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Open-Source versus Commercial Cloud Solution

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Note that Information contained in this document is for educational purposes.

ABSTRACT

This paper will discuss the features, advantages, and disadvantages of commercial solutions for private cloud services and make a comparison to an open-source, free alternative with a focus primarily on the storage aspect. The best practices to secure ownCloud, prevent unwanted visitors from accessing user files and keep files safely stored will also be investigated.

To investigate a market-leading private cloud provider; Google Drive's various features and pricing plans were investigated. For investigating free, open-source alternative solution ownCloud version 9.1.1 was installed with Apache web server on Ubuntu 15.10.

The paper will discuss the main features of open-source versus commercial cloud solutions, describe the benefits and restrictions of each system and make a decision on which version is the best option for the company. Each system had its benefits, but ultimately being in control of your data is the most important aspect, and for that reason ownCloud is the recommendation as a primary storage method.

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1. INTRODUCTION

This paper aims to investigate the main differences between a private cloud solution and a free, open-source alternative with a focus primarily on the storage aspect of private cloud. The open-source solution (ownCloud) will be configured with basic settings to get the service running, and some suggestions will be made for how to improve the configuration for a production environment.

A comparison to a market-leading commercial solution will also be made (G Suite/Google Drive in this case) and, ultimately, a decision will be made as to which service is better for the business use case.

A private cloud allows companies to outsource servers with rapid expandability and simple management. The private cloud will make use of one of many virtualisation technologies (depending on the cloud provider) to distribute large, powerful server's resources between multiple clients.

Private cloud can be located in different places: it can either be hosted locally within the company office/datacentre or elsewhere at a cloud provider's datacentre. It can also be managed by the customer or the cloud provider, regardless of whichever combination of the above option is used, the customer is always responsible for the costs that the cloud provider sets.

The estimated running costs of a private cloud will vary depending on a few factors. Firstly; management. Is the cloud managed by the client, or the cloud provider? Secondly; location. Is the hardware located in the cloud provider's datacentre using their equipment or client-hosted and only managed by the cloud provider? Finally, resource usage. Server load such as bandwidth, CPU, memory and storage usage is measured. If, for example, a company has a particularly busy month, experiences higher than regular traffic to their website and allocate more resources to the server then the cost would increase accordingly.

1.1 PRIVATE CLOUD DEFINITION

The National Institute of Standards and Technology (a U.S. government agency that sets standards) requires cloud computing to have the following characteristics:

On-demand self-service: The consumer can provision computing resources such as storage and server time automatically without having to interact with another human at the cloud computing service provider.

Broad network access: The services offered by the cloud provider are accessed through multiple standardised means (e.g. through mobile phones, tablets, laptops and workstations).

Resource pooling: The cloud provider's resources (such as storage, processing power, memory and network bandwidth) must be shared between every client of the service, with the resources allocation varying dependant on consumer demand.

Rapid elasticity: Server resources must be dynamically allocated for more and less capabilities based on consumer demand, with the consumer having the ability to change at any time.

Measured service: The cloud service's usage must be monitored to control and optimise resource utilisation. This allows for reporting to the cloud provider and consumer of effective usage. (NIST, 2011).

Based on the above definitions, Google Drive meets the requirements of a private cloud. Not only can the user increase storage space in an instant, files can be accessed from mobile applications, desktop clients and through a web interface. Using G Suite (Google's Business Storage solution) the monthly billing can also vary month-to-month depending on the amount of users actively using the service.

Private cloud uses virtualisation technologies from various vendors (depending on the cloud provider) to allow multiple instances of various operating systems to run on the same server. The most common virtualisation technologies are VMware vCloud, Microsoft Hyper-V and OpenStack. (Tom's IT Pro, 2015). Private cloud has a variety of uses including:

Storage: This allows customers to keep files in the cloud for access anywhere with an internet connection (Some services even offer the ability to save files offline for future access where internet is unavailable).

Databases: Companies can use cloud services to maintain large databases that allows for simple and rapid expansion if, and when, required.

Computation/Deep Learning: A researcher may require a powerful computer for deep learning purposes. Rather than building a multi-CPU/GPU machine costing thousands of pounds to increase the speed the researcher could "rent time" with a cloud service that has powerful servers readily available.

2. INVESTIGATION

2.1 G SUITE (COMMERCIAL SOLUTION)

This is a product offered by Google that integrates Google Docs, Mail, Drive, Hangouts, Calendar and a few more Google products into one package as a business solution. This paper focused on the cloud storage aspect so Google Drive within G Suite was investigated.

The service was monitored for usage and the option to increase to an unlimited storage tier was available. There were two tiers offered that were priced on a per-user basis. G Suite Basic was priced at £3.30 per user per month and offered:

- Business email addresses (e.g. name@domain.com).
- Video and voice calls using Google Hangouts.
- Integrated online calendars using Google Calendar.
- 30GB of online storage in Google Drive.
- Google Docs, Slides and Sheets for productivity.
- Website templates.
- Admin control and security panel.
- 24/7 support.

The second tier was called G Suite Business. It was priced at £6.60 per user per month and it offered all of the above plus:

- Unlimited storage (or 1TB per user for less than 5 users).
- Better administrator control over Google Drive.
- Auditing and reporting for Google Drive content.
- Google Vault (email, instant message and file archiving).
- Search and export functionality.
- Place and enforce litigation holds on inboxes.

The number of users (how monthly cost is calculated) was based on the amount of personalised email addresses within the suite. However, generic group email addresses (such as support@domain.com or donotreply@domain.com) did not count towards the user quota and were not chargeable. Users could be added and deleted dynamically so the monthly billing could vary depending on staff turnaround. (Google, [no date]).

Google drive offers access through a variety of services including a web interface, clients for Windows and OS X and through mobile clients for Android and iOS. A preview of the web interface can be viewed in *Figure 1*.

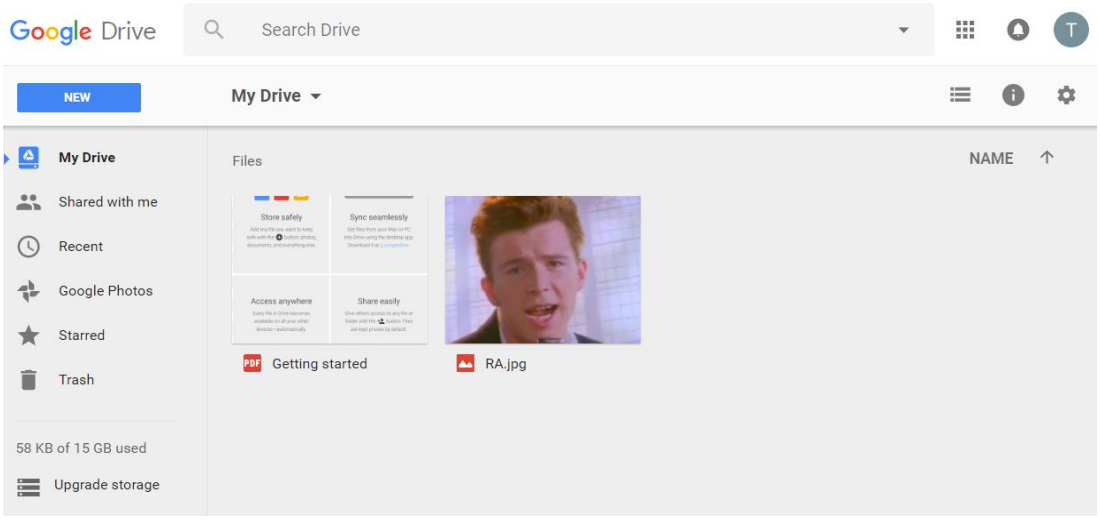

Figure 1: Google Drive Web Interface

Administrative tasks for G Suite (such as user management, viewing logs and contacting support) can be managed through the web interface or through the *Google Admin* app (available for Android and iOS). An example password reset can be viewed in *Figure 2*. (Google, [no date]). An interactive demo of G Suite management is also available from: https://gsuite.google.co.uk/intl/en_uk/products/admin/

