided on and it was ready for use.
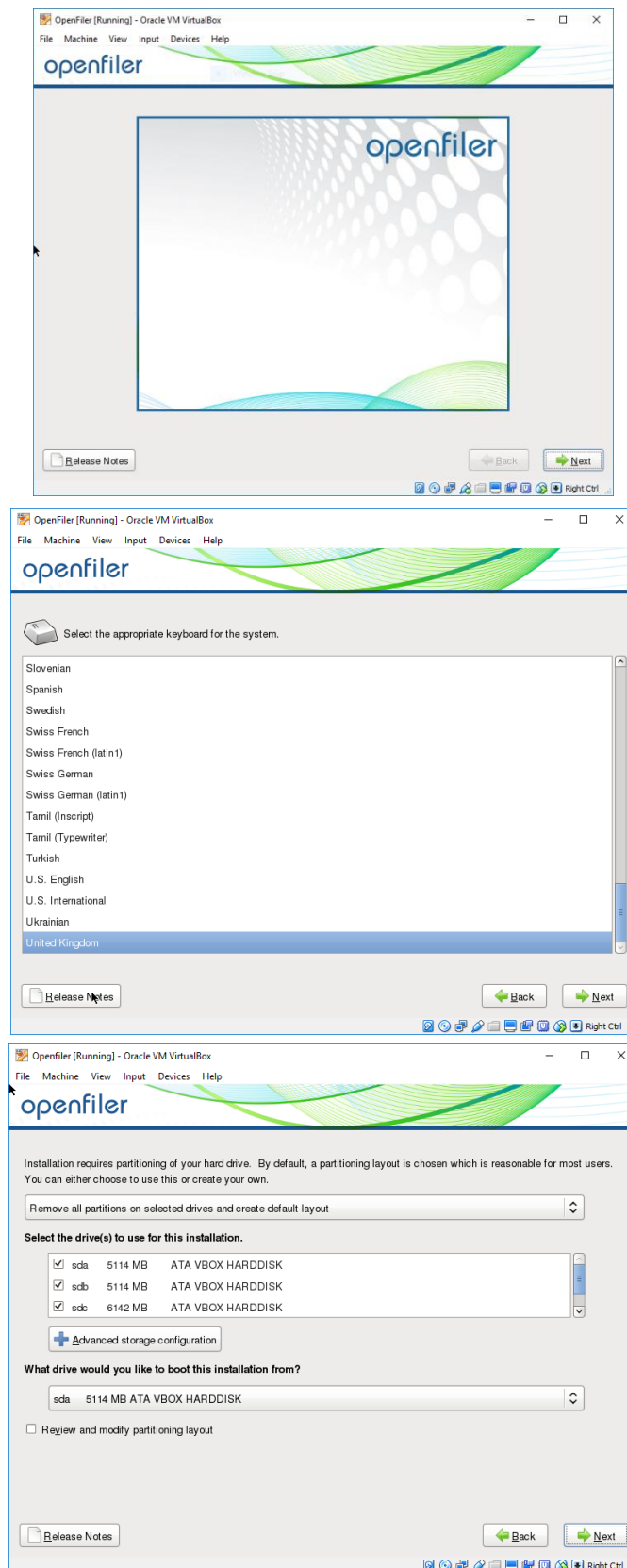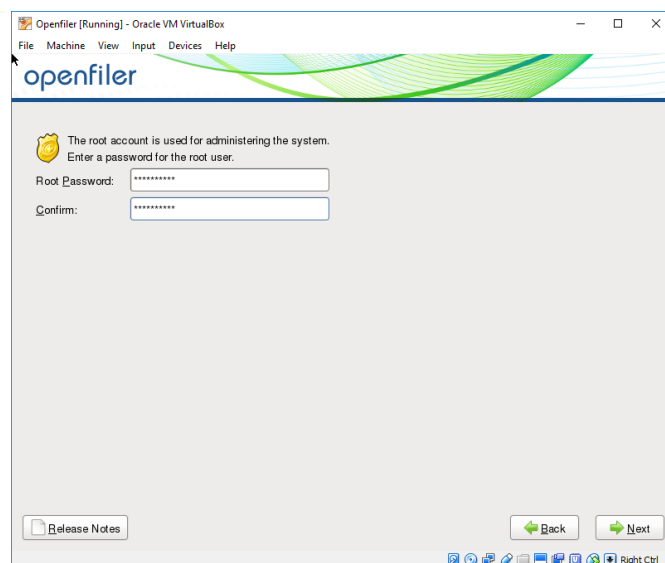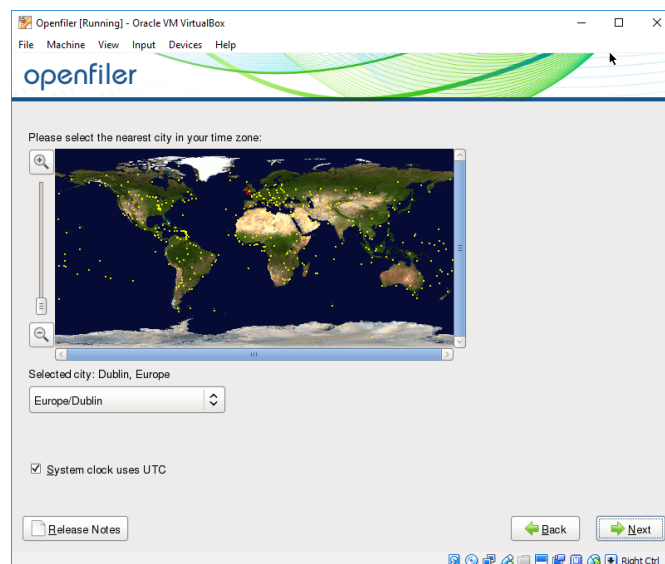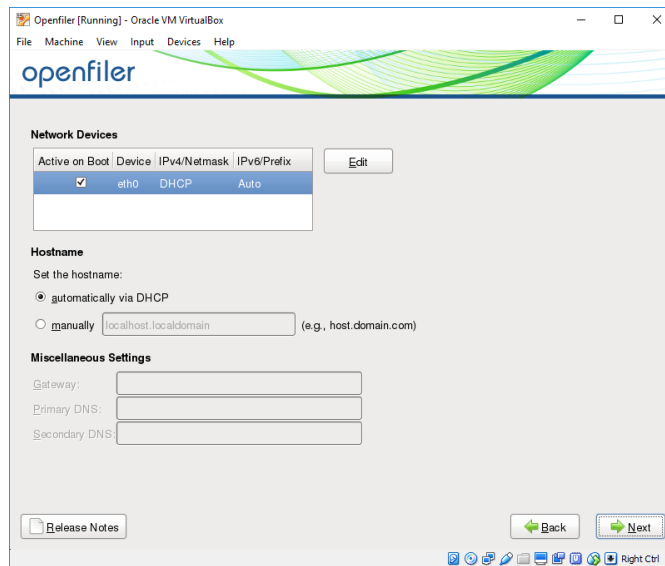