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Construction**

**CE6014 – Computer Mediated Communication**

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**Title:** Private Cloud - file sharing for SME in AEC domain

This project report describes how to build and configure a private cloud network attached storage solution. The NAS solution will be used to test technologies to support a file sharing service for use in a small or medium enterprise which will enable remote access to up to date project files. The private cloud solution was eventually implemented on minimal Linux virtual machine configured on a live server.

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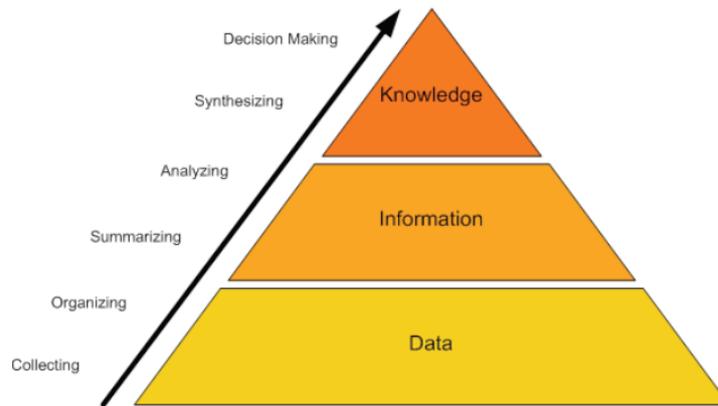
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## 1. Introduction

In the background section the basic forms of knowledge in an organisation are outlined and the Nonaka & Takeuchi model for knowledge creation is described which will form the basis for the knowledge management solution. In section 3 the visualisation of knowledge is described through the use of a mind map. In section 4 a description of the problem domain is discussed with the need for remote file sharing and collaboration. A solution to the problems is described in section 6 particularly the merits of a cloud infrastructure. A conclusion is presented in section 7 describing the implementation of the solution and merits of its application.

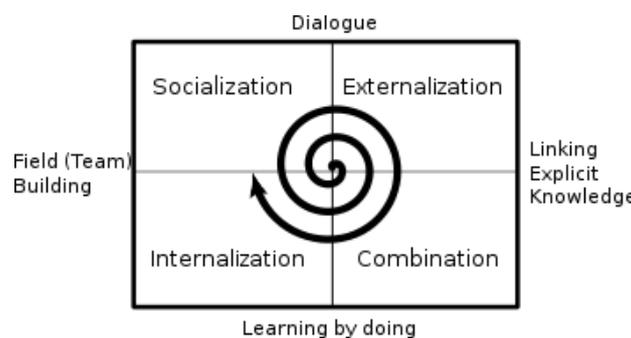
## 2. Background

In an organisation, knowledge exists in tacit, explicit and implicit form. Tacit knowledge refers the personal knowledge of an individual which is gathered through experience, personal belief, instinct and values. It is a dynamic form constantly updating and changing. Tacit knowledge is difficult to extract for an organisation and is an extremely valuable asset. Explicit knowledge is ideally what tacit knowledge needs to become. Explicit knowledge takes the form of structured language and is easily transferred to others through IT techniques. Implicit knowledge on the other hand is unstructured and difficult to explain and share with others. Knowledge can be described in terms of “know what”, “know how” and “know why”. In figure 1, the creation of knowledge is shown as a pyramid beginning as data gathered from experience and organised into information which can be shared and analysed to become knowledge used in decision making.



**Figure 1 - Knowledge creation**

The SECI model for the knowledge creation process was described by Ikujiro Nonaka and Hirotaka Takeuchi in 1995. It describes the processes in knowledge creation as a spiral where explicit and tacit knowledge are constantly growing. An individual's knowledge is shared with others to become new knowledge. The spiral of knowledge contains 4 modes of knowledge conversion shown in figure 2.



**Figure 2 - Nonaka & Takeuchi SECI model**

### Socialization

Tacit knowledge is shared with others through face-to-face communication or shared experience eg. Apprentice

### Externalization

Tacit knowledge is converted to explicit knowledge by developing concepts and models so it can be understood and used by others eg. Work instructions

### Combination

Explicit knowledge is analysed in conjunction with existing knowledge and organized into structured standards eg. Work flow diagram

## Internalization

When explicit knowledge is shared and understood it is internalized and becomes part of an individual's tacit knowledge.

The spiral grows in scale through the 4 modes of conversion which can start new spirals of knowledge creation. According to Nonaka, in an organisation there are 5 enablers for knowledge creation.

1. A knowledge vision of how the organisation wishes to grow.
2. A knowledge strategy to develop core competences.
3. A knowledge system used to network knowledge throughout the organisation.
4. A knowledge structure for effective transfer.
5. Staff intrinsically involved in knowledge transfer in the organisation.

## 3. Visualisation of Knowledge

A basic structure of a hypothetical SME is shown in figure 3. It shows the flow of data and information through the organisation. The information is dynamic and constantly changing through project development. It is the responsibility of management to effectively convey the information up and down the chain so all stakeholders are informed at each stage of the project. Management must have a knowledge vision and develop a knowledge strategy for the organisation. The IT team have the responsibility for the knowledge system and the knowledge structure. They must effectively maintain systems and network infrastructure for staff ensuring explicit knowledge in the organisation is effectively communicated throughout the organisation. Quality systems for electronic document management and effective procedural processes have to be maintained and developed by the IT team. The project team are responsible for the development of each stage of the project from planning to design and construction. It is the project team that develops the tacit knowledge through project experience. This knowledge needs to be extracted and converted to explicit knowledge for future projects. Planning and design inefficiencies are identified through the effective collaboration and innovation of standard documents, with the result of growth in the organisation's knowledge and core competencies.



Figure 3 - Organisational Knowledge

## 4. Problem Description

Small and medium enterprises establish a basic IT infrastructure for email and web and file services. These basic services can be hosted either on site or in a data centre. A public cloud is managed by a third party provider and is usually a subscription service. The alternative is a private cloud hosted within the SME premises. Although this offers complete privacy and control over the organisations data, it requires IT skills and initial capital expenditure to build, configure and maintain.

A good quality of service must be established in either environment through service level agreements or suitably qualified staff on site. The provisioning of resources and time is expensive and the decision on either public or private cloud implementation should be thoroughly thought through so as to prevent undesirable vendor lock-in for instance.

As the organisation grows so does its digital storage requirements, files such as Technical, Financial and Design documents hold sensitive information.

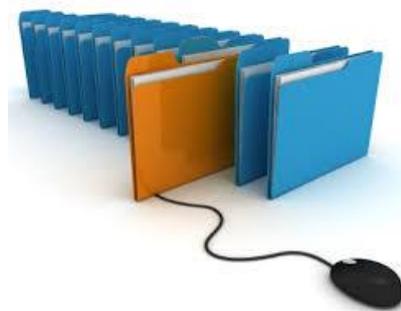


Figure 4 - Digital Storage

There are several public cloud services available such as Dropbox and Google drive which allow the storage and sharing of these documents. However good these services perform there is always the privacy and security aspect to consider.



