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Senior Project Report

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Creating a Cloud Storage using Raspberry Pi

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Abstract

The integration of cloud computing has led to the creations of many online services. One in particular relies on the topic surrounding personal storing of online data and information. This report will discuss more on the topics of cloud computing and its importance in the current generation. In addition, this report will provide an brief rundown on the cloud's history, analyzing its benefits and drawbacks, and deliver an informal instruction on how to setup up your own personal cloud storage by using a Raspberry Pi circuit board and an open-source software called Nextcloud. I hope you find this report useful.

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Finally, I would like to thank my family for raising me into the person I have become today. To my mother, Mayrian Mao, father, Map Mao, brother, Christian Mao, my dogs, Shadow and Coco, and the rest of my dominate family, there were times in the past that we can no longer forget nor change. Nevertheless, as I move forward to the future, I will make sure to turn these moments into life lessons, to myself and the world around me. Thank you.

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1. Introduction

1.1 Purpose

The purpose of this senior project is to bring awareness to the importance of cloud computing and to showcase alternative methods in keeping your files safe and secured. People often overlook the concept of security when it comes to cloud storages. When we store files onto third party services such as Google Drive, Dropbox, or iCloud, we are not sure where they are being located or sent. As we continue through the report, I will demonstrate how simple and accessible it is to create your own personal cloud storage.

1.2 Goals

My main goal is to have a working and fully-functional personal cloud storage server that can be used within and outside of the network in order to upload files. Refer to the Requirements section for more information on the equipment used. Along with that, I seek to share my research on cloud computing ranging from third-party providers to the pros and cons in order to give readers the awareness. Refer to the Background section for more information. Lastly, I hope by creating this project I can contribute to society by showcasing peers the security aspects of cloud servicing.

1.3 Motivation

Before selecting this topic, I was interested in the studies of cloud computing and storages. One factor of motivation is to seek more information on the cloud in order to increase my knowledge of the study. As technology advances, the equipment changes. We can see many

businesses move away from physical storages to remotely storing information in an online server. Not to say every company will be running by the cloud. Though those in the Computer Technology field should have an proficient grasp on the topic. Another factor of motivation is my personal experience using third-party storages. As beneficial these applications and services are, they can be pretty pricey especially after their free trial which usually grants users a maximum of 5GB-15GB amounts of storage. I find it ridiculous to pay for services in order to increase your memory. Not to mention that third-party services like Google has some reputation in leaking data. In the process of creating my project, I am motivated to create my own storage that supplies a sufficient amount of memory space compared to third-parties, availability of security standards, and a trust in knowing where my data is being stored.

1.4 Contributions

I will contribute to the project by using the Raspberry Pi's terminal/command line in order to grab all of the information and resources needed to create the cloud storage server. In addition, I will conduct in-depth research on the studies of cloud storage services and provide my own perspective and commentary on the cloud. Through the courtesy of the Computer Science Department's trust, I will ensure that I am properly using every equipment I am borrowing in its efficient and safe state. At the end of the project, I wish to use this report to provide feedback on the current state of cloud computing issues for many individuals to read.

2. Background

2.1 What is a Cloud?

To start let us begin by explaining what exactly a “cloud” is. According to Google, cloud is a “visible mass of condensed water vapor floating in the atmosphere, typically high above the ground.” Of course, in the computer field the concept of their “cloud” is completely different. Described from Microsoft Azure’s definition of the “cloud”, it is “not a physical entity, but instead is a vast network of remote servers around the globe which are hooked together and meant to operate as a single ecosystem” [9]. Essentially, the “cloud” is a collective group of hosts that has the capabilities to do various activities including the ability to store data, run applications, and deliver content such as streaming movies, shows, or music. Imagine that you do not need to buy the CD of your favorite band and instead download it from a streaming service. That concept is what the “cloud” is all about; the idea that these files, data, or information is available on your fingertips thanks to remote accessing rather than physical storage.

Contrasting from cloud, the definition cloud computing, according to Microsoft Azure, is the “delivery of computing services – including servers, storage, databases, networking, software, analytics, and intelligence – over the Internet”. There are different methods in deploying cloud resources. In the following subsections, I will go over each one and their capabilities.

2.1.1 Public

Public clouds refers to the cloud deployment in which resources and services are owned and operated by third-party cloud service providers over the Internet. This is a common deployment used as services may be free or cost for a reasonable low price. Public clouds gains access to the common applications such as web-based emails, applications, and of course, storages.

Advantages include high scalability, flexibility, and low costs. While you do get access to many cloud computing components, you are still sharing the same hardware, storage, and network devices with other organizations during a public deployment.

2.1.2 Private

Private cloud refers to the cloud computing services and resources used solely for a single company. They can be physically located on the company's on-site datacenter or hosted by a third-party service provider. Unlike public cloud, private clouds are maintained on a private network and the hardware and software used are specifically made for that one organization. Advantages of private clouds includes high scalability, efficiency, and security. However, deploying such method can often cost a lot. Along with that, security measures are great however not everyone in the company may have a hard time getting used to it. Remember, too much security is not good security. It is all about balance.

2.1.3 Hybrid

Hybrid clouds are essentially a mixture between the public and private clouds. Sharing components from both methods, hybrid clouds are orchestrated as an integrated infrastructure environment that allows applications and data to be shared between the two cloud deployments. The advantages is that you get the best of both worlds with the two cloud methods as they give you greater flexibility, scalability, reliability, and security options. However performing such feat can get expensive. Infrastructure of deployment can become quite complexed and can lose focus of the organization's direct control.

2.2 History of Cloud Computing

According to Keith D. Foote's article on the history of cloud computing, cloud computing is said to exist since the 1960s [2]. Cloud computing had its roots traced back to 1963 when an MIT funding campaign for a “computer to be used by two or more people, simultaneously” was issued. The requirement was around \$2 million and this gigantic computer made with magnetic tapes for memory was said to be the precursor to what has now become cloud computing. The word “virtualization” was used to describe the situation, but would later expand in its definition years ahead.

In 1969, psychologist and computer scientist J.C.R Licklider aided in the development of the ARPANET (Advanced Research Projects Agency Network), which was an old version of the Internet. Licklider promoted a vision titled the Intergalactic Computer Network where everyone in the world would be interconnected through computers and the accessibility of information would be common.

The term “virtualization” began to shift its meaning during the 1970s. During this time, virtualization describes the creation of a virtual machine, which acts as a real computer on an already existing operating system. Virtual computers become popular in the 1990s thus leading to the development of the modern cloud computing infrastructure.

During the late 1990s, the ideal of the cloud has become popular among companies who wish to gain a better understanding of its services and usefulness. For example in 1999, Salesforce successfully used the capabilities of cloud computing by using the Internet to deliver software programs to the end users. Programs can be accessed and downloaded by anyone with Internet access.

In 2002, Amazon introduced its web-based retail services. It was the first major business to effectively used the Cloud Computing Infrastructure Model, giving them the flexibility to use their computer's capacity much more efficiently. Following in 2006, Amazon continued the cloud trend by releasing Amazon Web Services, which offers a variety of online services to websites or clients. One of the service was the Elastic Compute Cloud (EC2), which allowed users to rent virtual computers and use their own programs and applications. Another service was the Amazon Mechanical Turk, which provided a variety of cloud-based services like storage, computation, and human intelligence.