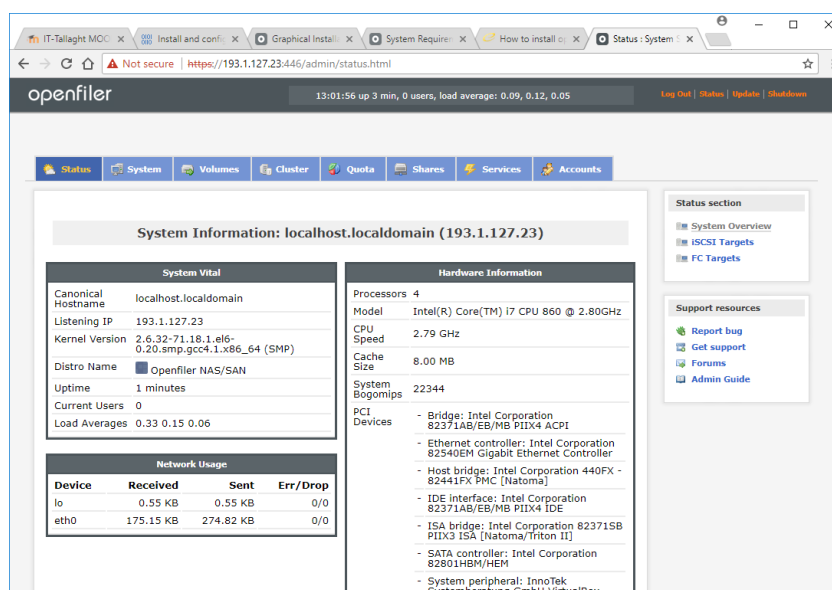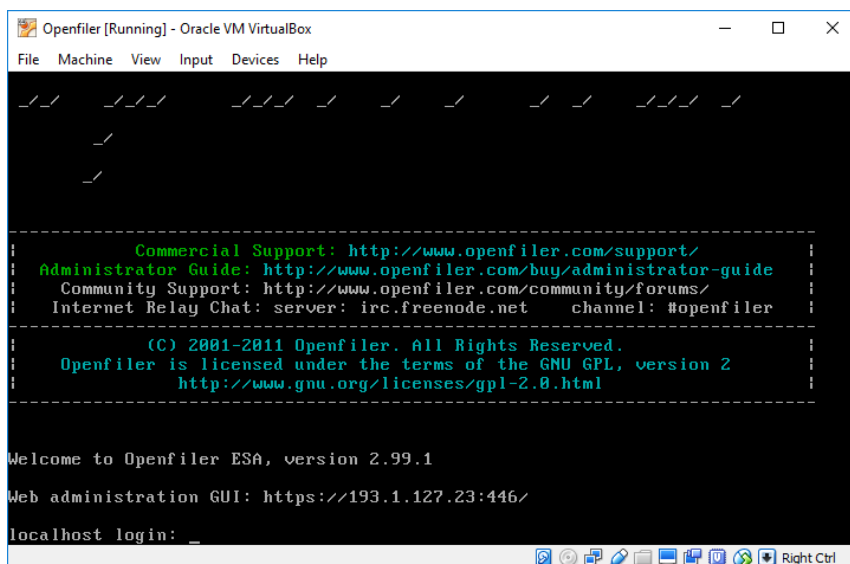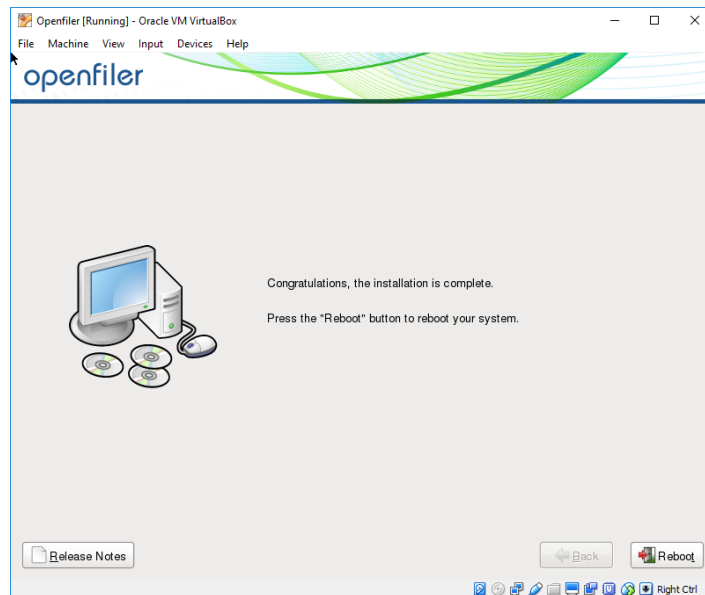
Excluding the error which delayed my installation, the entire process took me exactly 18 minutes and 23 seconds, which was a longer installation time than FreeNAS. When you start up OpenFiler for the first time there is no helpful wizard to guide you and help you utilise its features like there was with FreeNAS.