Figure 5 - Public Cloud Service's

## 5. Problem Solution

Today, the use of internal clouds over external clouds is increasing due to the various risks associated with external clouds, including security, data privacy and service availability. A common discouragement is that IT has to build this environment and no single vendor provides all the pieces. The objective of this project is firstly to provide a storage facility for the explicit knowledge which is gathered over time through project experience and team collaboration and innovation. A quality electronic document management system can ensure procedures are followed which leads to accountability. The main functionality for this service is to allow staff access to historical and relevant project data from a remote location. The service intended provides a highly effective sharing environment both on site and from remote locations.

The solution is to use Network attached storage built by FreeNAS a unix environment based on FreeBSD. This centralized storage system is an open source project and distributed under the FreeBSD license. The capacity can be easily scaled and a high level of data integrity is provided by the ZFS filesystem.

There are 2 open source project which I intend to use for file sharing owncloud has been around longer than Pydio but both provide similar service. The shared interface can be used in a web browser on most devices. The service allows for document sync and remote access. Both owncloud and Pydio are freely distributed under the GNU AGPLv3 license.

*ownCloud is a software system for what is commonly termed "cloud storage". As such, ownCloud is very similar to the widely-used DropBox, with the primary difference being that ownCloud is free and open-source, and thereby allowing anyone to install and operate it without charge on a private server, with no limits on such things as storage space or the number of users and client machines connecting.*

## 6. Implementation

### 6.1 Virtual environment

Initial testing was carried out on a Windows machine using Oracle VirtualBox. This is free software released under GNU GPLv2 which allows the creation of emulated or virtualized environments using guest OS's on a single host OS. The guest's selected in this project are FreeNAS 9.2, CentOS 7 and Windows 7. The virtual machines are created with allocated memory and storage from the host. The operating system on each VM is installed by mounting the downloaded .iso file on the virtual disk drive in the storage settings on the VM. The VM is started and the installer runs. Install takes a couple of minutes after completion shutdown and remove the virtual disk .iso from storage settings and start the VM. This procedure is done for each guest OS.

The user manual provided by the developers of the FreeNAS software is extensive and very helpful when configuring the system. I also found several online FreeNAS communities and free online introductory training videos which were a great starting point. The FreeNAS VM is configured with a SCSI controller with 3 virtual hard disks to be used as storage devices. The number of disks should suit the type of RAID implemented, in this case RAIDZ1 requires at least 3 disks. This RAID configuration is equivalent to RAID 5 which has the benefit of block striping (mirroring of data) and distributed parity which enable a tolerance for 1 disk to fail and be rebuilt upon replacement.

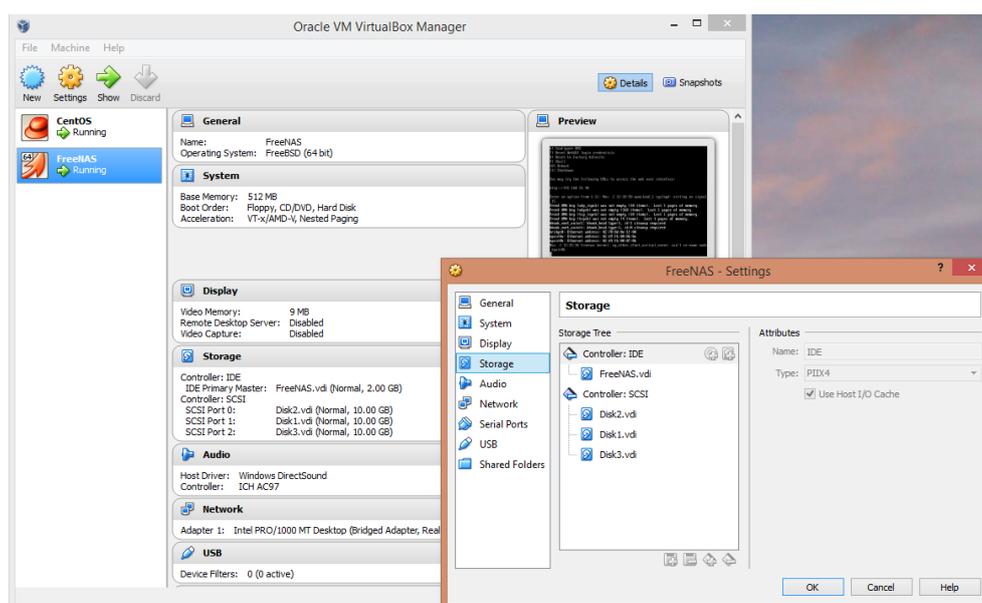


Figure 6 - SCSI virtual storage

When the OS is installed on the VM it is configured with a static IPV4 address and netmask from option 1

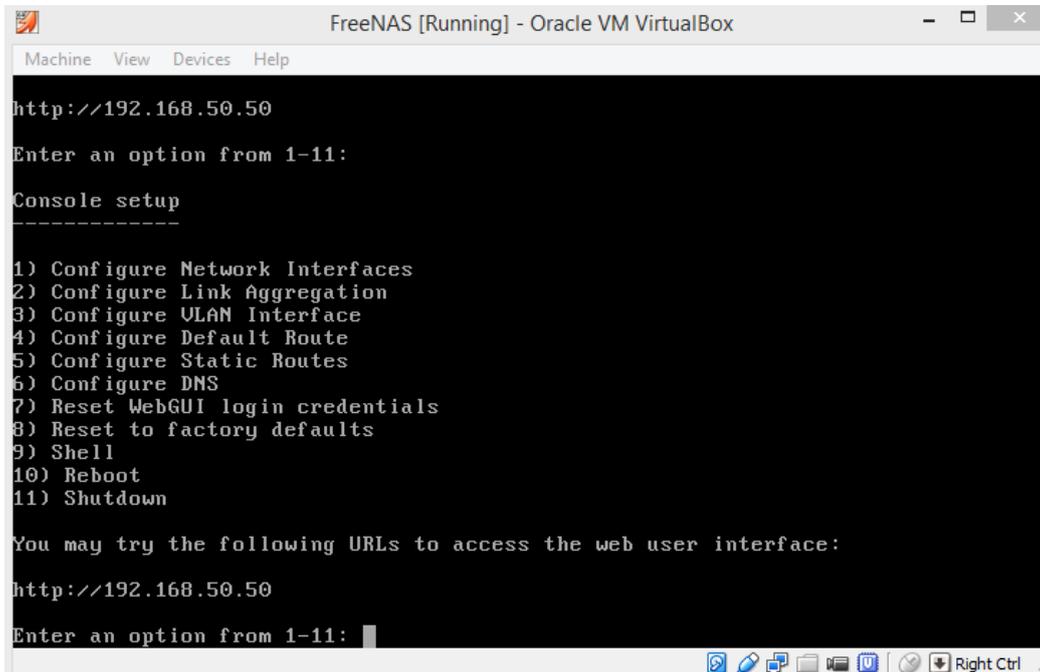


Figure 7 - Network configuration

Next the CentOS VM can be configured on the same network to allow for web browser configuration of the FreeNAS system through a GUI interface. The IP address is entered into the address bar and FreeNAS is presented but before configuration the admin account password is created.