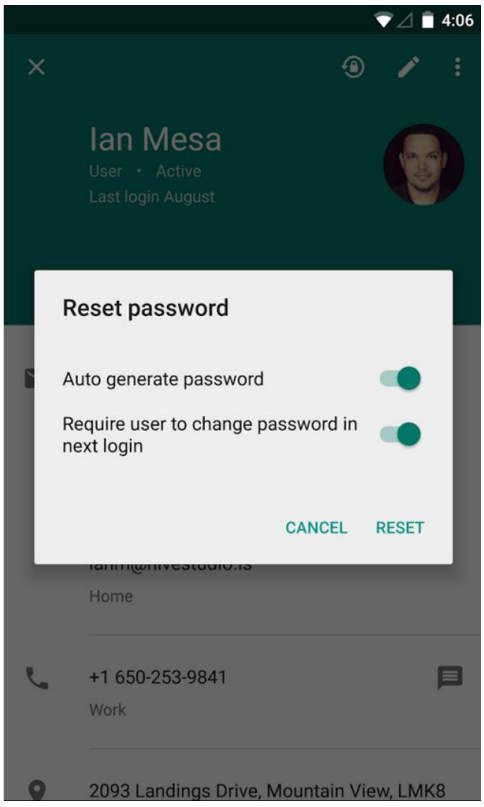

Figure 2: Google Admin Android App

2.2 OWNCLOUD (OPEN-SOURCE SOLUTION)

Google Drive was compared to a free, open-source alternative. In this case ownCloud was used. OwnCloud is a self-hosted file server. It allowed administrative control and file access through a web interface, as well as desktop clients for Windows, Mac and Linux and for Android and iOS for file access.

ownCloud offeed two versions of their software; the community edition and the enterprise edition. The community edition was free and the enterprise edition was subscription based, however the features added with the enterprise edition (such as migration assistance, SharePoint integration, Windows Network drive integration and a file firewall) were not necessarily essential for the current use case. (ownCloud, [no date]).

The data was organised in a hierarchical file structure (i.e. sub-folders and files within folders) and integrated seamlessly into the file system using the desktop clients. For example, the Windows client can be seen in *Figure 3* below, the Linux client in *Figure 4,* the web interface in *Figure 5* and the same files and folders visible in the Android app in *Figure 6.*