In 2008, NASA's OpenNebula program provided the first open-source software for deploying Private and Hybrid Clouds. Most of the features were focused on major businesses, but was a huge step for making the software open-sourced.

As we step forth into the future, we can see many companies joining in on the cloud craze. In 2011, many cloud-based moments were made: IBM created their IBM SmartCloud framework, Apple launched their iCloud storage service, Microsoft brought awareness to the cloud's abilities of storing photos and videos with ease. And lastly, Oracle announced their Oracle Cloud in 2012 which offered the three services for businesses, which will be covered in the next section. What can we expect for the future of clouds? With all of the news surrounding hacking and data leaking, the talk of keeping the cloud secured will be a prominent feature and discussion for times to come. For now, it is up to us to decide how we would like to expand and grow the cloud.

2.3 Types of Cloud Services

A cloud service is defined as “any service made available to users on demand via the Internet from a cloud computing provider's servers as opposed to being provided from a company's own on-premises servers” [1]. In other words, services can be accessed anytime, anywhere through the Internet. There are three types of public cloud services which are IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service). Comparing the three services together is often referred to as the cloud computing stack (see fig. 1). In the following subsections, I will describe each service and see how each one differs in the aid of cloud computing.

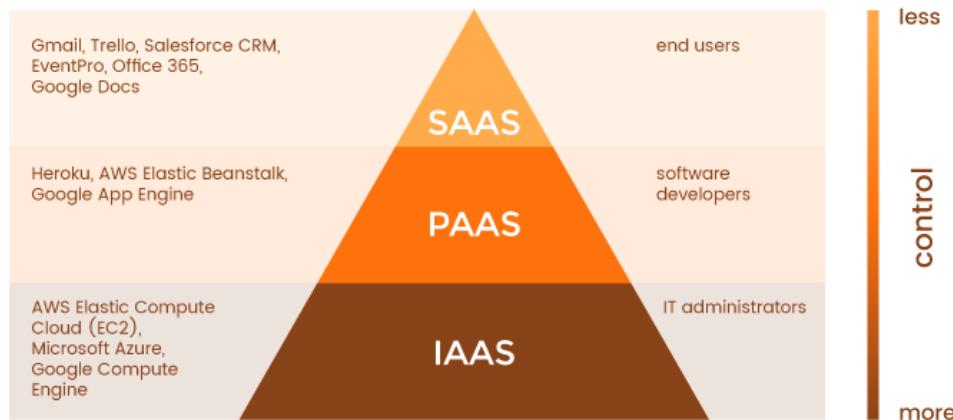


Fig.1: Cloud Services hierarchy diagram. dGraph from Gleb B [1], Choosing the Right Cloud Service: IaaS, PaaS, or SaaS. 8 August 2017. Web. 20 March 2019.

2.3.1 *Infrastructure as a Service (IaaS)*

Infrastructure as a Service is the most basic category. This concept essentially allows an organization to rent out the IT infrastructure from a public cloud provider. In other words, it enables an organization to have a virtualized infrastructure. This means that the service provider maintains and manages this infrastructure for you. Some of the infrastructure that can be rented

are things like servers, storages, networks, and operating systems. There are quite some benefits when using this service, such as not having to worry about managing or maintaining physical servers or database infrastructure and improving business continuity and disaster recovery.

However some disadvantages is that IaaS can be more expensive than the other two and that issues on management of your virtual machine are your responsibility. Some examples of IaaS are AWS (Amazon Web Services) and Microsoft Azure.

2.3.2 Platform as a Service (PaaS)

Platform as a Service is more of a deployment environment. PaaS allows developers to solely focus on developing or managing applications while the service providers focuses on maintaining the servers, storage, and networking infrastructure. PaaS is very similar to what IaaS is except that PaaS provides development tools and database management systems. In addition, PaaS supports the complete application lifecycle. This allows you to build, test, deploy, manage and update all within the same environment. Just like IaaS, this is also a pay as you go basis.

2.3.3 Software as a Service (SaaS)

Software as a Service allows software applications to be used over the internet rather than locally. In order words, a third-party provider host the application and makes it accessible for users over the internet. It often does not require clients to download and install on their computers as they are usually accessible through an online web-browser. This service manages all the infrastructure, middleware, and any potential technical issues within this service.

Advantages of this service include eliminating the need for IT staff to manually do updates and patch management. It also reduces time to do tedious task such as installing, managing, and upgrading software. In addition, the biggest advantage to using SaaS is its accessibility. With the

software application being on the cloud, any client can access the data from any internet-connected device. Some of the most popular examples of SaaS are Office365, Adobe Creative Cloud, DropBox, and Google G Suite.

2.4 Cloud Storage Providers

There are many cloud-computing services offered around the world. Most notably, the availability of cloud storage providers sets a new wave in the digital world. As cloud storage providers grow, the need for physical storages becomes obsolete. However, each provider differs from one another in certain aspects. In this section, I will list some cloud storage providers, give a quick synopsis on their background, and discuss the pros and cons of each service.

2.4.1 *Google Drive*

Google Drive is a cloud-based storage service that allows users to store and access files on the cloud, rather than in their Hard Drives [6]. With this capability, users are able to view their files across multiple platforms such as tablets, mobile devices, and personal computers. To access google drive, a user must create or sign in with their Gmail account. Once signed, a user can create folder, documents, files, etc. and save them on the cloud. The ease of accessibility can definitely be beneficial to users that are not tech-savvy. As much as I really enjoy this service myself, I have noticed many downfalls. This includes having to pay for online storage after surpassing 15 GB of data. There is a monthly fee associated with this service if you need to have more than 15 GB of storage. One big concern that I feel that most consumers are not fully aware of is Google Drive's terms of services. For instance, it states, "When you upload, submit, store, send or receive content to or through Google Drive, you give Google a worldwide license to use, host, store, reproduce, modify, create derivative works." In other words, anything you upload

grants Google to access and keep the information. Google also states in their privacy policy that they may “retain data for limited periods when it needs to be kept for legitimate business or legal purposes.” I am skeptical on what they mean for businesses and wonder why they need to know our data in the first place. I find this very suspicious. However, despite these rules, many organizations, including our own university, uses Google services due to its ease of availability and access.

2.4.2 Dropbox

Dropbox is a service that allows users to store their files online, allowing their consumers to save space and share files quickly anytime, anywhere [8]. Similarly, to Google Drive, users are able to use only a chunk of memory (2GB) before switching to a paid subscription for more memory. The downfall with DropBox is that there are a lot of security issues that come into play. For example, DropBox uses 256-bit AES encryption and claims that client security is their highest priority. However, most users are unaware that DropBox has the power to decrypt all the files and can view them whenever they want to. While it is true that they use an encryption tunnel, which makes it hard for anyone to intercept, they have the decryption keys to view those files. DropBox has also claimed that if they wanted to disclose your data to a third party, they can willingly do so. They have the ability to decrypt your data and hand it over. This means that their employees have these decryption keys stored somewhere, which can possibly allow an employee to give out confidential information or higher risk of having an attacker attain these keys. Another factor is their account deletion policy. It states that while you can delete your account, it will take about 30 days to initiate. Other things to note: “(1) there might be some latency in deleting this information from our servers and back-up storage; and (2) we may retain

this information if necessary to comply with our legal obligations, resolve disputes, or enforce our agreements.” Does that mean that they can hold on to your information while your account is being deleted? Will they discard of the data after your account deletion?