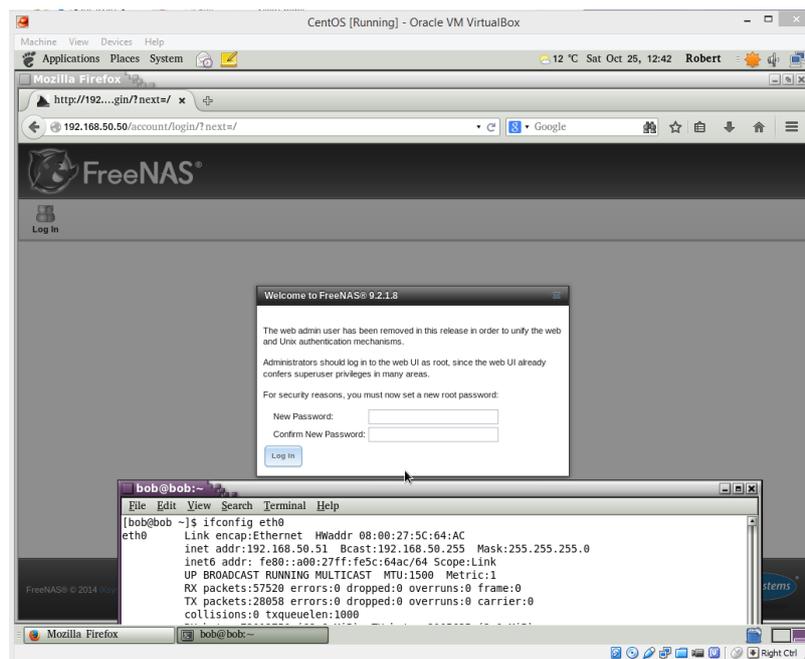


Figure 8 - Web GUI interface

A problem was encountered while setting up the network interfaces Virtualbox needed to be reinstalled as administrator to allow virtual interfaces on the network interface card. Also bridged adapter mode needs to be selected.

## 6.2 Encryption

Public/Private key authentication using encrypted keys has many benefits. It removes the need to enter a password and once public/private key pair has been set up unauthorized access is strictly not permitted. A public/private key pair can be generated on a client which is to be used with the server by the doing the following from the CLI each client machine.

```
$ ssh-keygen -t rsa
```

This will create two files in your (hidden) `~/.ssh` directory called: `id_rsa` and `id_rsa.pub` The first: `id_rsa` is your private key and the other: `id_rsa.pub` is your public key.

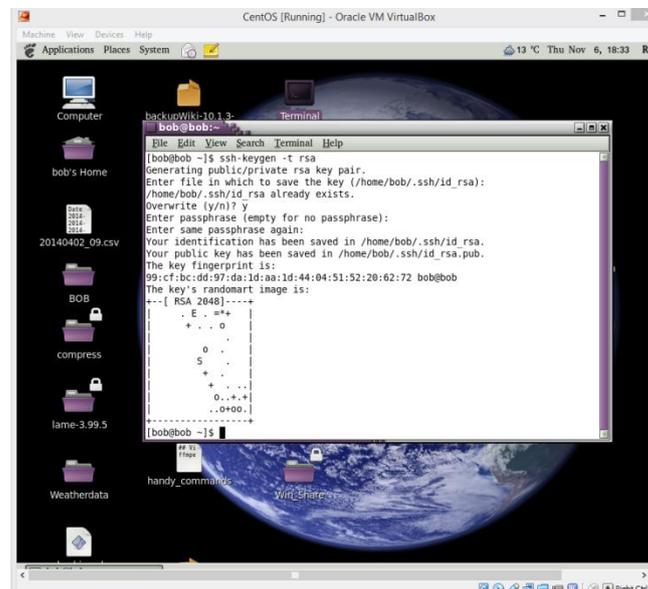


Figure 9 - CentOS Public/Private key creation

Now set permissions on your private key:

```
$ chmod 700 ~/.ssh
```

```
$ chmod 600 ~/.ssh/id_rsa
```

Copy the public key **id\_rsa.pub** to the server and install it to the `authorized_keys` list:

```
$ cat id_rsa.pub >> ~/.ssh/authorized_keys
```

Finally set file permissions on the server:

```
$ chmod 700 ~/.ssh
```

```
$ chmod 600 ~/.ssh/authorized_keys
```

The above permissions are *required* if `StrictModes` is set to `yes` in `/etc/ssh/sshd_config` (the default).

Ensure the correct SELinux contexts are set:

```
$ restorecon -Rv ~/.ssh
```

By default, `ssh` will first try to authenticate using keys. If no keys are found or authentication fails, then `ssh` will fall back to conventional password. The process is a little easier on Windows 7 VM with the use of `PuTTYgen.exe` and the `PuTTY` tool.

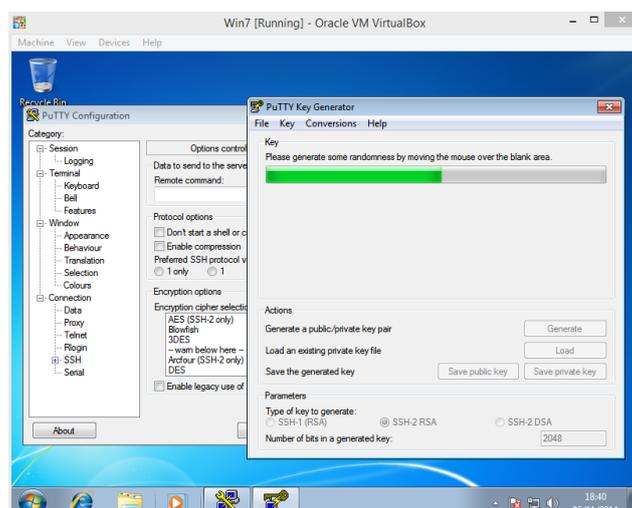


Figure 10 - PuTTY Public/Private key creation

### 6.3 ZFS Volumes and datasets

To configure storage a ZFS volume is created in RAIDZ1 with the 3 virtual disks attached to the SCSI controller.