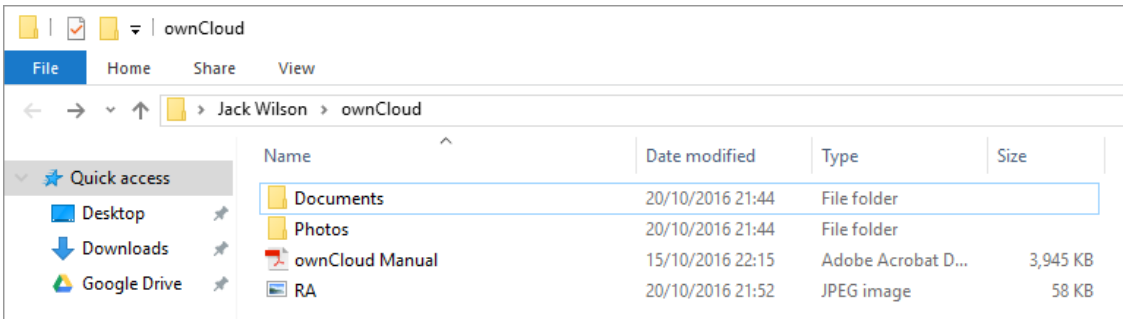

Figure 3: ownCloud Windows Desktop Client

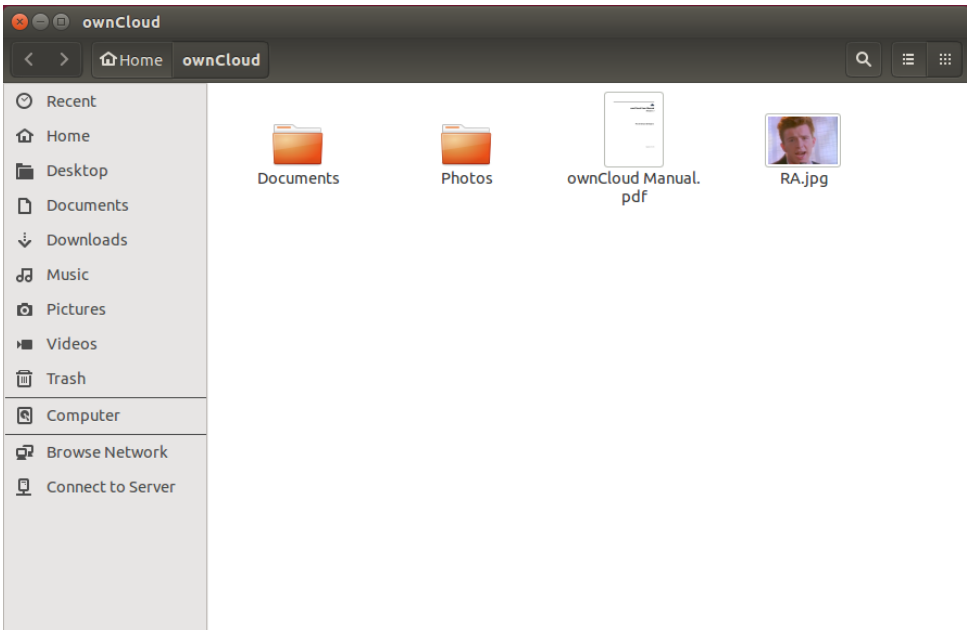

Figure 4: ownCloud Linux Desktop Client

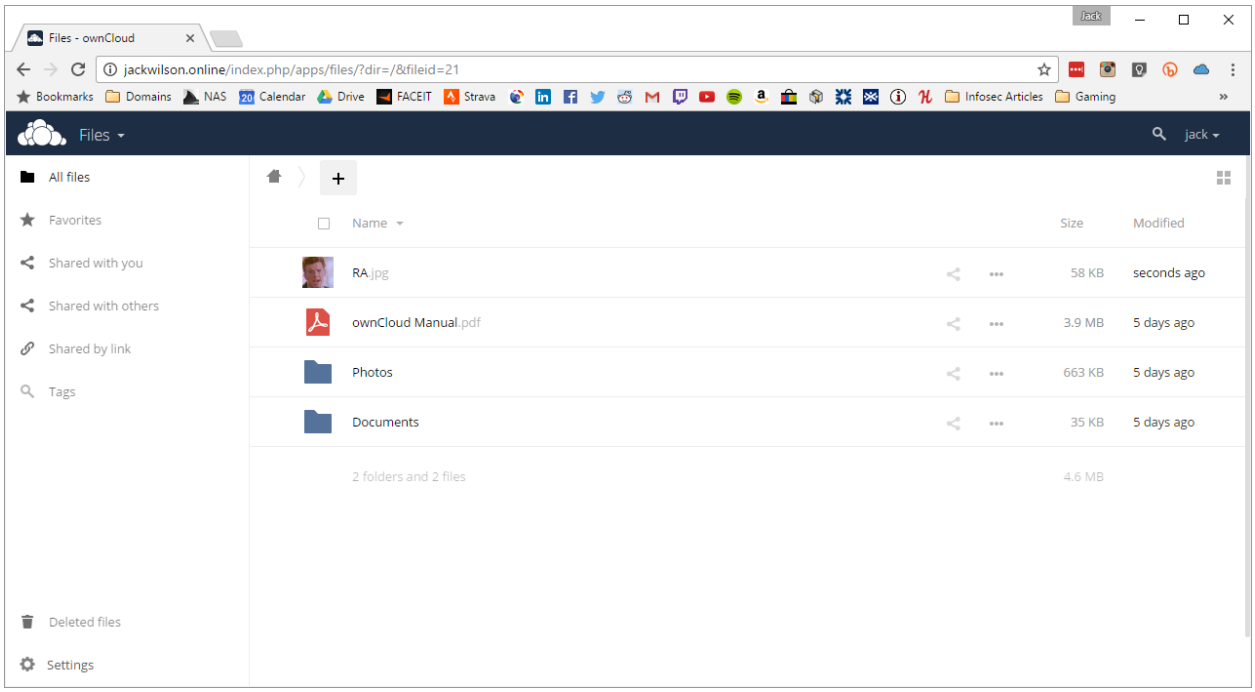

Figure 5: ownCloud Web Interface

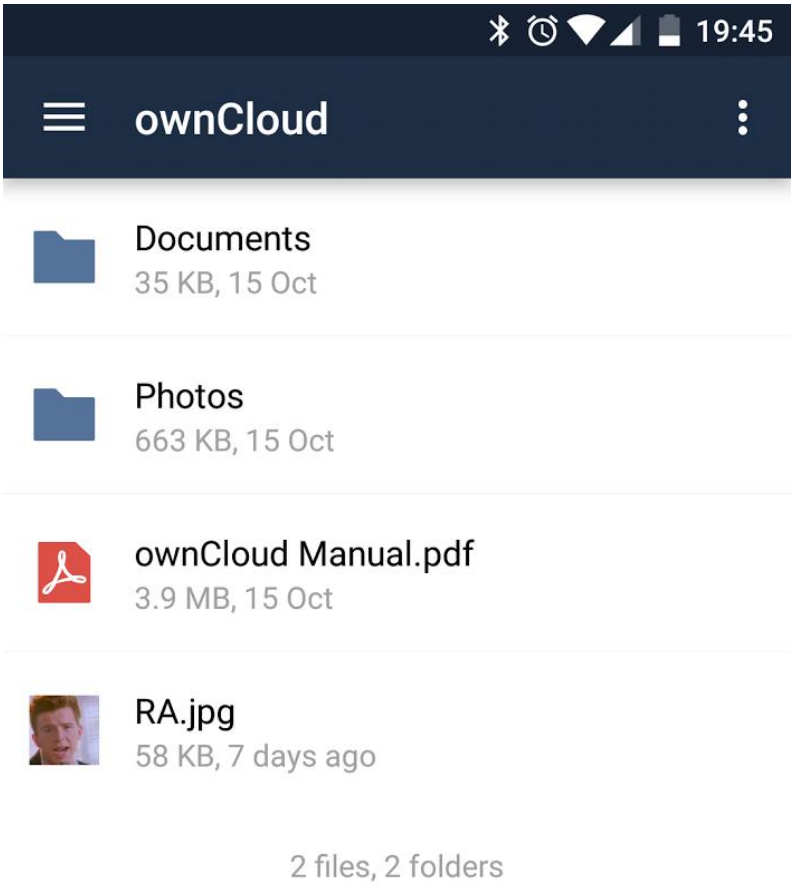

Figure 6: Android App Interface

2.2.1 Admin Settings Page

The administrative portal for ownCloud covered almost every base required by an administrator in a simple to navigate web-based GUI that can be previewed in *Figure 7,* below.

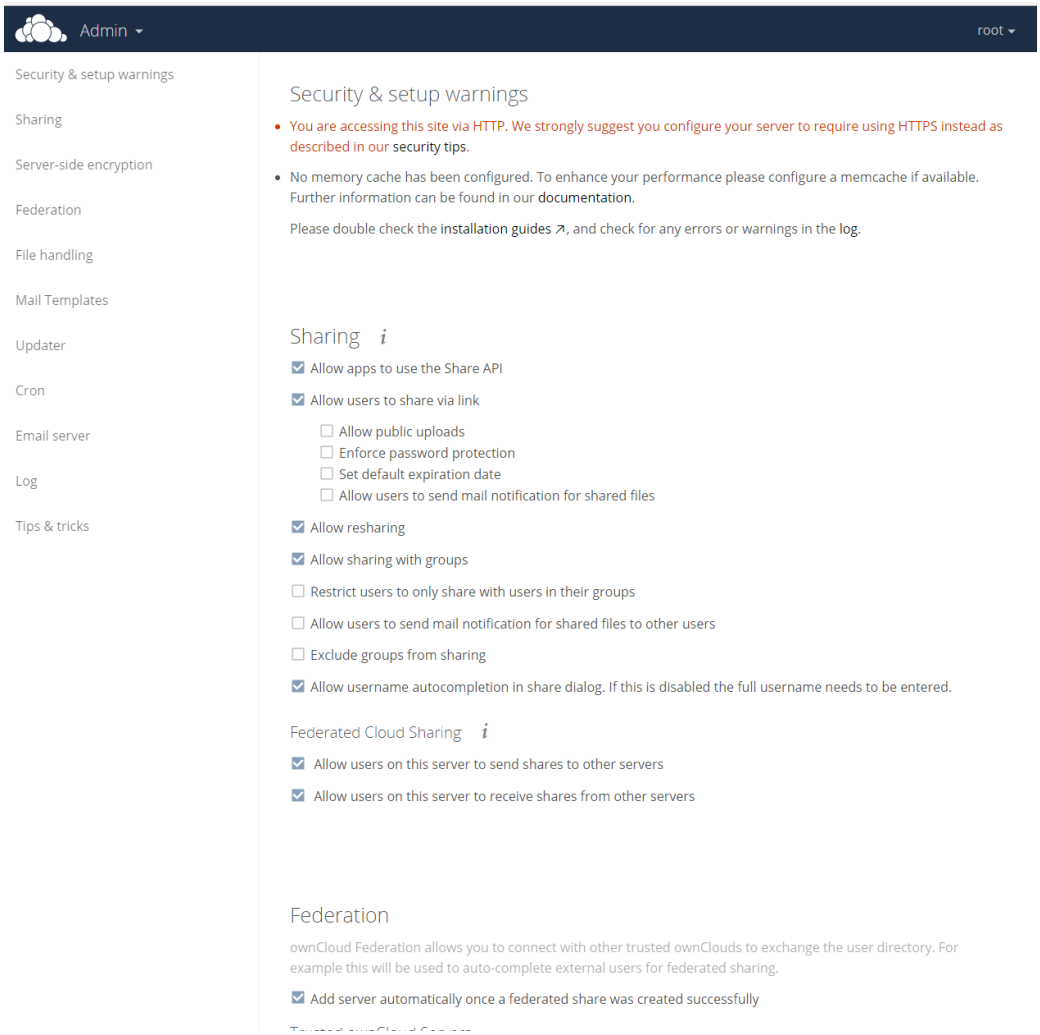

Figure 7: ownCloud Admin Portal

Security and Setup Warnings

The first item offered was some warnings about the configuration of ownCloud. In the case shown in *Figure 7*, it was recommended that support for HTTPS was added to the website to encrypt all data travelling to and from the server (such as usernames and passwords) to prevent man-in-the-middle attacks. OwnCloud also recommended setting up memory caching to improve performance and referred to the official documentation for a guide on setting up caching.

Sharing

The next bunch of settings were for the management of file sharing. OwnCloud files could either be shared by a link, or by entering a specific username of a user who had access to the server. This area of settings managed how widely files could be shared: files can be set to only be shareable within the creator's group (e.g. a sales team may be in a group), sharing links could

also be password protected for additional security and users could also be notified via email that a file had been shared with them (although this required connecting ownCloud to an external mail server).

File Handling

Maximum file sizes could be set to, for example, stop a user filling uploading unnecessary, large files to a server and eating into critical space. OwnCloud was focused on making management as simple as possible, and this settings ease of adjustability can be previewed in *Figure 8.*

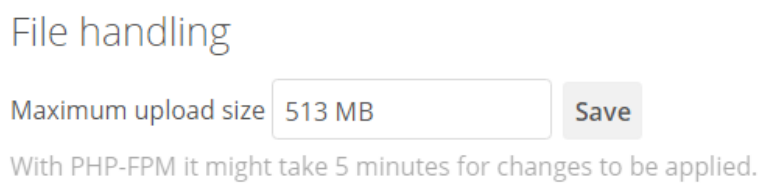

Figure 8: Maximum File Upload Size Interface

Mail Templates

ownCloud included some basic templates for sending emails. These templates required some tweaking to adjust variables such as usernames and URL's within the email, however they were simply there as a basic template, and custom templates could be imported. The pre-installed templates can be viewed in *Figure 9* and the example HTML output for a new user email can be previewed in *Figure 10.*