2.4.3 iCloud

iCloud is a cloud storage and computing service that is owned by Apple Inc [5]. This service permits users to utilize their Internet services within an Apple account. A notable factor of iCloud enables its users to sync and store personal content and making it accessible from Apple’s compatible devices. Some of the data that is associated with the user’s personal content includes contact information, calendar syncing, photos and videos, notes and reminders taken, documents, applications downloaded and saved, and personal email. If iCloud is enabled on a device, the user’s content will automatically be sent to and stored by Apple for later accessibility. iCloud stores data within an encrypted format and uses secure tokens for authentication. Enabling two-factor authentication for extra security runs the end-to-end encryption process. iCloud uses a minimum of 128-bit AES encryption. Apple’s iCloud storage grants first-time users a minimum of 5GB of storage for free, with additional storage for payments. There were many incidents of privacy breaches coming from iCloud’s servers. For instance, there have been claims that a discovered flaw in the Apple servers allowed a user to view data from random iCloud accounts through knowing the associated phone number of the iCloud account [4]. Does syncing phone numbers with the cloud server increase the levels of security, or does it open more doors for intruders to sneak in?

2.5 Why Create Your Own Cloud Storage?

There are many reasons as to why you should create your own personal cloud storage. As mentioned from the previous section, some of these third-party providers may seem very suspicious with the way they handle data being saved to their service and the reception that they received due to questionable business practices. Nevertheless, just as there are pros to building your cloud storage, there will be some cons about the situation [7]. Again, it is all about balancing your way of keeping your cloud storage safe and secured. To end it off, I will be discussing the advantages and disadvantages when coming across your own cloud storage and accessing cloud storage in general.

2.5.1 Advantages of Cloud Storage

There are various advantages when choosing Cloud storage over physical storage. One of the biggest advantages is the ability to save on costs. By choosing to use this storage, one will save lots on operating costs than someone relying on in-house solutions or traditional hard drives. In addition to this, the ability for offsite-management is a plus. Offsite management is essentially having someone else physically maintain the data center. The benefit to this is that it allows the IT team to focus their attention on other priorities. In addition, probably the biggest pro about using cloud storage is its accessibility. The main reason why users switch to cloud storage is the ease of accessibility; access anytime, anywhere. This allows users to access all files in the cloud from any device in the world, of course as long as they have the correct credentials and a valid internet connection. In addition to your own cloud storage, you have complete control on the whole capabilities and storage. You are not dependent with a cloud servicer, so go all out and decide what you want to do and what you want to store.

2.5.2 Disadvantages of Cloud Storage

The biggest downfall to using cloud storage is the threat of security. Security is the biggest concern as the cloud grows because hackers are launching attacks that are more complex. When you sign up to use cloud storage, you are putting your data at risk. Breaches are always occurring against third-party cloud service providers, so when one chooses to sign up, they have to accept that they are vulnerable to attacks. Another big downfall using cloud storage is its dependency on an internet connection. What makes physical storages still reliable is that no internet connection is needed. However, with LTE services and the upcoming 5G coming to play for mobile carriers, internet access should be much more common. Of course, we would have to see it for ourselves. When it comes to your own cloud storage, definitely a huge con would have to be the difficulty in setting up one. But this is why we are here, to learn and try to develop one for ourselves. In the next chapter, I will discuss the requirements needed before moving on to our cloud storage development.

3. Requirements

3.1 Software Needed

To begin, an operating software is needed to boot up the Raspberry Pi. In this case, I will be using Raspbian, which is a Debian-based OS typically used on Raspberry Pi single boards. It is a free and open-source software that anyone can find and download for themselves. Images for the OS can be found on the official Raspbian website.

I will be using Nextcloud software. The reason I will be using this software is because it is an open source and free software. Unlike third-party services, this service packs in a personalized experience for your cloud, making it a much more private alternative. Some of the features that are available for Nextcloud are file storage, file sharing, full text search, folder sharing, PDF viewer, photo galleries, large file support, file access control, and file locking. Nextcloud is available for web clients, desktop clients (Windows, Mac, Linux), as well as on mobile devices and suites (Google Play Android and Apple App store).

3.2 Hardware Needed

The main component of my project is the Raspberry Pi 3 Model B. This model provides a newer and faster processor than previous version to increase its speed. Along with that, this model contains Wi-Fi and Bluetooth capabilities. It essentially is a credit card size circuit board that can be used for various projects, but for this project I will be using it to act as a cloud storage server. The single-board itself is only \$35, making it an inexpensive product. However purchasing the board does not come with keyboards, mice, cables, case, or memory, meaning that you would need to find those separately.

In that sense, I will have to purchase a Micro SD card so I can install the OS into the device. For only installing the OS on the SD card, I will be purchasing a 16GB card. Furthermore, I will be purchasing a case to protect the circuit board and a power supply which is 2.5A to power on the device. Lastly, and most importantly, I will need to buy an external storage device. External storages may be needed to provide additional memory space.

Luckily, I was able to borrow a previously used Raspberry Pi courtesy of the Computer Science Department, issued by Ken Leyba. My Raspberry Pi was preinstalled with the Rasbian operating software. In this case, I will touch only a little bit on how to obtain the Raspberry Pi OS. Supplies that was also given to me includes an Ethernet cable, power supply with an on/off switch, and a 16GB micro SD card.

4. Project Development

4.1 Hardware Setup

For this part, I will highlight the design and setup of my project. The equipment I will be using includes a Raspberry Pi model 3, 16GB micro SD card, power supply with on/off switch, monitor, keyboard, and mouse. I have decided that I will implement the cloud storage server through wireless connection (WiFi). In this case, I will exclude the need for an Ethernet cable. It is suggested to use a wired connection for this project, as it will provide users with a faster and stable experience; however, I would like to test out if the results remain the same with an alternative means of connection. In addition, the Raspberry Pi model 3 comes with WiFi and Bluetooth inbuilt within the board. I am also excluding the need for an external drive. While it is optional to mount a copy of the cloud data onto a separate USB or drive, I will not conduct this method.

The following figure displays my project design and sets as a visual representation on how I am conducting the project.

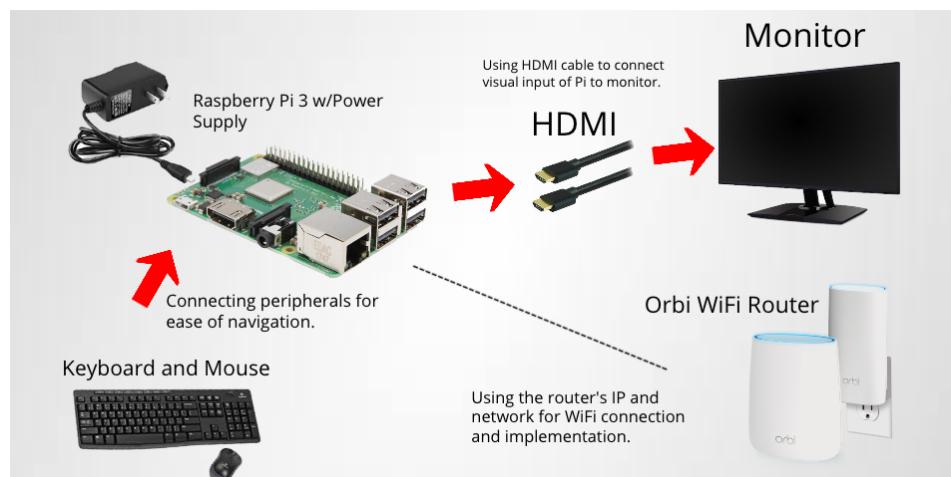


Fig. 2: Project Design (Created by myself)

The following picture is how my setup looks in real life. I do not have a professional or sophisticated setup, but it is the best that I can do. Regardless, I am able to work on the features without the proper setup.