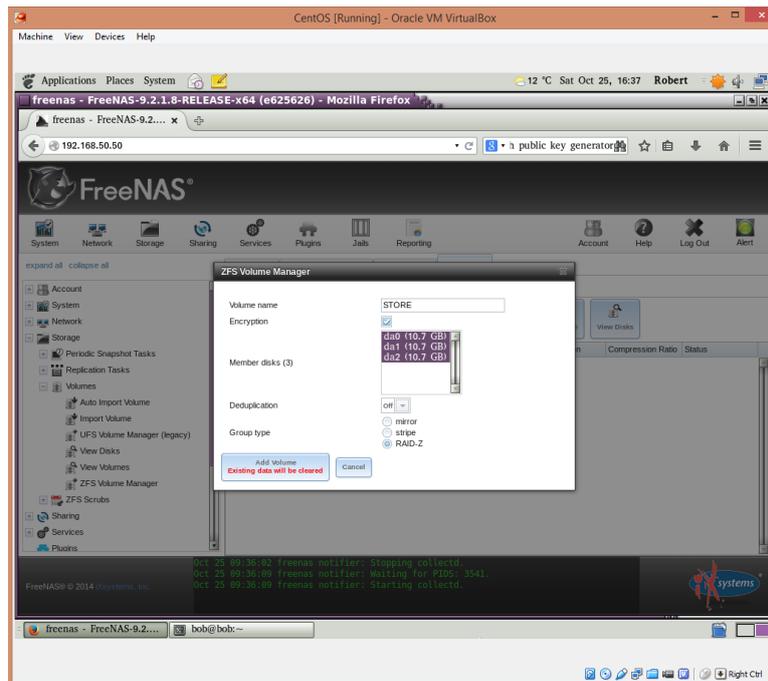


Figure 11 - ZFS volume creation

The volume is named STORE and next the sharing is created for both Windows which uses a CIFS share and CentOS which use a NFS share. These have to be enabled in the services section.

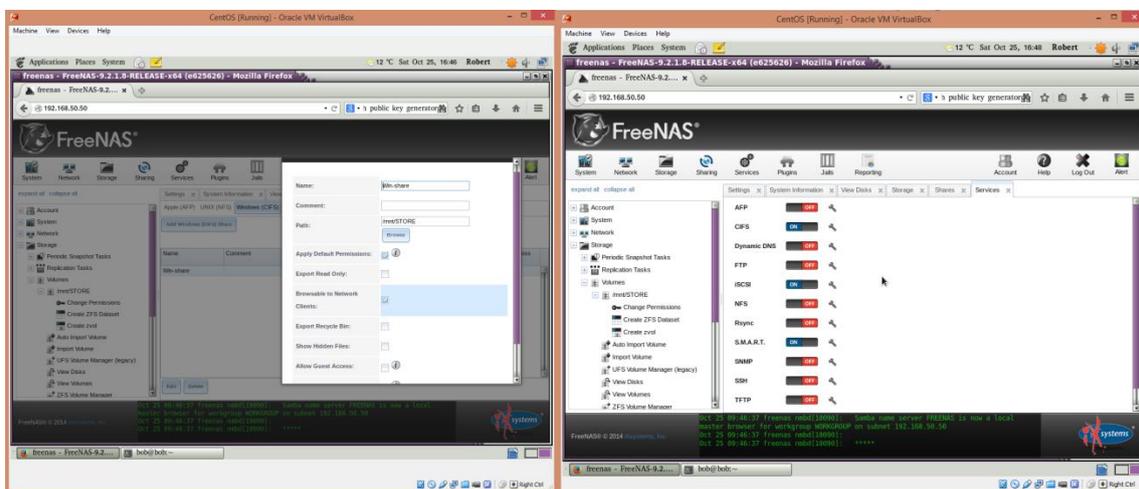


Figure 12 - Windows share

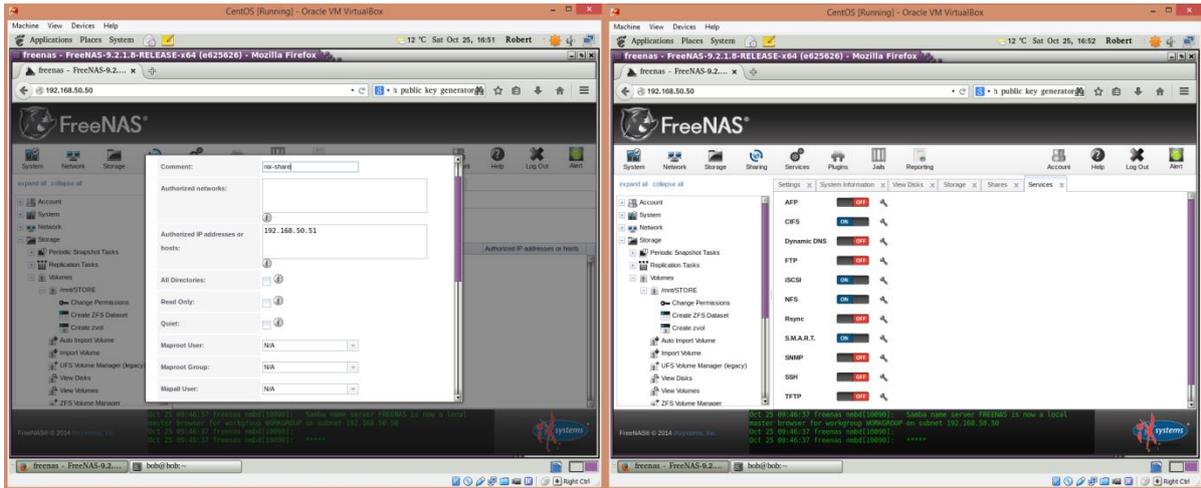


Figure 13 - Linux share

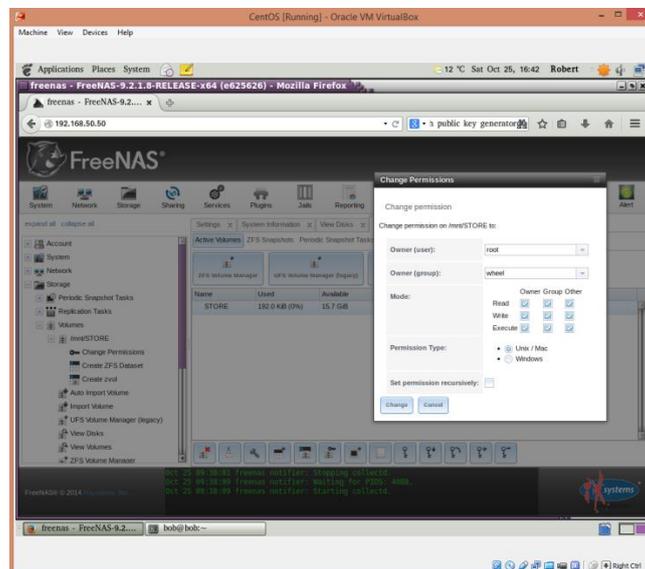


Figure 14 - Permissions read/write

Next read and write permissions need to be given so that the volume can function as a storage device for its clients.

## 6.4 Owncloud

The owncloud installation can be done in 2 way's, the first is by creating a jail however a good understanding of IT and networking skills is required to build the system however it does provide more control of the software installation. The second method is by utilizing the plugins available this needs to be configured through the FreeNAS download repository by entering the URL. Then the available plugins were visible and download/install can automatically create its own jail.