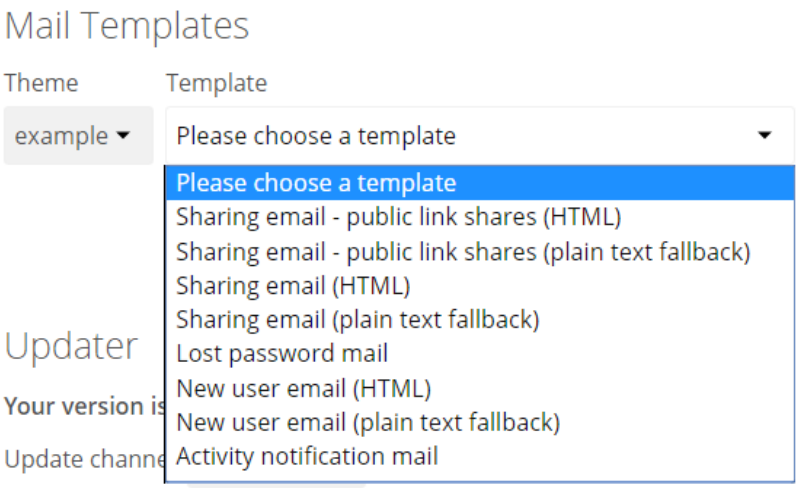

Figure 9: Pre-Installed Mail Templates

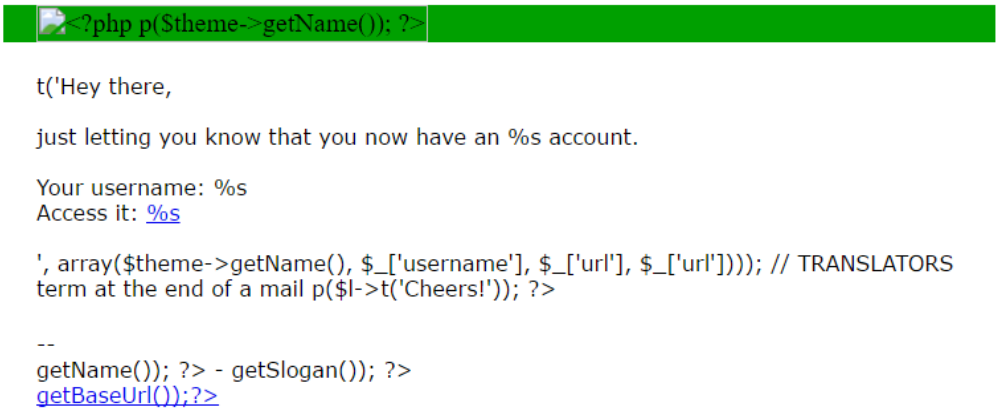

Figure 10: New User Email Template

Updater

This set of options was for updating the version of ownCloud. There were a few different options for updating: stable, daily, beta and production. Groups could also be specified to send notifications to about available updates.

Cron

This setting allowed for adding "cron jobs" which are automated tasks that require no user interaction. The cron jobs were typically bash scripts that are executed routinely (e.g. once per hour or on a specified date like the first of every month).

The default cron scheduler was AJAX which was built-in to ownCloud and triggered every time a user visited the ownCloud page. Options for third-party services such as Webcron were also present that offered more flexibility but required additional configuration to get the scripts running on a regular basis. (ownCloud, [no date]).

Server-Side Encryption

OwnCloud can encrypt files both locally and on remote servers. This option allows the administrator to encrypt files before sending them to a third-party connected storage service. (ownCloud, [no date]).

Email Server

This setting allowed for automated emails to be sent out to users to notify of activity such as share creation and for the purposes of password resets (e.g. using the examples shown in the above *Mail Templates* section). OwnCloud does not act as a fully functioning mail server, instead it could connect to a pre-existing mail server using PHP or SMTP. (ownCloud, [no date]).

Log

Logging in ownCloud allowed for the admin to monitor interesting activity on the ownCloud server, from failed access attempts to errors that occur. The very first time ownCloud was accessed via a domain (e.g. example.com) instead of directly by the server's public IP address,

this was detected by the logging system as a "Trusted domain error" and the administrator had to make a one-off approval that the domain was an approved way to access ownCloud. The administrator could also decide how much information ownCloud would log as shown in *Figure 11,* below.

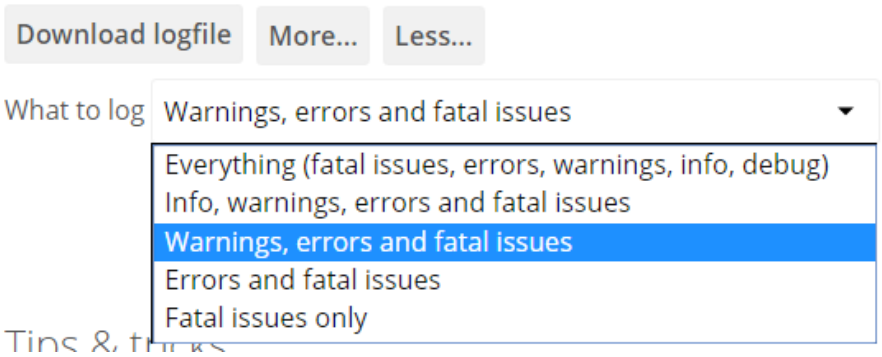

Figure 11: ownCloud Logging Options

Tips and Tricks

The final section of the admin portal offered some links to the official documentation for ownCloud covering some common areas an administrator may want to investigate after setting ownCloud up such as:

- Creating backups.
- Advanced monitoring.
- Performance tuning.
- Improving the configuration file (config.php).
- Adding graphical themes to ownCloud.
- Hardening and security guidance.

2.2.2 Users Settings Page

All of the above configuration settings were under the admin panel. There was a further page for managing users. The left panel (shown in *Figure 12,* below) was for managing groups. Multiple groups could be created and users could be part of multiple groups. One such example would be having groups for sales, technical support, development team, operations and management. This would not only restrict ownCloud admin access to certain groups, but would also allow file sharing within teams without having to share with a list of individual users.

From this page an administrator could also create new users, change user passwords and set a quota on a per-user basis to restrict how much storage space each user was allowed to use on the server.

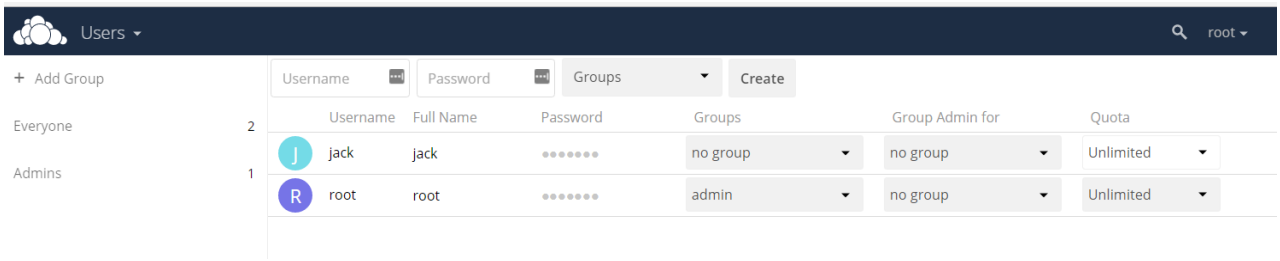

Figure 12: ownCloud User Management

2.2.3 Personal Settings Page

This settings page is available to every ownCloud user. It allows for modification of personal details such as name and email address, password resets and language preferences. There was also an area to view currently active sessions and remove them (useful if a user left a session logged in by accident) as shown in *Figure 13*.

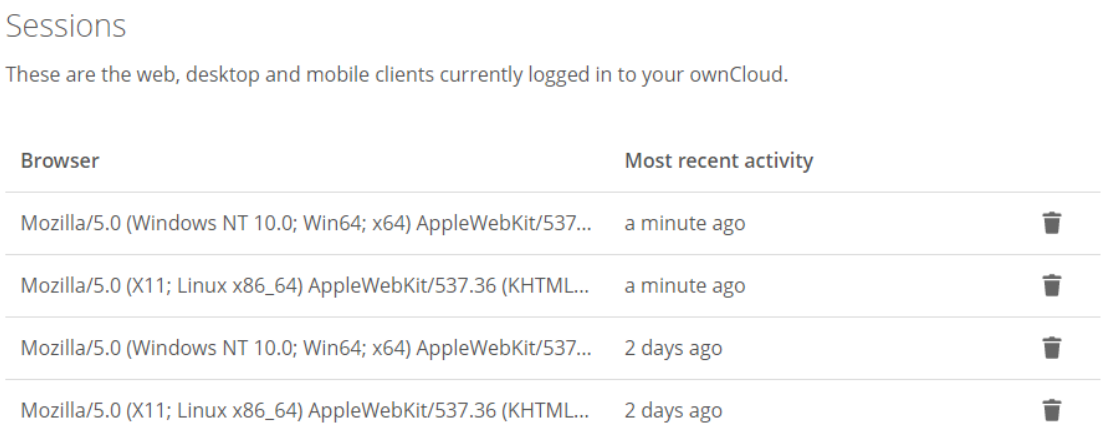

Figure 13: ownCloud Session Management

2.2.4 Reporting

OwnCloud did not have built-in reporting. However, with the product being open-source and supporting third-party plugins the community had written tools that would allow for user reporting. One such tool was called *Storage Usage/Activity Charts*. The plugin allowed for monitoring of several statistics including:

- Used space and free space on server.
- Data usage over the last month.
- Average data usage over several months.
- Monthly activity chart.