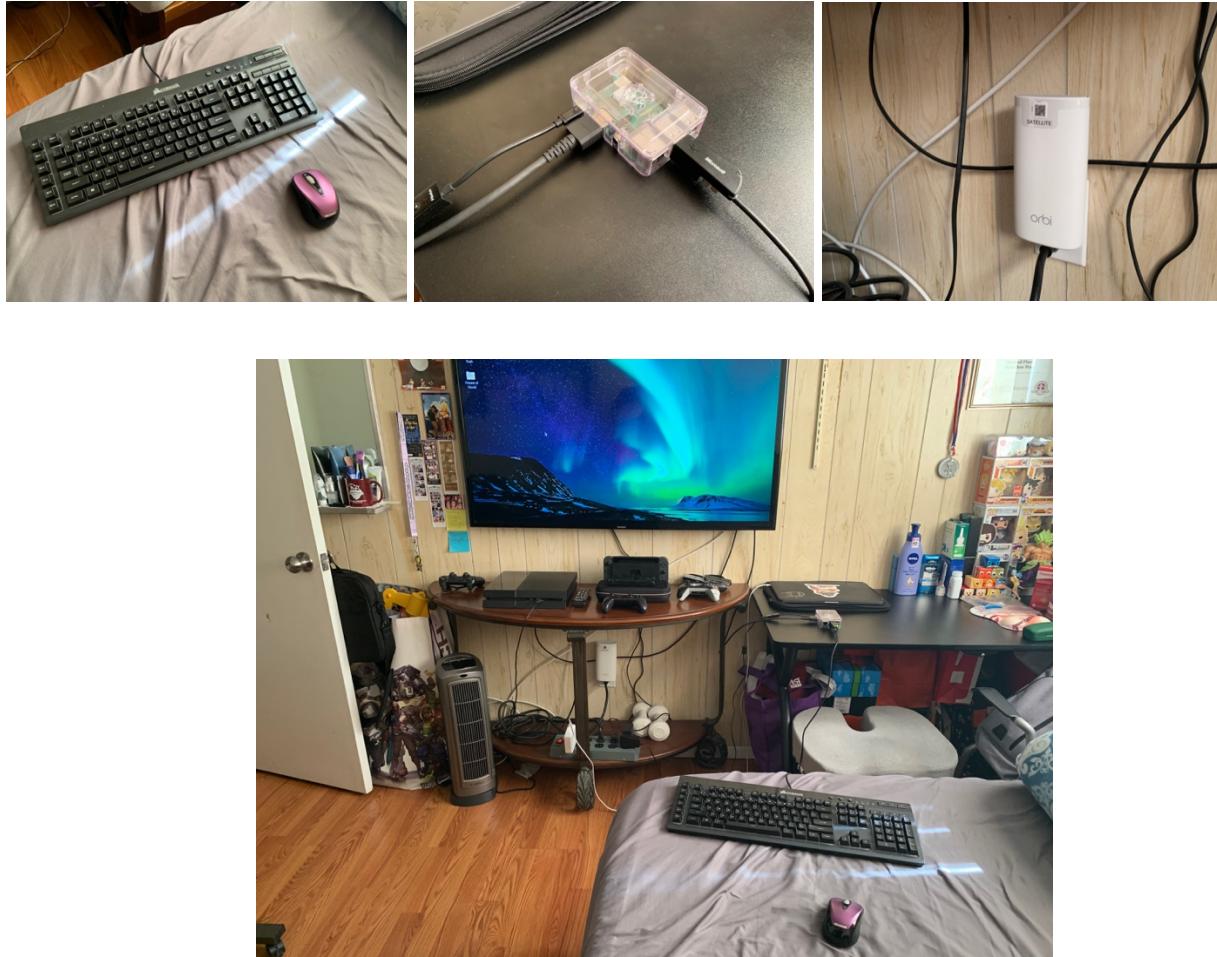


Fig. 3: Real-Life Setup featuring Peripherals, Router, and Raspberry Pi (Taken by myself)

4.2 Nextcloud Installation

In this section, I will go over the steps to successfully implement your own Nextcloud storage server in a Raspberry Pi. The majority of the installation will take place in the Raspbian's Terminal application.

Since I already have the Rasbian OS installed, I will skip that part of the project. Users can grab the operating software from the Raspberry Pi's official website and configure it from there. The image is available free to download. Once configured onto the Pi, users should be greeted to the Raspberry Pi's GUI. Raspbian is Linux-based, so most of the commands and coding will be similar.

The tutorial I will be following will be based from PiMyLifeUp.com, created by Gus [3].

Once the OS is installed, it is time to set up the cloud storage. Before we begin, we will go ahead and make sure that Apache and PHP is installed. To do this, open the Terminal located on the top left. First we will update our package repositories by using the commands:

```
sudo apt-get update
```

```
sudo apt-get upgrade
```

Next, we will install Apache by using the command: *sudo apt-get install apache2*. After Apache2 is installed, we will install PHP and its packages by running the command:

```
sudo apt-get install php7.3 php7.3-gd sqlite php7.3-sqlite3 php7.3-curl php7.3-zip  
php7.3-xml php7.3-mbstring
```

This code will ensure that the Raspberry Pi's PHP is up to date and is currently running in PHP 7.3. Once both the Apache and PHP are installed, we will restart Apache with the following line: *sudo service apache2 restart*. We will be using this command many times in order to refresh any updates or installations made within the Terminal.

Now that we have both Apache2 and PHP updated and installed, we will now commence the Nextcloud installation. First we will move to our html directory with the following command: `cd /var/www/html`. Within the directory, run the following command:

```
curl https://download.nextcloud.com/server/releases/nextcloud-16.0.3.tar.bz2 | sudo tar -jxv
```

This code will help us download and extract the latest version of Nextcloud straight from their download site. After installation will take a while, but packages and applications of Nextcloud should be created. After a successful installation, we will now create a directory for Nextcloud to operate in. We will make the folder in the html/nextcloud directory with the following: `sudo mkdir -p /var/www/html/nextcloud/data`. Next, we will run the following command in order to give the correct user and group control over the entire Nextcloud folder and everything within it: `sudo chown -R www-data:www-data /var/www/html/nextcloud`. Finally, run this command to give the right permissions: `sudo chmod 750 /var/www/html/nextcloud/data`. Now that we are finished installing Nextcloud, we can now go to the Nextcloud service itself. To check if it is working, you will enter the information on a web browser:

IP address (xxx.xxx.x.xx)/nextcloud

If you are unsure of your IP address, using the following command on Terminal: `hostname -I`.