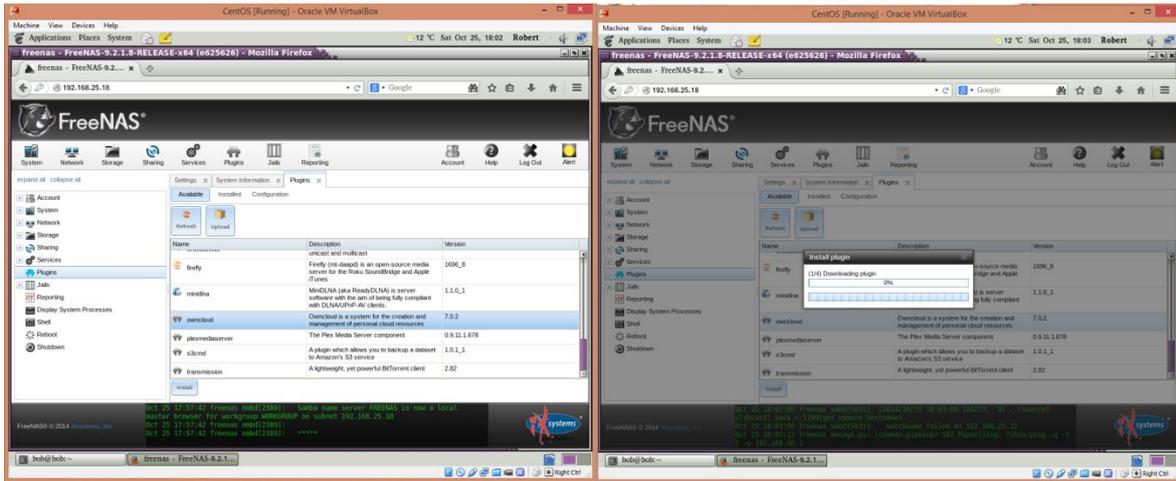


Figure 15 - Owncloud plugin

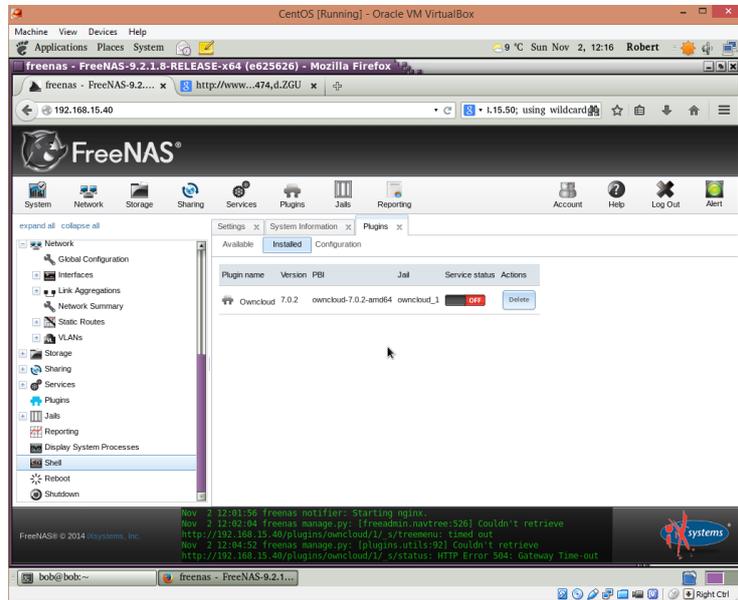


Figure 16 - Enabling owncloud service

However when the service was initialized the following error occurred.

**http://download.freenas.org/jails/9.2/x64/freenas-standard-9.2-RELEASE.tgz: No address record ERROR: Failed extracting: http://download.freenas.org/jails/9.2/x64/freenas-standard-9.2-RELEASE.tgz cannot open 'owncloud/.warden-template-standard': dataset does not exist ERROR: Failed to create ZFS base dataset**

This error could not be rectified and a decision had to be made to abandon the FreeNAS set-up, due to time constraints, for an alternative deployment in my workplace.

## 6.4 Workplace implementation

A Dell PowerEdge server was used in the deployment of the owncloud service for staff in my workplace. The server is a virtualized VMware environment administered through VMware VSphere client software from a remote desktop Windows machine. The procedure to create a virtual machine in VMware is as follows