The plugin was available for both regular users and administrators, with regular users having the ability to monitor their own usage and administrators having the ability to monitor all of the above for every user. The plugin interface can be previewed in *Figure 14*. (ownCloud, 2014).

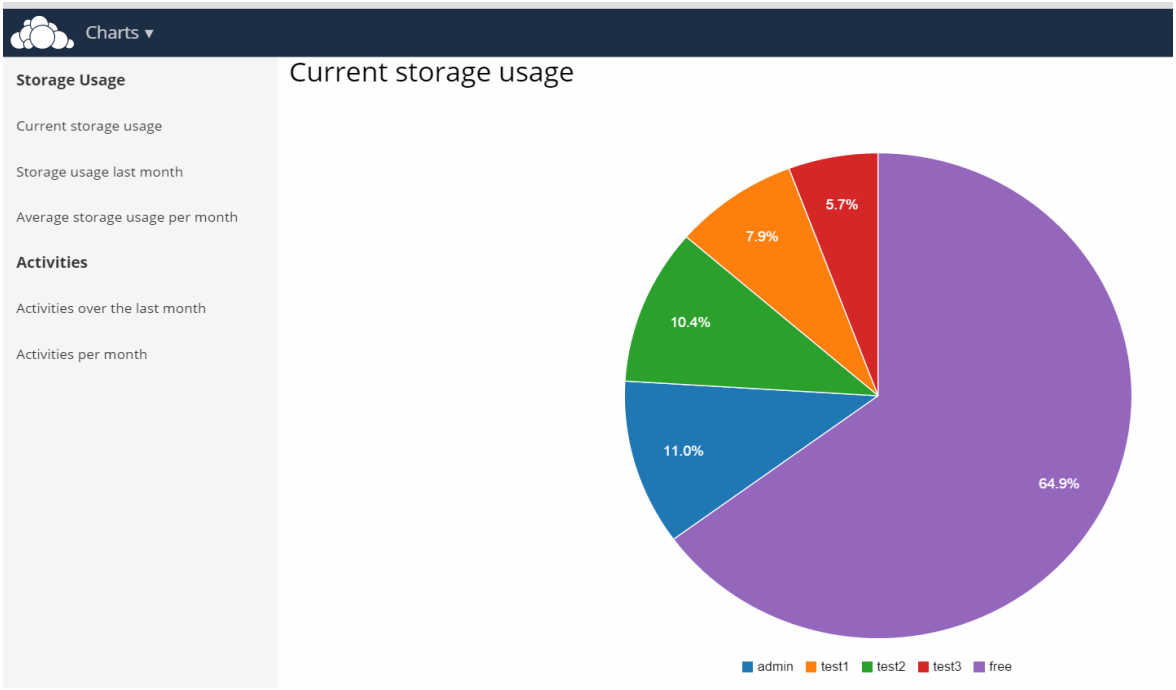

Figure 14: Storage Usage/Activity Charts Interface Example

3. DISCUSSION

3.1 BENEFITS OF COMMERCIAL SOLUTION

There are several benefits of a commercial service, but they in turn come at a cost. The most obvious benefit is the multitude of additional features that come on top of the storage space. The most substantial features include: managed email, website templates and 24/7 support in case of any problems or questions. All server-side activity is also managed by the provider, meaning a business can leave the commercial service responsible for keeping systems up-to-date and managing, for example, SSL certificates and hardware failure.

Offloading the storage to a third-party also allows for some environmental benefits within an office. Not only is no space required to accommodate for a file server, the lack of server will reduce heat, noise and the company's electricity usage. Another additional benefit of G Suite is that management is available from a dedicated mobile app. Doing this on ownCloud would require accessing the management through a mobile browser.

3.2 BENEFITS OF OPEN-SOURCE SOLUTION

The first benefit of ownCloud is in the title. Open-source. This allows for anyone to develop their own add-ons to the service to add additional functionality. One such example is called "Checksum". (ownCloud, 2013). The add-on generates MD5 hashes for files stored within ownCloud, and displays them in the web interface. The hash can be compared to the downloaded file's hash to ensure no tampering has taken place. (GHacks, 2009). The non-commercial version of ownCloud is also free to use, and installed on Ubuntu (which is recommended) is also free, so no licenses are required for software or operating systems.

Furthermore, self-hosting allows for full control over the files and the server. The company can set their own firewall rules, keep the data encrypted, properly practice security procedures as-per their policy, control maintenance and backup schedules. (Claromentis, 2016).

3.3 COST ESTIMATES

The costs for an example business (with 50 employees and 10TB of storage) can be calculated as follows:

G Suite

£6.60 per person per month x 50 employees x 12 months

£3960 per year

Over 5 years (assuming no change in Google pricing): £19,800

ownCloud

5TB Western Digital Red Hard Drive = £165

4x5TB = £660 (in RAID 10 allows for 10TB usable + redundancy)

Rest of server components: ~£340 (Intel Core i3 CPU, 16GB RAM, Motherboard, Case and Power Supply)

Power usage: ~£200 per year (Based on 152W power draw from server and UK average electricity cost of 15.37p/kWh. (Sust-IT, [no date]).

Over 5 years: £2000

There is a margin for error in the ownCloud cost calculation. Although equipment purchase cost and electricity is accounted for, the Total Cost of Ownership (TCO) is not fully considered. Maintenance, management and setup costs are not factored for, this will vary depending on the size of the environment, the time spent managing the server and salary of the system administrator(s), although TCO can be as much as five times the initial purchase cost of the equipment in a large-scale enterprise environment.

Furthermore, the cost does not factor in equipment failure. The hard drives come with a 3-year warranty from the manufacturer (Western Digital, [no date]), but it is hard to estimate the failure rate of equipment.

3.4 SECURING OWNCLOUD

3.4.1 HTTPS

OwnCloud comes with some recommendations to make the service more secure. The first, and most obvious is adding HTTPS support as mentioned previously. HTTPS encrypts all the traffic going to and from the server to prevent file, username and password theft. An SSL certificate could be added by applying to a certificate authority, some domain registrars such as 123-reg and GoDaddy sell SSL certificates. A free alternative to this would be *Let's Encrypt!*, which is a free certificate authority. The only downside to Let's Encrypt! is that certificates expire after 90 days; however, this could be countered by automating the certificate application process. (Let's Encrypt, [no date]).

3.4.2 Kernel Module

Security-Enhanced Linux (SELinux) is a kernel module that was originally developed by the NSA. (Debian, [no date]). Essentially, access to the file system by a service, program or user is denied by default and exceptions are added by the administrator. This means that if a user of the system (or a hacker) tries to access a file they do not have permission to they are denied and the action is logged for the administrator to review. The module may be tedious to set up, but for long-term security it may be beneficial. (CentOS, [no date]).

4. CONCLUSIONS

4.1 SUMMARY

To summarise briefly, each product has benefits and disadvantages. OwnCloud allows companies and users to keep control of their own data, develop add-ons and integrate third-party add-ons and requires no licensing for software but it requires a lot more time to set up, configure and manage. OwnCloud was also substantially cheaper to run based on the cost estimated in *Section 3.3*.

G Suite and Google Drive are very mature products with a simple interface for both users and administrators. It also offloads some work for administrators, no continuous work is required to keep the server up-to-date or to fix any issues, and if any issues were to arise 24/7 support is available.

As mentioned in the *Server-Side Encryption* section above, ownCloud can integrate with services such as Google Drive and Dropbox. This is done through the use of the Google Drive API. (ownCloud, [no date]). For the current business use-case scenario it is recommended to use ownCloud as the primary method of storage, meaning the data stays property of the company and use the built-in, encrypted, Google Drive integration to upload backups to Google's servers.

Not only is keeping off-site backups generally regarded as good practice in any environment, ownCloud has the ability to do this automatically and keep the backups encrypted so Google has no access to the data.

4.2 FUTURE WORK

Given additional time, more practical work would have been done on hardening ownCloud using the methods mentioned in *Section 3.4* to investigate how easy the recommendations were to implement. Furthermore, ownCloud could have been connected to a Google Drive account to investigate the effectiveness of the Google Drive API.