Once the information has been entered, you will be greeted to the following screen:

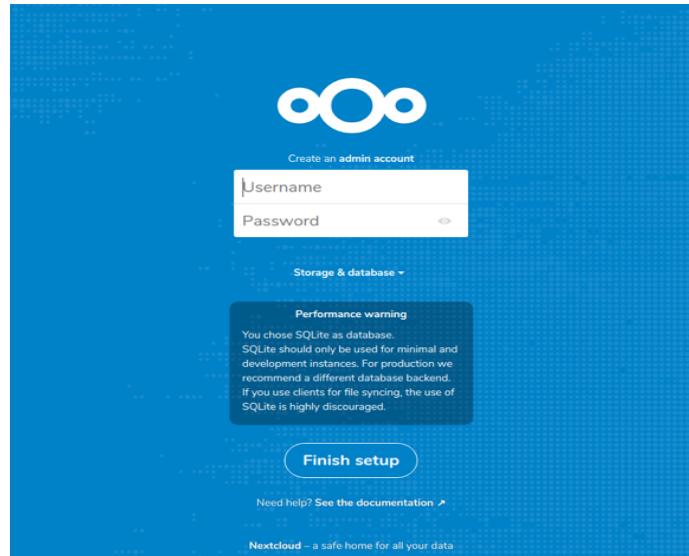


Fig. 4: Nextcloud Login Screen (Taken by myself)

In here you will type in the Username and Password that you intend to use as the admin account.

For instance, my Username is “Ulap” (cloud in Filipino/Tagalog) and my password is 14 characters long in order to keep my profile secured. Once satisfied, hit Finish setup. The cloud creation should take some time to finish. The following screen should appear once the process is done:

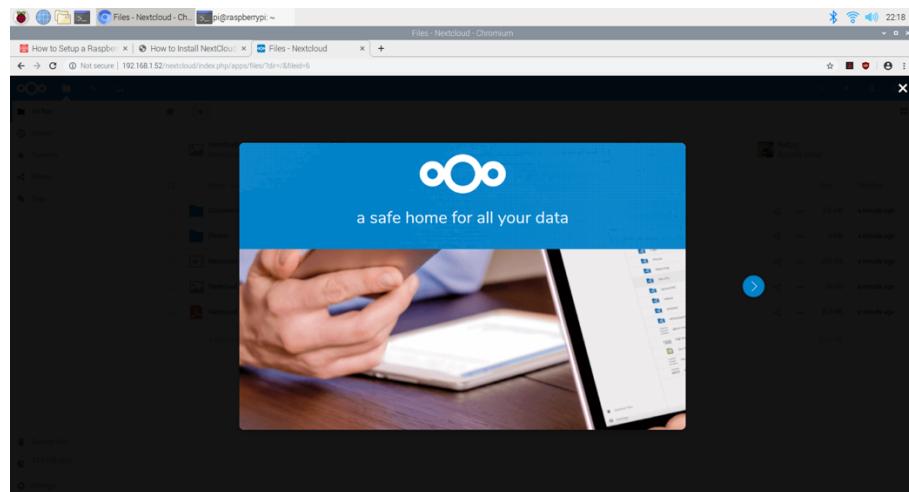


Fig. 5: Successful Login for First Time (Taken by myself)

Clicking the arrow will lay you more information on the programs that Nextcloud enables and has. Here is how the Nextcloud storage interface looks like:

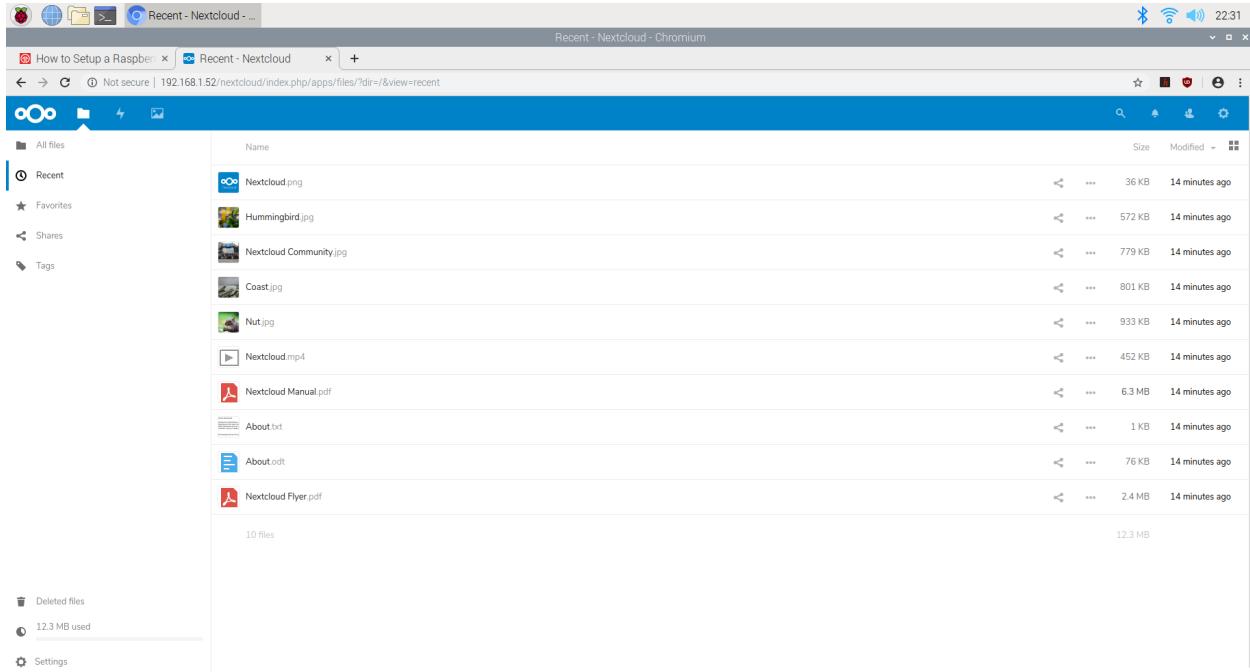


Fig. 6: Nextcloud storage files (Taken by myself)

Users are able to store any files. An activity feed shows what users have done. Admins can adjust settings for user access and experience. Desktop and mobile apps are available if you would like to access the cloud off of the Pi. Make sure that the Pi is on. Once it is off, the server will stop working.

From this point on, I will discuss the additional features that I setup and features that were potential to the setup but were later disregarded for several reasons. First off let us discuss the setup for configuring SSL for Nextcloud. This feature would allow me to run the Nextcloud server through HTTPS rather than HTTP. Before that, we will need to assign a self-signed

certificate for my hosting site. To start off, enter this command: `sudo mkdir -p /etc/apache2` to make a directory to store it. Next, generate the certificate by entering:

```
sudo openssl req -x509 -nodes -days 365 -newkey rsa:4096 -keyout
/etc/apache2/ssl/apache.key -out /etc/apache2/ssl/apache.crt
```

The following terms lists the descriptions of each of the command arguments

`req`: This specifies a subcommand for X.509 certificate signing request (CSR) management.

`-x509`: This option specifies that we want to make a self-signed certificate file instead of generating a certificate request.

`-nodes`: This tells the openssl application that we don't want to specify a passphrase, a passphrase will require us to enter it every time Apache is restarted which is painful to deal with.

`-days 365`: This specifies the amount of days we want the certificate to remain valid for, after this amount of days you will have to generate a new certificate.

`-newkey rsa:4096`: This will create the certificate request and a new private key at the same time. You will need to do this since we didn't create a private key in advance. The `rsa:2048` tells OpenSSL to generate an RSA key that is 2048 bits long.

`-keyout`: This parameter names the output file for the private key file that is being created.

-out: This option names the output file for the certificate that we are generating.