Features

OpenFiler, similar to FreeNAS has some very good features. These features include:

- OpenFiler's biggest feature is that it provides unified SAN and NAS storage. This means that it can appeal to larger audience than FreeNAS, as that only allows for NAS.
- A web based GUI. Like FreeNAS, OpenFiler also has a nice GUI to use. It is not as well laid out as the FreeNAS one as it can be hard to find certain things and takes some time to get used to.
- OpenFiler provides very powerful block level storage virtualisation. It supports both iSCSI and Fibre Channel protocols. It also provides synchronous and asynchronous volume migration and replication.
- OpenFiler also allows for the creation of users and volume shares just like FreeNAS. When I went to test these features I encountered a bug that seems to be persistent across OpenFiler implementations as many others seem to have had the same issue. OpenFiler would not allow me to create a physical volume. When I clicked the create button, the page would reload but nothing would happen. I discovered that for me to be able to create a volume, I had to set the 'start cylinder' value 80 higher than the current one. Only then would a volume be created. The entire process of creating a Windows share in OpenFiler was much more complicated than it was in FreeNAS. First, I configured network access configuration under the 'System' tab. Then I created a user and added him to a group through the command line. Then I had to enable CIFS. After this, I had to create a physical volume using one of the virtual disks I allocated. This was followed by the creation of a volume group. Inside this volume group I had to then create another volume which I called 'kylesharevolume' and allocated it 5GB. These tasks were difficult to figure out and slightly complicated and I was only able to begin creating a share once I figured out and carried out these steps. I selected the volume which I wanted to create the share, and created a subfolder called 'KylesShare' and then selected make share. Here, I set the share to have controlled access so a password would be required and changed the group access configuration and host access configuration. Finally, I opened the windows Run program and entered the IP address which I configured and it brought me to the network shared folder.

Network Access Configuration

Delete	Name	Network/Host	Netmask	Type
☐	kyle-share-access	192.168.0.2	255.255.255.0	Share
New			0.0.0.0 ▼	Share ▼

Update

Manage Services

| Service	Boot Status	Modify Boot	Current Status	Start / Stop
CIFS Server	Enabled	Disable	Running	Stop

```
Openfiler2 [Running] - Oracle VM VirtualBox                    —    □    ×
File  Machine  View  Input  Devices  Help
-----------------------------------------------------------------------
|      Commercial Support: http://www.openfiler.com/support/          |
|   Administrator Guide: http://www.openfiler.com/buy/administrator-guide|
|    Community Support: http://www.openfiler.com/community/forums/     |
|    Internet Relay Chat: server: irc.freenode.net    channel: #openfiler|
-----------------------------------------------------------------------
|        (C) 2001-2011 Openfiler. All Rights Reserved.                |
|    Openfiler is licensed under the terms of the GNU GPL, version 2  |
|            http://www.gnu.org/licenses/gpl-2.0.html                 |
-----------------------------------------------------------------------


Welcome to Openfiler ESA, version 2.99.1

Web administration GUI: https://193.1.127.7:446/

localhost login: root
Password:
[root@localhost ~]# useradd kyle
[root@localhost ~]# groupadd group1
[root@localhost ~]# smbpasswd -a kyle
New SMB password:
Retype new SMB password:
Added user kyle.
[root@localhost ~]# _
```

Select Volume Group

Please select a volume group to display.

kyle-test ▾ [Change]

Volumes in volume group "kyle-test" (9152 MB)
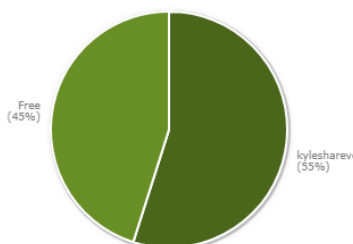
Volume name	Volume description	Volume size	File system type	File system size	FS used space	FS free space	Delete	Properties	Snapshots
kylesharevolume	share for user kyle	5024 MB	Ext4	4.9G	138M	4.5G	Delete	Edit	Create

0 MB allocated to snapshots

4128 MB of free space left

⚠ No filesystem volumes configured. Please create a new filesystem volume.

Network Shares

🖴 **kyle-test** (/mnt/kyle-test/)

    🖴 share for user kyle (/mnt/kyle-test/kylesharevolume/)

       🖥 KylesShare (/mnt/kyle-test/kylesharevolume/KylesShare/)

Shares section

🖳 Existing Shares

🖳 Snapshot Shares

Support resources

🐞 Report bug

🖼 Get support

✉ Forums

📖 Admin Guide

Share Access Control Mode

   ◯ **Public guest access**

   ⦿ **Controlled access**

[Update]

Group access configuration

[Back to shares list]

💡 If you want to see groups from network directory servers here, please configure them in the authentication section.