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6. APPENDICES

6.1 OWNCLOUD SETUP

For the purpose of this research ownCloud 9.1.1 is installed alongside Apache web server on Ubuntu 15.10. (IT Tutorials, 2016). First ensure the repositories and distribution of Linux are up-to-date:

sudo apt-get update

sudo apt-get upgrade

sudo apt-get dist-upgrade

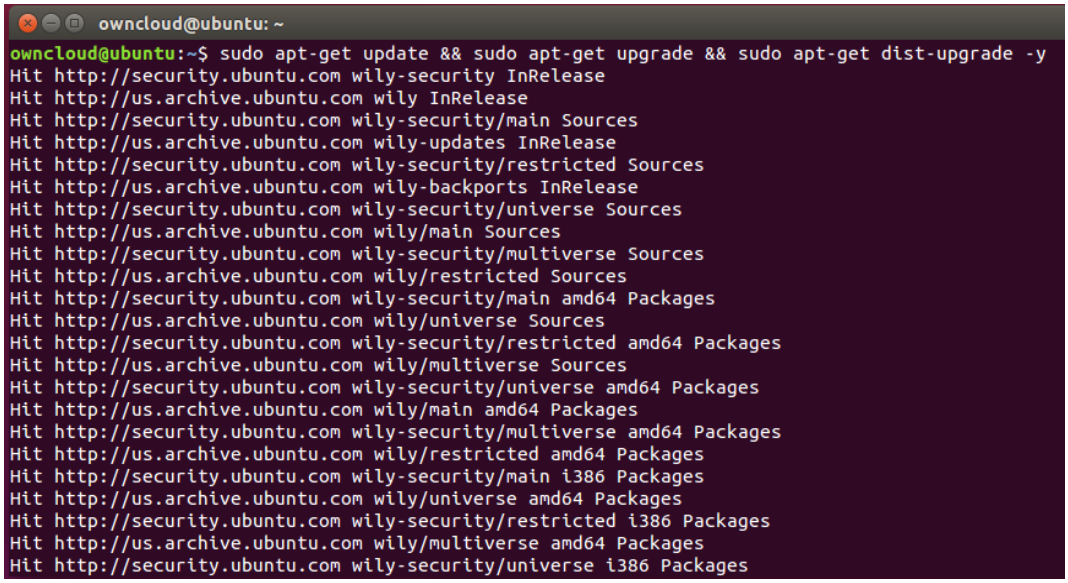

Figure 15: Updating Ubuntu Installation

Set server's IP address to static to ensure it never changes. Install tasksel, which is a custom installer used to install the LAMP stack. The LAMP stack is a web platform that includes utilities such as Apache and MySQL. (Turnkey Linux, 2016).

sudo apt-get install tasksel

sudo tasksel install lamp-server

The above command will immediately open the GUI (shown in *Figure 16)* for installing the LAMP stack. It will also set up a MySQL database automatically and request a password for the root user of the database. Enter a password and confirm it.

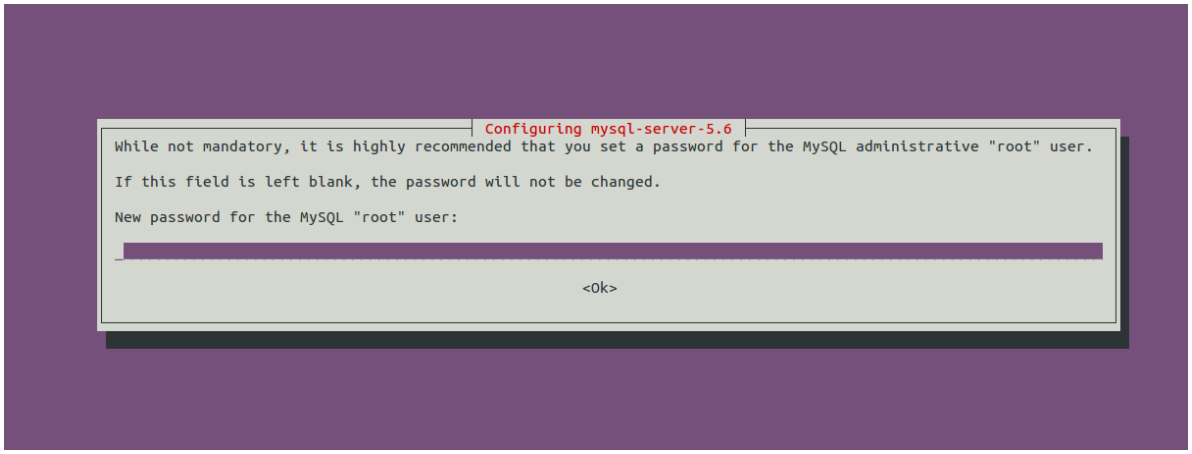

Figure 16: MySQL Database Setup

The default maximum file size for uploading is 2 megabytes. This can (optionally) be increased by editing *upload_max_filesize* variable the php.ini file as shown in *Figure 17*.

sudo nano /etc/php5/apache2/php.ini

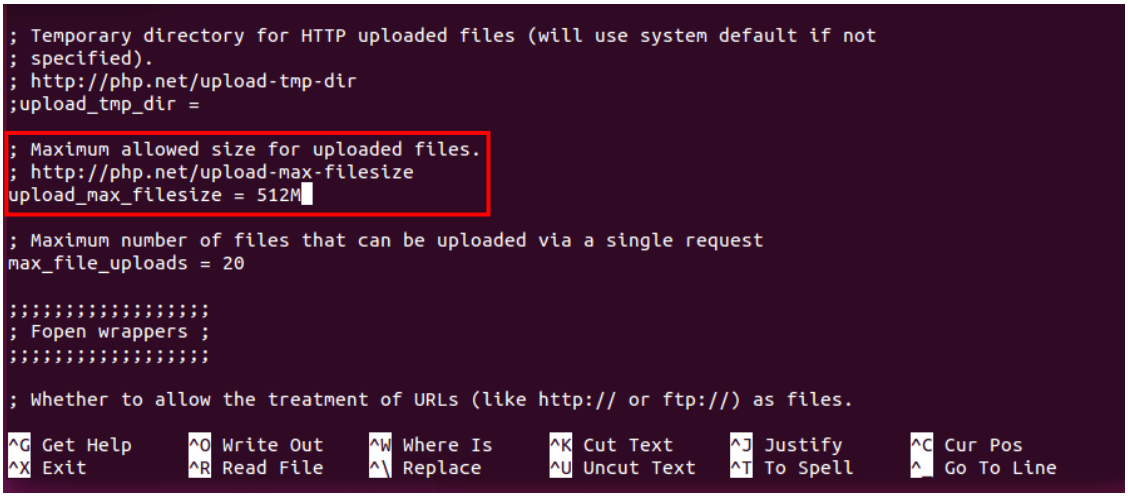

Figure 17: Maximum File Upload Option

The MySQL database set up a few steps ago now needs set up with user(s). Enter the following command to enter the MySQL shell:

Mysql -u root -p

Create a database for the users, replace <database name> with your chosen database name. I called the database ‘owncloud’. The example database setup can be previewed in *Figure 18*.

CREATE DATABASE <database name>;

Create user(s) so they can log in to the ownCloud web interface. Replace <username> and <password> below with the user(s) you wish to create and set passwords. After this give the user(s) full permissions in the database.

CREATE USER ‘<username>’@’localhost’ IDENTIFIED BY ‘<password>’;

GRANT ALL PRIVILEGES ON <database name>. TO '<username>'@'localhost';*

FLUSH PRIVILEGES;

The database has now been configured. Exit the MySQL shell.