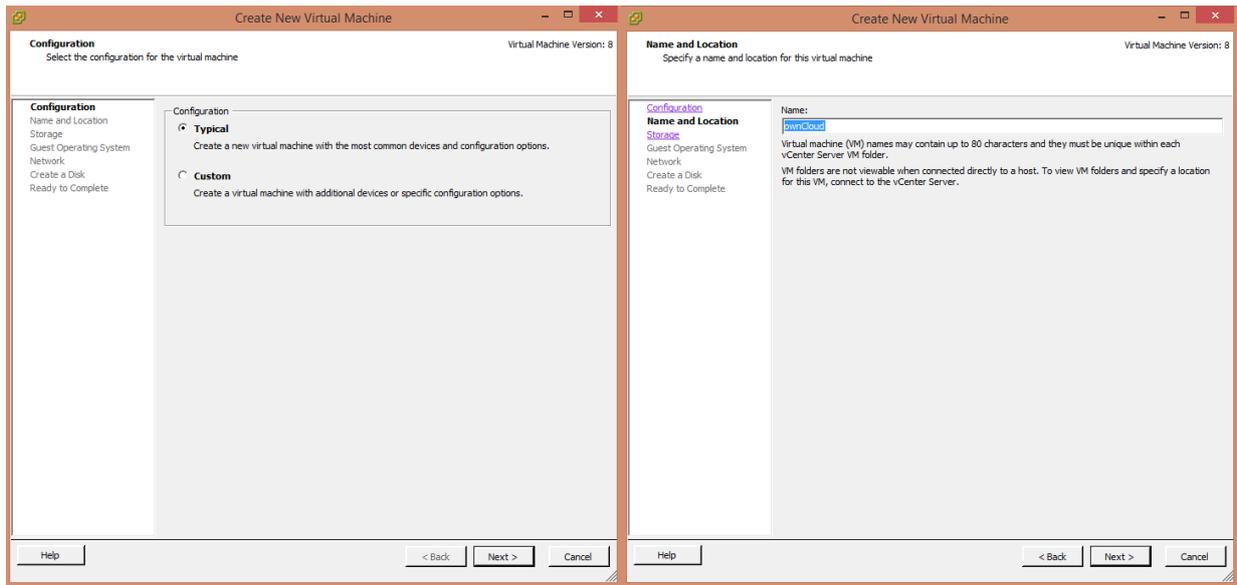


Figure 17 – Create, name and location of machine

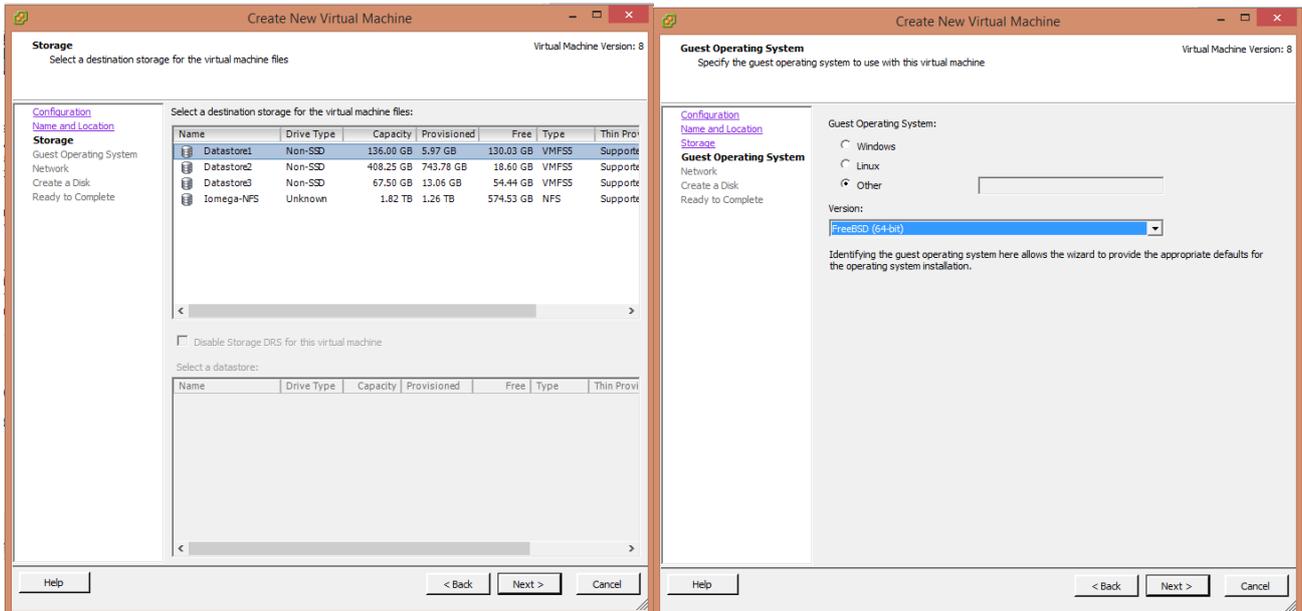


Figure 18 - Storage and operating system

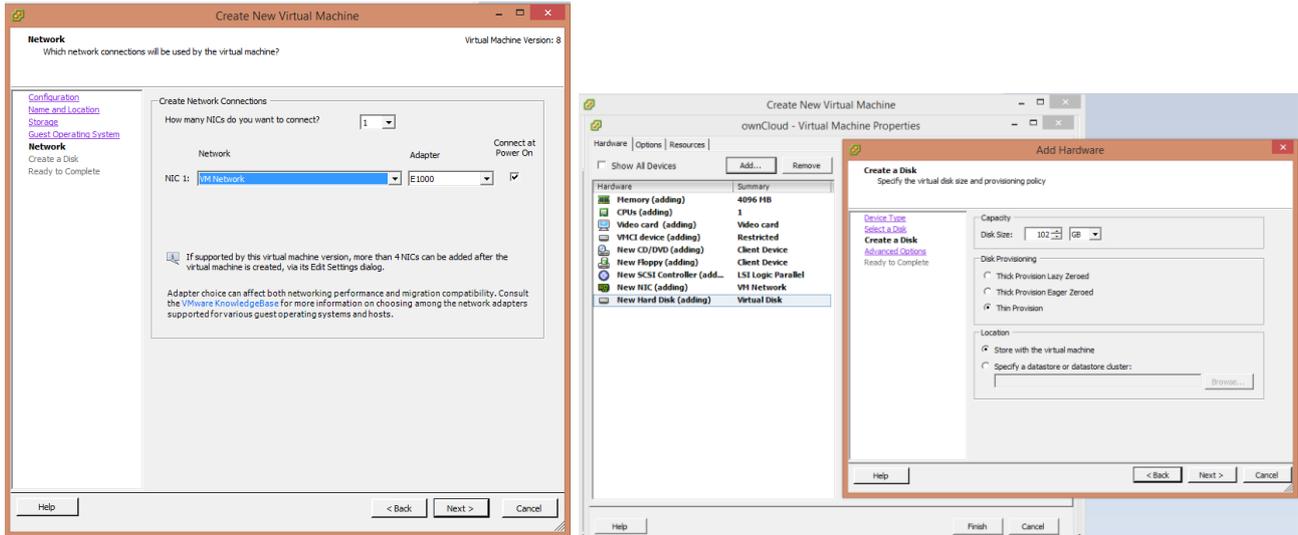


Figure 19 - NIC and virtual disk size

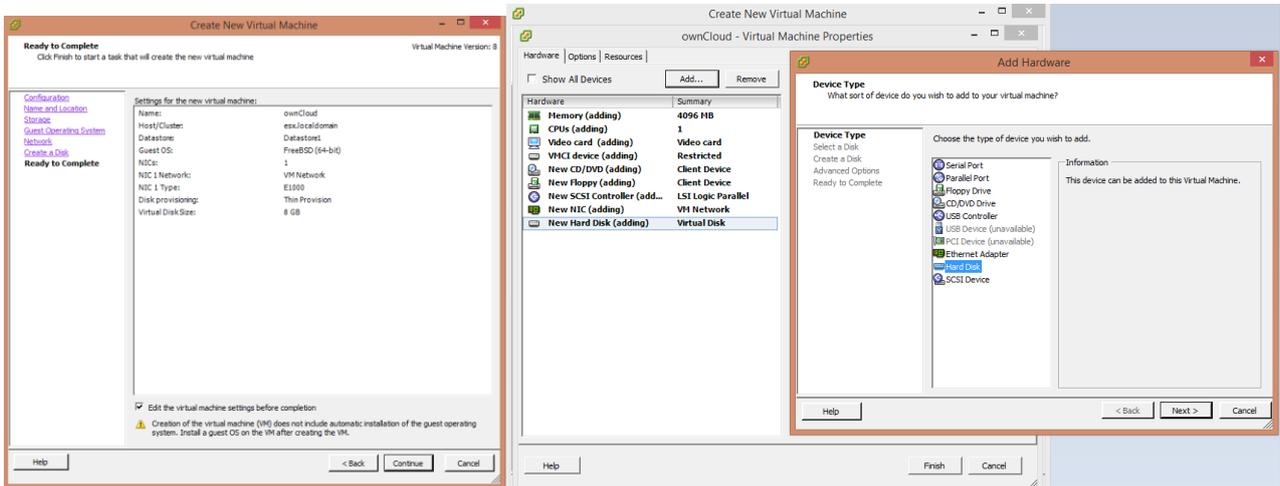


Figure 20 - Virtual machine settings

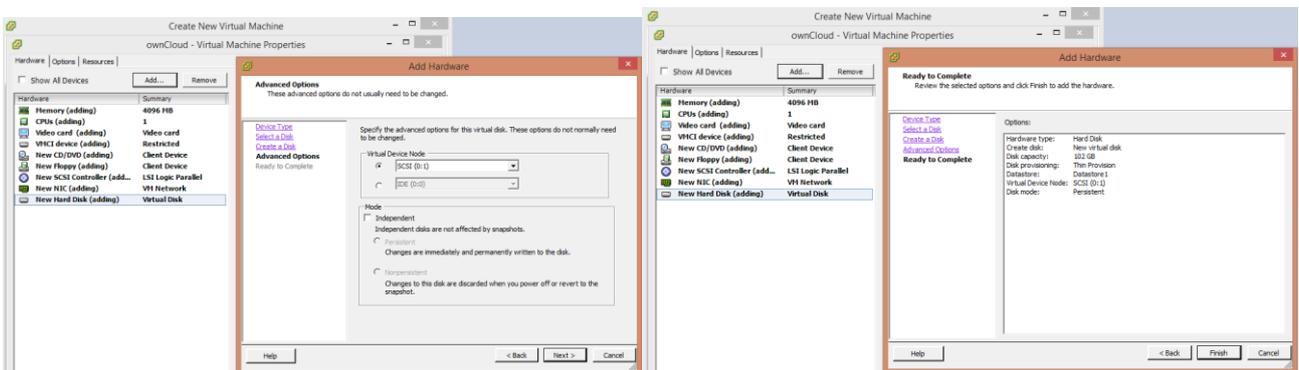
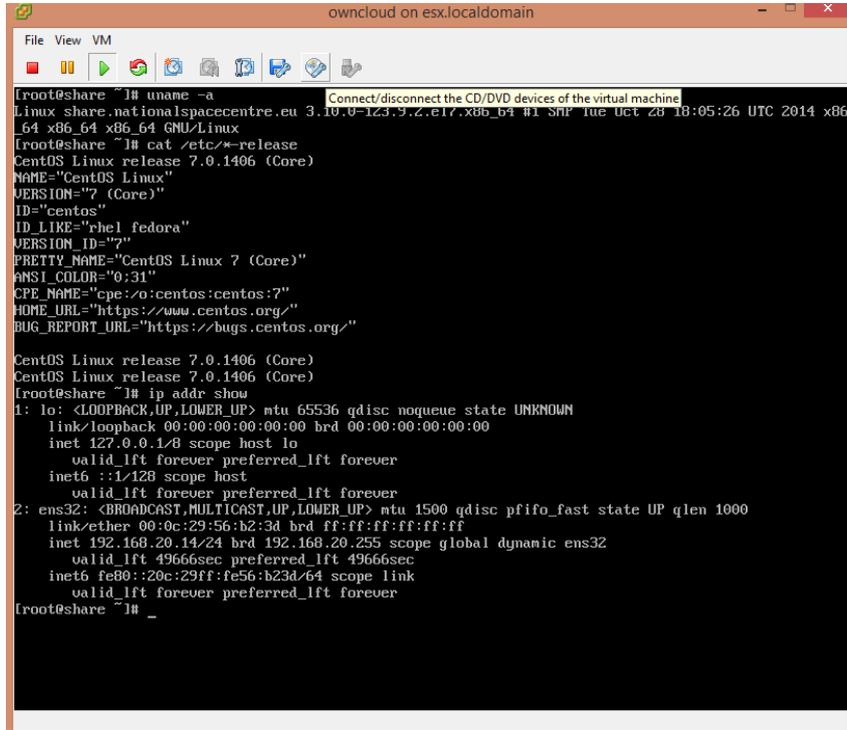


Figure 21 - Advanced options SCSI

The operating system CentOS 7 minimal .iso was downloaded from Heanet and attached by connecting the CD device of the of VM. System information is shown below.



```

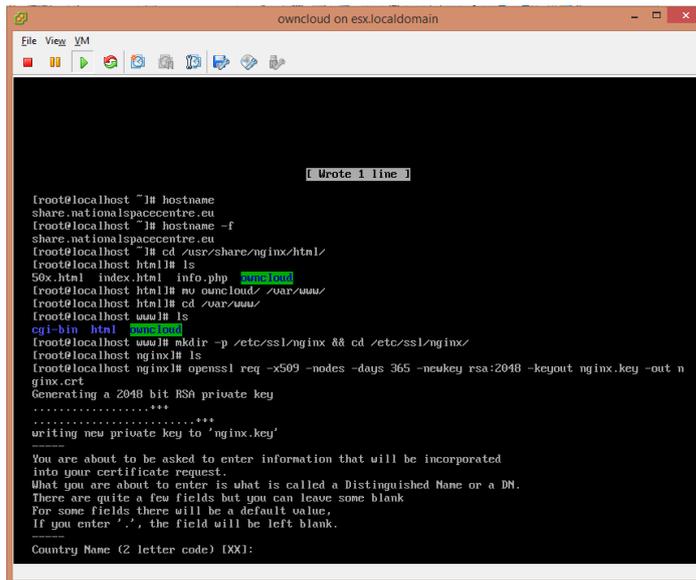
[root@share ~]# uname -a
Linux share.nationalspacecentre.eu 3.10.0-123.9.2.el7.x86_64 #1 SMP Tue Oct 28 18:05:26 UTC 2014 x86_64 x86_64 x86_64 GNU/Linux
[root@share ~]# cat /etc/*-release
CentOS Linux release 7.0.1406 (Core)
NAME="CentOS Linux"
VERSION="7 (Core)"
ID="centos"
ID_LIKE="rhel fedora"
VERSION_ID="7"
PRETTY_NAME="CentOS Linux 7 (Core)"
ANSI_COLOR="0:31"
CPE_NAME="cpe:/o:centos:centos:7"
HOME_URL="https://www.centos.org/"
BUG_REPORT_URL="https://bugs.centos.org/"

CentOS Linux release 7.0.1406 (Core)
CentOS Linux release 7.0.1406 (Core)
[root@share ~]# ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens32: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 00:0c:29:56:b2:3d brd ff:ff:ff:ff:ff:ff
    inet 192.168.20.14/24 brd 192.168.20.255 scope global dynamic ens32