GID	Group Name	Type	PG	NO	RO	RW
497	riak	Local	◯	⦿	◯	◯
1234	desktop_admin_r	Local	◯	⦿	◯	◯
1235	desktop_user_r	Local	◯	⦿	◯	◯
500	kyle	Local	◯	⦿	◯	◯
1236	group1	Local	⦿	◯	◯	⦿

[Update]

Host access configuration (/mnt/kyle-test/kylesharevolume/KylesShare/)

[Back to shares list]

Name	Network	SMB/CIFS SMB/CIFS Options ☐ Restart services			NFS				HTTP(S) / WebDAV			FTP			Rsync Rsync Options		
		No	RO	RW	No	RO	RW	Options	No	RO	RW	No	RO	RW	No	RO	RW
kyle-share-access	192.168.0.2	◯	◯	⦿	⦿	◯	◯	Edit	⦿	◯	◯	⦿	◯	◯	⦿	◯	◯

[Update]

[Delete this share]

Overall, the entire process of creating volumes and shares in OpenFiler was much more complicated than it was in FreeNAS.

Performance

OpenFiler performed well as I was testing it. It ran very smoothly and I did not notice any hitches in performance or slowness in its operations. OpenFiler does not have a reporting feature to help with performance testing. Unlike FreeNAS, it doesn't consume all the memory allocated straight away. FreeNAS populates the entire amount of memory allocated with cached information, whereas in OpenFiler cached memory has the lowest CPU usage, excluding disk swap. Physical memory uses the highest percentage of memory with the kernel and applications has the second highest memory usage.

Memory Usage				
Type	**Percent Capacity**	**Free**	**Used**	**Size**
Physical Memory	8%	5.04 GB	424.27 MB	5.45 GB
- Kernel + applications	4%		244.89 MB	
- Buffers	2%		84.55 MB	
- Cached	2%		94.82 MB	
Disk Swap	0%	1.00 GB	0.00 KB	1.00 GB

Licensing & Cost

OpenFiler is released under the terms of the GNU GPL license version 2. Like FreeNAS's BSD license, it states that a disclaimer and copyright notice must be provided. It goes further however, and states that users may charge a fee for transferring copies of OpenFiler, or for warranty protection. It also states other terms such as the need for contacting the author if you wish to incorporate parts of the program into other free programs. OpenFiler can be modified in any way possible once a notice is included to explain so.

Basic OpenFiler is free to download meaning there is very little cost involved in implementing it. All that is required is to ensure you have the right hardware specs to be able to successfully set up a SAN or NAS through it. Although, here is also commercial OpenFiler, one for SMEs and one for enterprise, which is available. Both conform to an SLA response time of 4Hrs however there are several benefits in the enterprise edition which make it better, and more expensive than the SME edition, such as 24/7 service availability. You need to contact their sales team to get a quote on the pricing.

Support

I was unimpressed with the support provided for OpenFiler. OpenFiler has not received a patch or an update since 2011. There is no active community in which you can seek help with issues as the forums no longer exist because the program has been discontinued. To receive any form of support, you must pay a fee.

Conclusion

Both FreeNAS and OpenFiler have plenty of features to take advantage of. However, the choice of choosing one over the other resides in their drawbacks. The big advantages of OpenFiler are that it provides unified NAS and SAN storage, fast speeds and can be implemented at a relatively low cost. However, OpenFiler has far more disadvantages which, in my opinion, make FreeNAS a better option. For starters, OpenFiler is now discontinued and hasn't received an update or a patch since 2011. That's 6 years which this product hasn't been supported as opposed to FreeNAS which is still active and supported regularly with updates and patches. FreeNAS has a very large, active community of users whereas OpenFiler forums don't even exist anymore which makes getting help for any issues incredibly hard. If you need support you also have to pay for it. OpenFiler also doesn't support plugins which may turn most users off. This means that services such as bacula, BT Sync, MineOS and more cannot be used with OpenFiler.

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