Once the user presses enter, they will be presented to fill out the following options:

Country Name (2 letter code) [AU]:

State or Province Name (full name) [Some-State]:

Locality Name (eg, city) []:

Organization Name (eg, company) [Internet Widgits Pty Ltd]:

Organizational Unit Name (eg, section) []:

Common Name (e.g. server FQDN or YOUR name) []:

Email Address []:

Filling out the following information will have them saved and listed in the certificate we are creating. Now, we will let Apache2 run SSL and utilize our generated certificate. First, enable the SSL module for Apache with the command: `sudo a2enmod ssl`. Next, modify the file by running: `sudo nano /etc/apache2/sites-available/default-ssl.conf`. Within this file, two lines will need to be changed. Change:

SSLCertificateFile /etc/ssl/certs/ssl-cert-snakeoil.pem

SSLCertificateKeyFile /etc/ssl/private/ssl-cert-snakeoil.key

To:

SSLCertificateFile /etc/apache2/ssl/apache.crt

SSLCertificateKeyFile /etc/apache2/ssl/apache.key

Now save and quite with Ctrl+X and press Y and then Enter. Enable the default-ssl configuration and restart Apache to load in our new configuration with the two commands:

```
sudo a2ensite default-ssl.conf
```

```
sudo service apache2 restart
```

Now, our address should have the https:// in front of our IP address/URL and will have a certificate enabled (<https://xxx.xxx.x.xx/nextcloud>). It will first give a warning about the certificate being invalid. Since this is not coming from a legit certification provider, the certificate will act as unsigned. Regardless, having some security is better than having no security.

Lastly, I would like to touch upon port forwarding and dynamic DNS. Port forwarding allows you to have access to the Nextcloud server in and out of the home network, while the Raspberry Pi is on and connected. Creating a dynamic DNS provides a custom URL dedicated solely to the IP address. I personally did not want to try and implement these features for the project since I am only borrowing the equipment. These steps will require personal information being shared and permanently created, meaning that I should not go too far for equipment I will not be keeping. Though, I would like to try these steps out with my own Pi. Port forwarding and creating a DNS requires you to login to your IP's router login. For example, I use Orbi's satellite WiFi routers. Their login is "orbilogin.com" with the popup window asking for the username and password. In this case, the username is "admin" and the password is the same passcode used to login to the network. In the site, options to port forward and set up a dynamic DNS can be found. Routers have different ways to implement port forwarding and DNS, so configure those based on the router at hand.

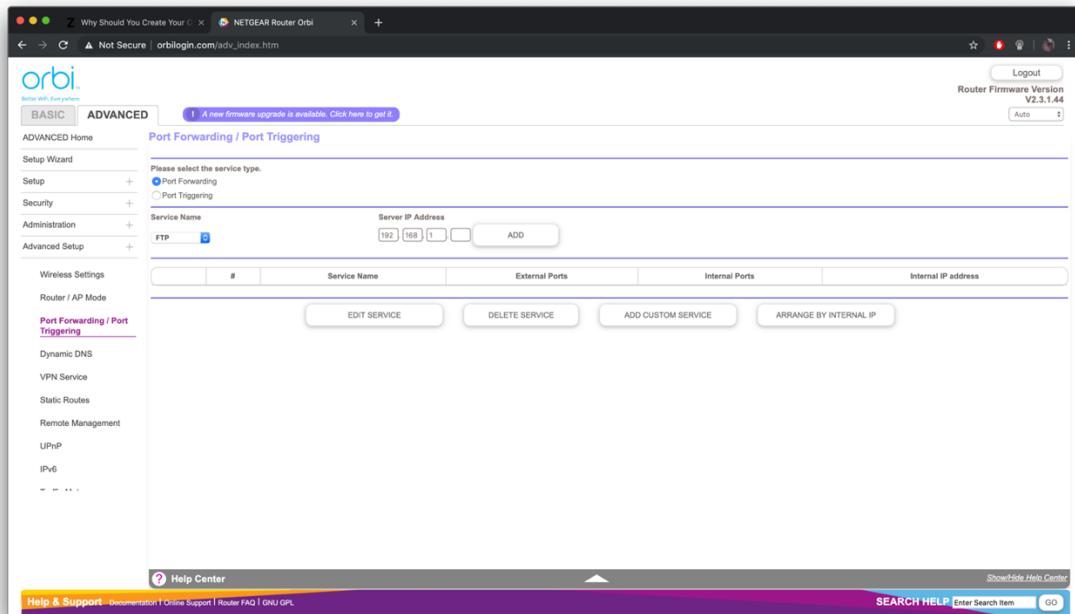


Fig. 7: Orbi Port Forwarding (Taken by myself)

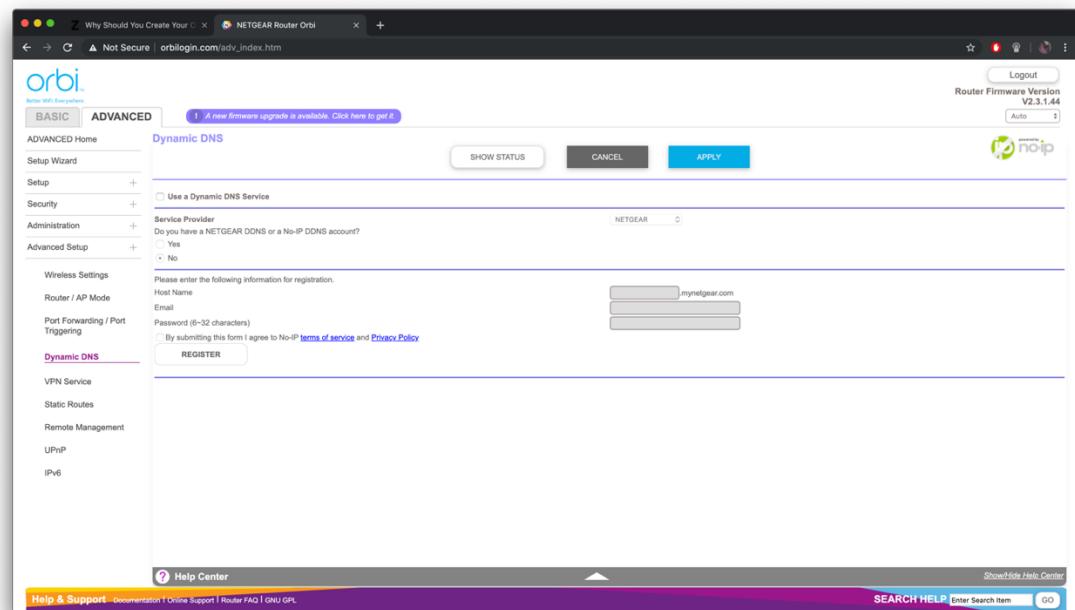


Fig. 8: Orbi Dynamic DNS (Taken by myself)

4.3 Testing Plan

Before my presentation, I will analyze the cloud's maximum storage space. Upon further investigation, I notice that admins can set up the maximum capacity of storage for each member. The maximum, surprisingly, was said to be unlimited. This puzzles me as to why. I will try to import as much files as I can to investigate whether the unlimited capacity is true. If not, I will test to see if I am able to mount my physical drive's memory into the storage.