        valid_lft 49666sec preferred_lft 49666sec
    inet6 fe80::20c:29ff:fe56:b23d/64 scope link
        valid_lft forever preferred_lft forever
[root@share ~]# _

```

Figure 22 - CentOS system information

Basic system or a “vanilla” OS is configured with ntp and static IPv4 address on the network. Yum and repository configuration is required to download and install MySQL, Nginx and PHP services.



```

[root@localhost ~]# hostname
share.nationalspacecentre.eu
[root@localhost ~]# hostname -f
share.nationalspacecentre.eu
[root@localhost ~]# cd /var/share/nginx/html/
[root@localhost html]# ls
50x.html index.html info.php www.html
[root@localhost html]# mv /var/www/ /var/www/
[root@localhost www]# ls
cgi-bin html
[root@localhost www]# mkdir -p /etc/ssl/nginx && cd /etc/ssl/nginx/
[root@localhost nginx]# ls
[root@localhost nginx]# openssl req -x509 -nodes -days 365 -newkey rsa:2048 -keyout nginx.key -out n
ginx.crt
Generating a 2048 bit RSA private key
.....
writing new private key to 'nginx.key'

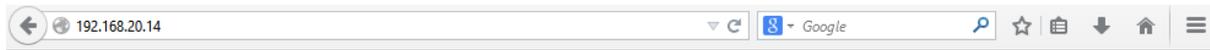
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.

-----
Country Name (2 letter code) [XX]:

```

Figure 23 - Server and SSL configuration

The configuration scripts for each service are available through many online sources and once these files have been edited on the machine the webserver is available. The webserver can be tested from a remote desktop machine with successful implementation shown below.



## Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to [nginx.org](http://nginx.org). Commercial support is available at [nginx.com](http://nginx.com).

*Thank you for using nginx.*

Figure 24 - Nginx webserver

Installing a MySQL drop-in replacement called MariaDB is used and will organize and provide access to databases where the site can store information it is a relational database management system. The database and user is easily configured with MySQL commands.

PHP is the component that will process code to display dynamic content. It can run scripts, connect to our MySQL databases to get information, and hand the processed content over to our web server to display. The PHP configuration can be tested by creating a file info.php in the web server directory successful configuration is shown below.

PHP Version 5.4.16	
<b>System</b>	Linux localhost.localdomain 3.10.0-123.el7.x86_64 #1 SMP Mon Jun 30 12:09:22 UTC 2014 x86_64
<b>Build Date</b>	Oct 13 2014 13:01:09
<b>Server API</b>	FFMDFastCGI
<b>Virtual Directory Support</b>	disabled
<b>Configuration File (php.ini) Path</b>	/etc
<b>Loaded Configuration File</b>	/etc/php.ini
<b>Scan this dir for additional .ini files</b>	/etc/php.d
<b>Additional .ini files parsed</b>	/etc/php.d/curl.ini, /etc/php.d/diffio.ini, /etc/php.d/json.ini, /etc/php.d/mysqli.ini, /etc/php.d/mysql.ini, /etc/php.d/openssl.ini, /etc/php.d/pdo_mysql.ini, /etc/php.d/pdo_sqlite.ini, /etc/php.d/phar.ini, /etc/php.d/sqlite3.ini, /etc/php.d/zip.ini
<b>PHP API</b>	20100412
<b>PHP Extension</b>	20100525
<b>Zend Extension</b>	220100525
<b>Zend Extension Build</b>	API220100525.NTS
<b>PHP Extension Build</b>	API20100525.NTS
<b>Debug Build</b>	no
<b>Thread Safety</b>	disabled
<b>Zend Signal Handling</b>	disabled
<b>Zend Memory Manager</b>	enabled
<b>Zend Multibyte Support</b>	disabled
<b>IPv6 Support</b>	enabled
<b>DTrace Support</b>	disabled
<b>Registered PHP Streams</b>	https, ftps, compress.zlib, compress.bzip2, php.file, glob, data, http, ftp, phar, zip
<b>Registered Stream Socket Transports</b>	tcp, udp, unix, udg, ssl, sshv3, sshv2, tls
<b>Registered Stream Filters</b>	zlib.*, bzip2.*, convert.iconv.*, string.rot13, string.toupper, string.tolower, string.strip_tags, convert.*, consumed, dechunk

This program makes use of the Zend Scripting Language Engine:  
 Zend Engine v2.4.0, Copyright (c) 1998-2013 Zend Technologies

Figure 25 - PHP info page

A problem was encountered with the presentation of owncloud service shown below.



Figure 26 - webserver issue

This error was initially thought to be a read/write permissions problem. To troubleshoot the directory owner was changed to the nginx user however this also resulted in the same error. Further investigation into Security Enhanced Linux (SELinux), which is enabled by default on CentOS, proved to be the problem it is a very robust security mechanism for the server and should be disabled during installation of the service.

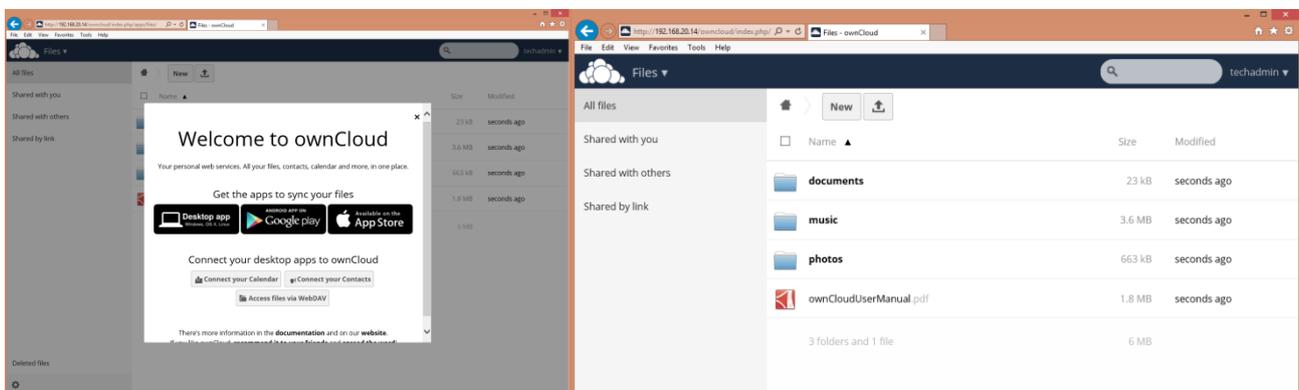


Figure 27 - Successful owncloud interface

## 7. Results and future configuration

Although the FreeNAS solution failed this is precisely why it was implemented in the test environment. It proved very challenging to configure the VM and network the services. Another look at the manual install of the owncloud jail might prove more successful. The implementation of owncloud in my workplace was very encouraging I believe it will prove to be a valuable service for staff especially when off site. It provides additional functions for users such as calendar and file syncing. These aspects of the service has not yet been configured and will be the next challenge in the project. When

this is successfully tested users and groups can be easily setup on the web GUI as admin user.

## 8. Conclusion

The solutions identified in this project provided a steep learning curve and a big challenge for my IT skills. The system implemented is based on the open source software stack referred to as LEMP – Linux, Nginx, MySQL and PHP. I found researching and configuring FOSS both challenging and rewarding.

## 9. References

- Nonaka & Takeuchi (1995). “The Knowledge Creating Company”
- iXsystems (2011-2014). “FreeNAS 9.2.1 Users Guide”
- Dolenc, Matevž (2014). “Computer Mediated Communication”
- Michael Anicas (2014) – “How to install Linux, Nginx, MySQL, PHP (LEMP) stack on CentOS 7”