Exit

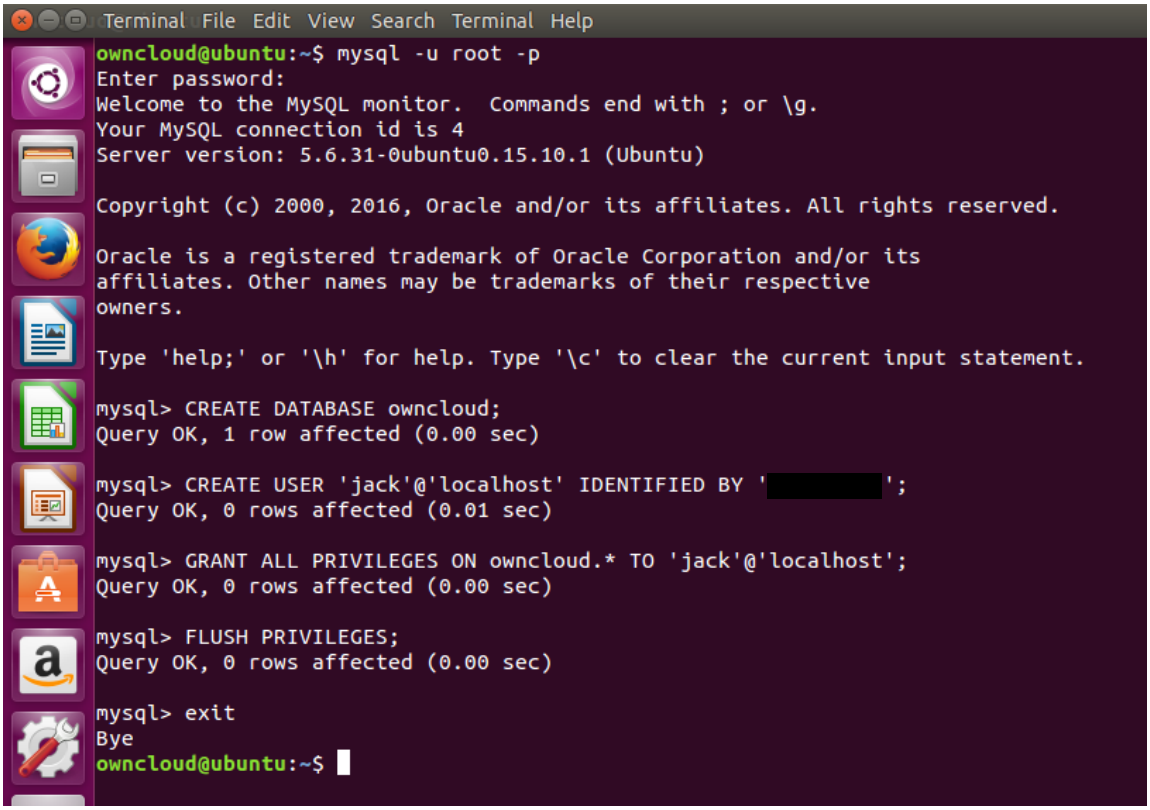

Figure 18: MySQL Configuration

Download ownCloud from owncloud.org (Download available from https://owncloud.org/install/) and unzip the .zip file.

sudo unzip owncloud-9.1.1.zip

Move the ownCloud files to the WWW web directory so Apache can find them.

sudo mv owncloud /var/www

Make apache the owner of the directory so it has permissions to access and edit the files.

sudo chown -R www-data:www-data /var/www/owncloud

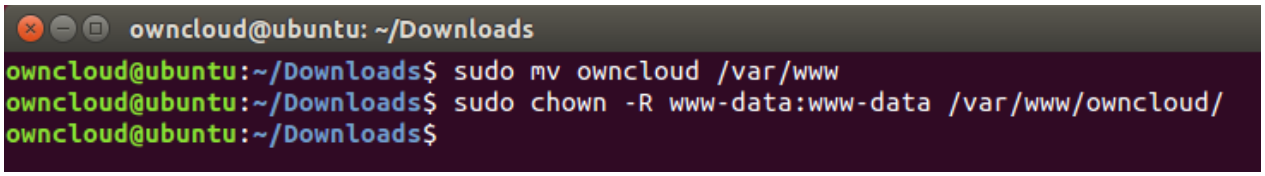

Figure 19: Moving ownCloud and Changing Ownership

Edit the apache virtual host file to tell apache to point to the ownCloud directory. This means, for example, the default Apache landing page will be replaced with the ownCloud landing page.

sudo nano /etc/apache2/sites-available/000-default.conf

Change the DocumentRoot within the configuration file to:

DocumentRoot /var/www/owncloud

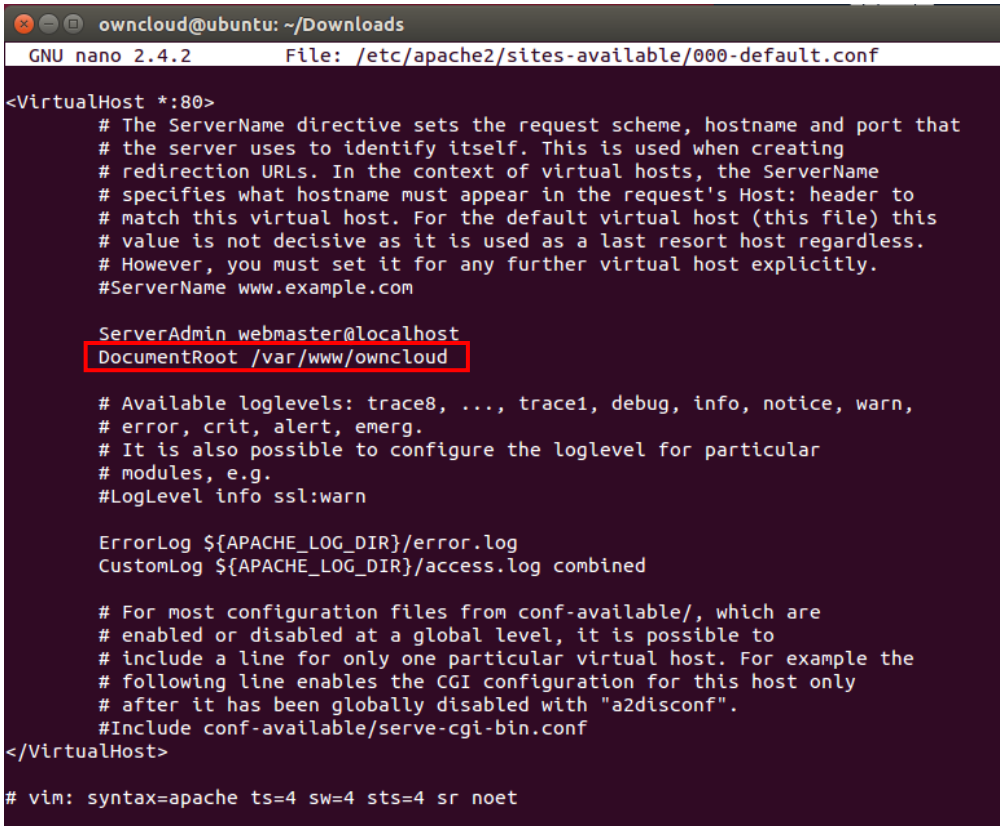

Figure 20: Changing Document Root Within VirtualHosts File

Some additional PHP modules (that include a graphics library and a library for getting files from a HTTP server) that were not included with the LAMP stack are required for ownCloud to work must be installed.

sudo apt-get install php5-gd && sudo apt-get install php5-curl

Restart the Apache service to make the changes take effect.

sudo service Apache2 restart

```
owncloud@ubuntu: ~/Downloads
owncloud@ubuntu:~/Downloads$ sudo apt-get install php5-gd && sudo apt-get install php5-curl && sudo service apache2 restart
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libntdb1 python-ntdb
Use 'apt-get autoremove' to remove them.
The following NEW packages will be installed:
  php5-gd
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 29.0 kB of archives.
After this operation, 136 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ wily-updates/main php5-gd amd64 5.6.11+dfsg-1ubuntu3.4 [29.0 kB]
Fetched 29.0 kB in 0s (95.8 kB/s)
Selecting previously unselected package php5-gd.
(Reading database ... 208267 files and directories currently installed.)
Preparing to unpack .../php5-gd_5.6.11+dfsg-1ubuntu3.4_amd64.deb ...
Unpacking php5-gd (5.6.11+dfsg-1ubuntu3.4) ...
Processing triggers for libapache2-mod-php5 (5.6.11+dfsg-1ubuntu3.4) ...
Setting up php5-gd (5.6.11+dfsg-1ubuntu3.4) ...

Creating config file /etc/php5/mods-available/gd.ini with new version
php5_invoke: Enable module gd for cli SAPI
php5_invoke: Enable module gd for apache2 SAPI
Processing triggers for libapache2-mod-php5 (5.6.11+dfsg-1ubuntu3.4) ...
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libntdb1 python-ntdb
Use 'apt-get autoremove' to remove them.
The following NEW packages will be installed:
  php5-curl
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 27.8 kB of archives.
After this operation, 112 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ wily-updates/main php5-curl amd64 5.6.11+dfsg-1ubuntu3.4 [27.8 kB]
Fetched 27.8 kB in 0s (93.1 kB/s)
Selecting previously unselected package php5-curl.
(Reading database ... 208274 files and directories currently installed.)
```

Figure 21: Acquiring Additional Modules

Navigating to http://*127.0.0.1* in a browser window shows the ownCloud setup page. Login using *root* username and the respective password created during setup. The data folder should remain unchanged in this case. The database user was previously created. In this case the user is jack and the respective password associated with that user account. The database name was also set earlier, in this case *owncloud.* See *Figure 22* for an example.