During my presentation, I plan to bring my Raspberry Pi and showcase the PowerPoint slides from there. I will not be creating a DNS or port forwarding my IP since I am merely borrowing the Pi and that I felt that it might permanently create some errors. If I choose to bring the Pi, I will instead be accessing the Nextcloud server with the “localhost” while on campus. This means that instead of entering my IP address on the URL tab, I will instead type “localhost” to access the cloud storage. This is because the localhost is a hostname that signifies that this computer, our own Raspberry Pi, can access the network service running on the host (our Pi). It essentially bypasses any local network interface hardware. In this case, entering localhost in my Raspberry Pi would bypass into the Nextcloud server since I set it up through Terminal to act that way. Using the “localhost” url on a separate device while the server is not running on the home IP will not work since port forwarding will not be enabled, and that I am physically taking the Pi out of the home area.

I will showcase a video as a quick demonstration on how storing files on the Nextcloud server works. I will showcase it for the Pi, on a separated laptop, and on the mobile application. In addition, I will do a live demonstration during class and examine the features within the cloud storage.

4.4 Errors Found

There was not a lot of errors that I have encountered. The majority of the errors were simple log errors. However, one error in particular has caused me to restart the whole installation process all over again. The occurrence of the error popped up once I decided to clear up my browser's data (history, cache, etc.). As I navigated my way back to my cloud storage site, I was unable to login to my cloud. An error message is displayed titled "Internal Server Error." The rest of the message is as follows:

"Internal Server Error

The server was unable to complete your request.

If this happens again, please send the technical details below to the server administrator.

More details can be found in the server log.

Technical details

Remote Address: xxx.xxx.x.xx (my IP address)

Request ID: xxxxxxxx (random set up variables)"

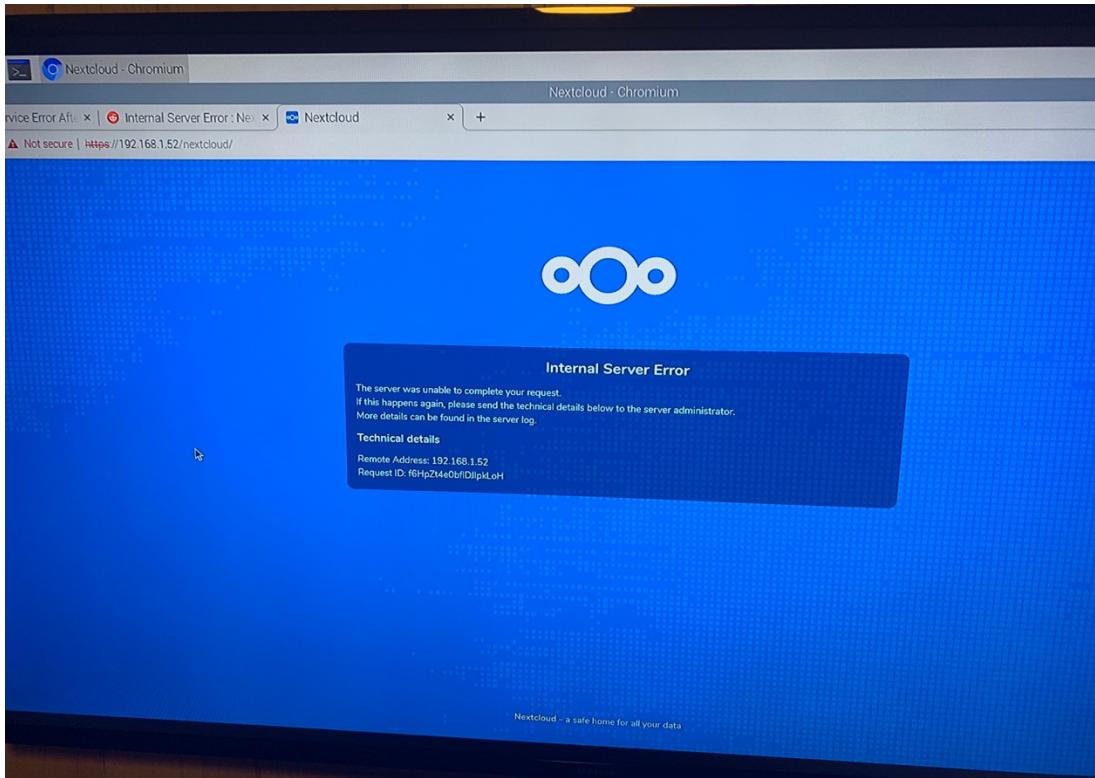


Fig. 9: Internal Server Error (Taken by myself)

I was unsure what this error message suggests. I checked my error logs and it suggests SSL warnings coming from the certificate that I have made for the cloud site. Perhaps something went wrong with the SSL as I cleared up the cloud storage's cache. Data files within my Nextcloud folder were all listed as an inode/x-corrupted file type.

```

Options Help
57:45:097613 2019] [mpm_prefork:notice] [pid 2350] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
57:45:097764 2019] [core:notice] [pid 2350] AH00094: Command line: '/usr/sbin/apache2'
18:27:146790 2019] [mpm_prefork:notice] [pid 2350] AH00169: caught SIGTERM, shutting down
18:34:437103 2019] [ssl:warn] [pid 455] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
18:36:448339 2019] [ssl:warn] [pid 498] AH01996: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
18:36:449565 2019] [ssl:warn] [pid 498] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
18:36:462767 2019] [mpm_prefork:notice] [pid 498] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
18:36:463727 2019] [core:notice] [pid 498] AH00094: Command line: '/usr/sbin/apache2'
11:11:526072 2019] [mpm_prefork:notice] [pid 498] AH00169: caught SIGTERM, shutting down
11:11:526268 2019] [ssl:warn] [pid 3286] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
11:13:11:657318 2019] [ssl:warn] [pid 3287] AH01999: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
11:13:11:657427 2019] [ssl:warn] [pid 3287] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
11:13:11:673232 2019] [mpm_prefork:notice] [pid 3287] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
11:13:11:673383 2019] [core:notice] [pid 3287] AH00094: Command line: '/usr/sbin/apache2'
11:56:42:698769 2019] [mpm_prefork:notice] [pid 497] AH00169: caught SIGTERM, shutting down
21:56:42:698769 2019] [ssl:warn] [pid 497] AH01996: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
21:56:44:624637 2019] [ssl:warn] [pid 497] AH01996: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
21:56:44:624837 2019] [ssl:warn] [pid 497] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
21:56:44:648109 2019] [mpm_prefork:notice] [pid 497] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
21:56:44:648202 2019] [core:notice] [pid 497] AH00094: Command line: '/usr/sbin/apache2'
23:21:44:574632 2019] [mpm_prefork:notice] [pid 497] AH00169: caught SIGTERM, shutting down
23:21:44:574632 2019] [ssl:warn] [pid 3264] AH01996: 127.0.1.1:443 You configured HTTPS(80) on the standard HTTPS(443) port!
23:21:44:594249 2019] [mpm_prefork:notice] [pid 3264] AH01999: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
23:21:44:946411 2019] [core:notice] [pid 3366] AH00094: Command line: '/usr/sbin/apache2'
23:23:31:592588 2019] [mpm_prefork:notice] [pid 3366] AH00169: caught SIGTERM, shutting down
23:23:31:592588 2019] [ssl:emerg] [pid 3366] AH02572: Failed to configure at least one certificate and key for 127.0.1.1:443
23:23:52:632099 2019] [ssl:warn] [pid 3366] AH02531: Fatal error initialising mod_ssl, exiting. See /var/log/apache2/error.log for more information
23:23:52:633093 2019] [ssl:emerg] [pid 3366] AH02531: Fatal error initialising mod_ssl, exiting. See /var/log/apache2/error.log for more information
6:23:15:31:448242 2019] [ssl:warn] [pid 3775] AH01996: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
6:23:15:31:448243 2019] [ssl:warn] [pid 3775] AH01999: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
6:23:25:31:575420 2019] [ssl:warn] [pid 3776] AH01996: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
6:23:25:31:575612 2019] [ssl:warn] [pid 3776] AH01999: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
6:23:25:31:592360 2019] [mpm_prefork:notice] [pid 3776] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
10:23:43:40:676763 2019] [mpm_prefork:notice] [pid 3776] AH00169: caught SIGTERM, shutting down
10:23:43:48:723822 2019] [ssl:warn] [pid 459] AH01996: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
06:23:43:48:727860 2019] [ssl:warn] [pid 459] AH01999: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
06:23:43:50:649367 2019] [ssl:warn] [pid 498] AH01996: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
06:23:43:50:676568 2019] [mpm_prefork:notice] [pid 498] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operations
06:23:43:50:676763 2019] [core:notice] [pid 498] AH00094: Command line: '/usr/sbin/apache2'