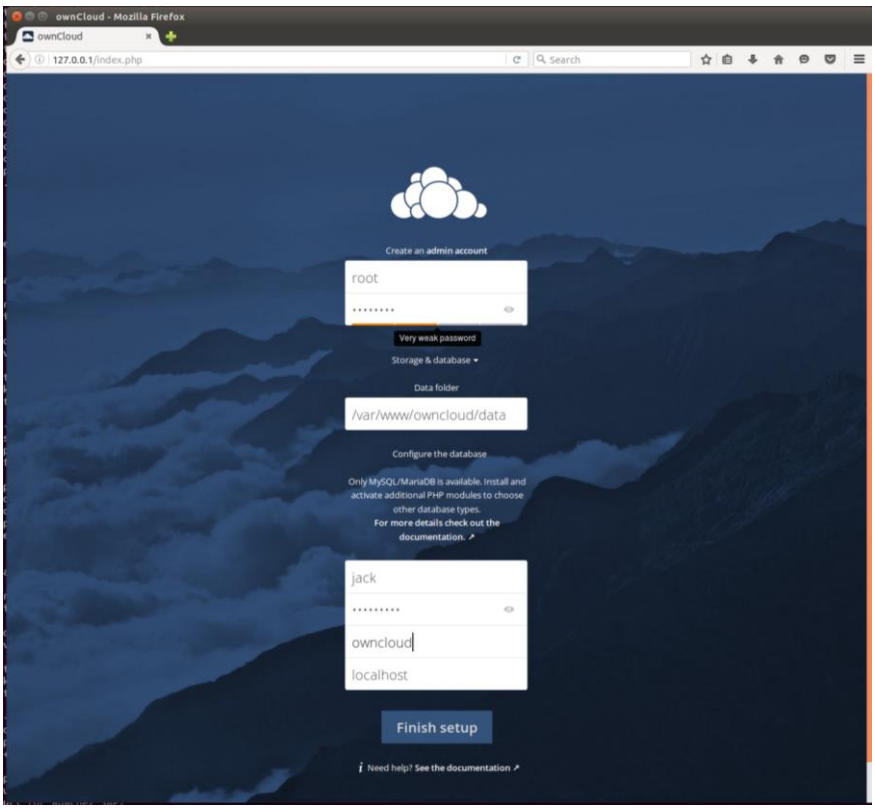

Figure 22: ownCloud Start Page

At this point ownCloud is essentially up and running and you are presented with the web interface visible in *Figure 23*. The test network required port-forwarding so that all traffic on port 80 was being forwarded to the local IP address associated with the ownCloud server. This process may vary on a per-router basis. If the server is being set up on a Virtual Private Server (VPS), port-forwarding is not required.

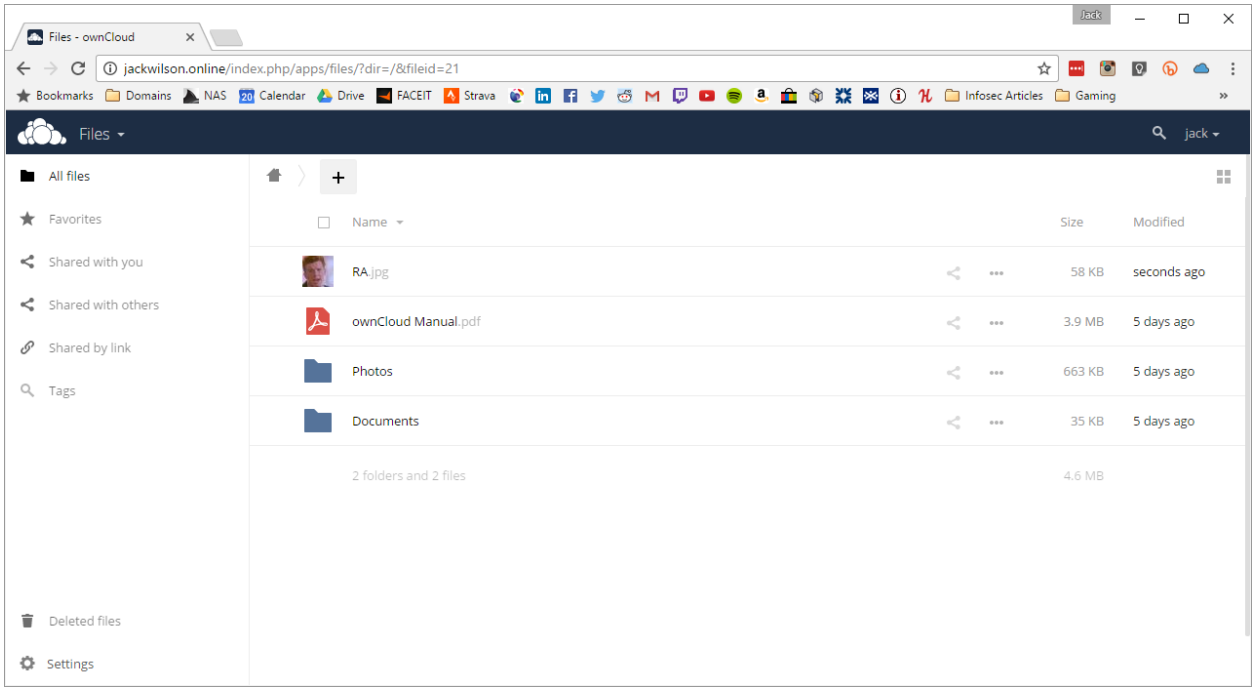

Figure 23: ownCloud Web Interface

The server can be accessed through the public IP address of the server's network, however adding a domain name improves the user experience.

To associate a domain name with the server, firstly, update the A record on the domain registrar's website to match the public IP address of the network. (AskUbuntu, 2012).

Edit the configuration file */etc/apache2/sites-available/000-default.conf*, uncomment the *ServerName* variable by removing the # and edit it as shown below, replacing *www.example.com* with your domain. These changes can be viewed in *Figure 23*.

ServerName www.example.com

While in the configuration file, several lines also must be added to fix a warning about files being accessible from the internet:

<Directory /var/www/owncloud>Options FollowSymLinks

AllowOverride All

Order allow,deny

allow from all

</Directory>

The above changes can be seen in *Figure 24* below:

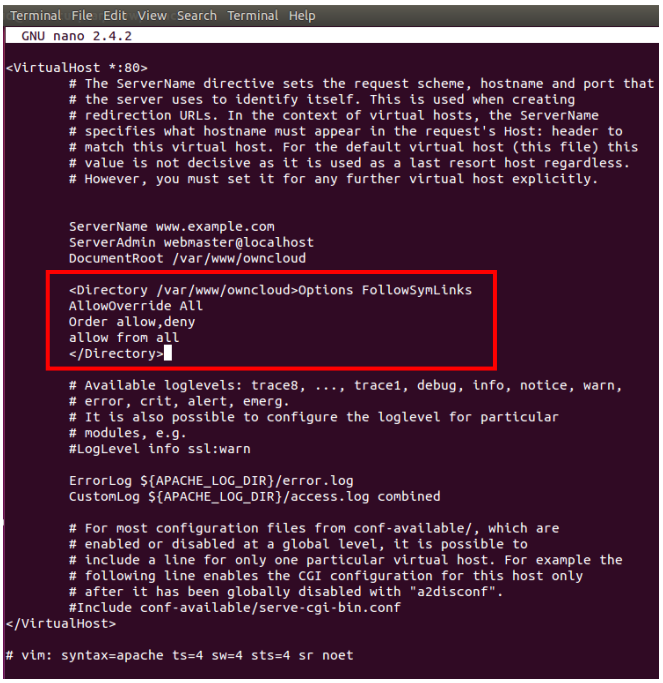

Figure 24: Virtual Hosts File Changes