```

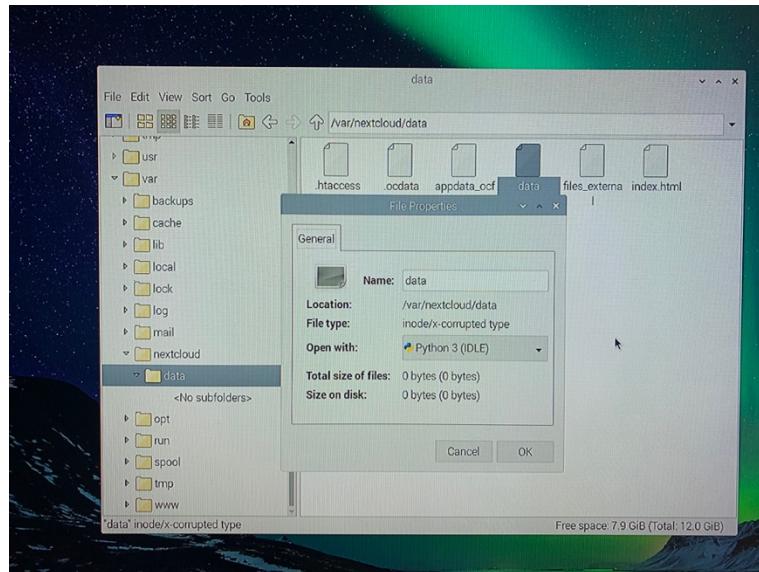


Fig. 10: Error signs/warnings (Taken by myself)

I visited Ken Leyba for assistance on the issue. Unfortunately, we were not able to fix this issue. None of the logs was able to detect the actual underlying reasoning for the internal

server error. It was bizarre that this error was never caught on by anyone. At the end, we decided to overwrite the current Rasbian data and restart the system from scratch. While this seems like an unfortunate timing, I was able to understand how to conduct a hard reset with the Raspberry Pi. This is come in handy in case I come through an issue like this again. Once the Rasbian OS was installed and updates were back to normal, I checked to see if my Nextcloud service was still up. In hindsight, the Nextcloud server cannot be found since it was never created; in this case, the cloud storage with my IP address was deleted.

The original cloud storage was unable to be repaired, but I am able to still create a new cloud storage using the same IP address. While not essentially back, a new server was successfully established. Just in case, I will not set up an SSL as setting up myself without a legit provider was potentially a factor for my errors.

5. Conclusion/Future Work

5.1 Checking Security Measures

Once my cloud storage server is up and running, I plan to continue on increasing the security aspects. This applies not only for my Nextcloud storage but also for the Raspberry Pi itself. For my cloud storage, I will implement a two-factor verification in case I add in more users to join in on my cloud. I will run the terminal and open up ports that deemed essential to my cloud server. I will make sure that my Raspberry Pi remains in a cool location while it is on and that it is physically protected from damaging its internal circuits. I would like to purchase a fan or cooler for my Raspberry Pi for moments where I can keep the circuit board running for a prolong amount of time. Anything that screams security should be analyzed for the present and the future.

5.2 Revamping Cloud Storage

In addition to my future work, I would like to look into the apps that are available within the Nextcloud application. There are many other applications that I am able to try and install. Unfortunately, I cannot try out the overwhelming abundance of applications. But I plan to look into some and witness the functionalities that the Nextcloud storage can offer. In addition, I plan to set certain rules for users accessing the cloud. For instance, only the admin user can grant the amount of storage available for certain local users.

5.3 Overall Summary

By performing this project, I was able to get a small grasp on how cloud computing works and how to set up your own home server. After returning all of my equipment, I wish to purchase a Raspberry Pi myself and create a cloud storage again for my personal use. I also want to find the other possibilities that the Raspberry Pi can be used for. Overall, my time spent researching and conducting the experiment enabled me to be more focused and independent on the career I am looking to align with. I hope this research serves as a tool and reference for those looking to focus on cloud computing, server building, and Raspberry Pi modification.

6. References

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- [2] Foote, Keith D. "A Brief History of Cloud Computing." *DATAVERSITY*, 22 June 2017, www.dataversity.net/brief-history-cloud-computing/#.
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- [4] Kumar, Mohit. "iCloud Possibly Suffered A Privacy Breach Last Year That Apple Kept a Secret." *The Hacker News*, 30 Jan. 2019, thehackernews.com/2019/01/icloud-privacy-breach.html.
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- [9] "What Is Cloud Computing? A Beginner's Guide: Microsoft Azure." *What Is Cloud Computing? A Beginner's Guide | Microsoft Azure*, azure.microsoft.com/en-us/overview/what-is-cloud-computing/.

7. Appendix

7.1 Proposal



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Project/Thesis Proposal

Select one:

CTC 492 _x_ ITC 492 __ CSC 492 __ CSC 590 __ CSC599 __

Track: Homeland Security

Semester: Summer

Year: 2019

Title: Creating a Cloud Storage using Raspberry Pi

Prepared by: Brandon Mao

Date: July 23, 2019

Faculty advisor

Signature

Date

Committee member

Signature

Date

Committee member

Signature

Date

Proposal Description:

My intended project and research will be based on my findings and experiences of the fundamentals of cloud computing. My goal is to use a client-server software in order to successfully build a cloud storage where files can be uploaded and accessed. The software that I have in mind is either between ownCloud or Nextcloud, both of which are open-source cloud software. Hardwares that may be needed includes a Raspberry Pi board to act as an external server, and an SD card for additional memory space. Further development would be to test its security measures, analyze its encryption methods, and mess with other features that the cloud storage can offer. In addition, research would contain background information on the history of cloud services, explanations as to why cloud storage services have been on the rise for many companies and descriptions to its importance in the security field. I also plan to list reasons as to why it is more efficient to set up your own cloud storage service by comparing the service to other free storage services like Google Drive or Dropbox. Pictures and charts may be used to show how the cloud functions, as well as comparisons between personal storages and third-party services. I will also analyze the advantages and disadvantages of installing cloud storages and studies of the cloud in general. This project will allow the audience to understand cloud storage servicing more in an in-depth demonstration and show the process in creating their own storage outside of third-party services.

7.2 Presentation Slides



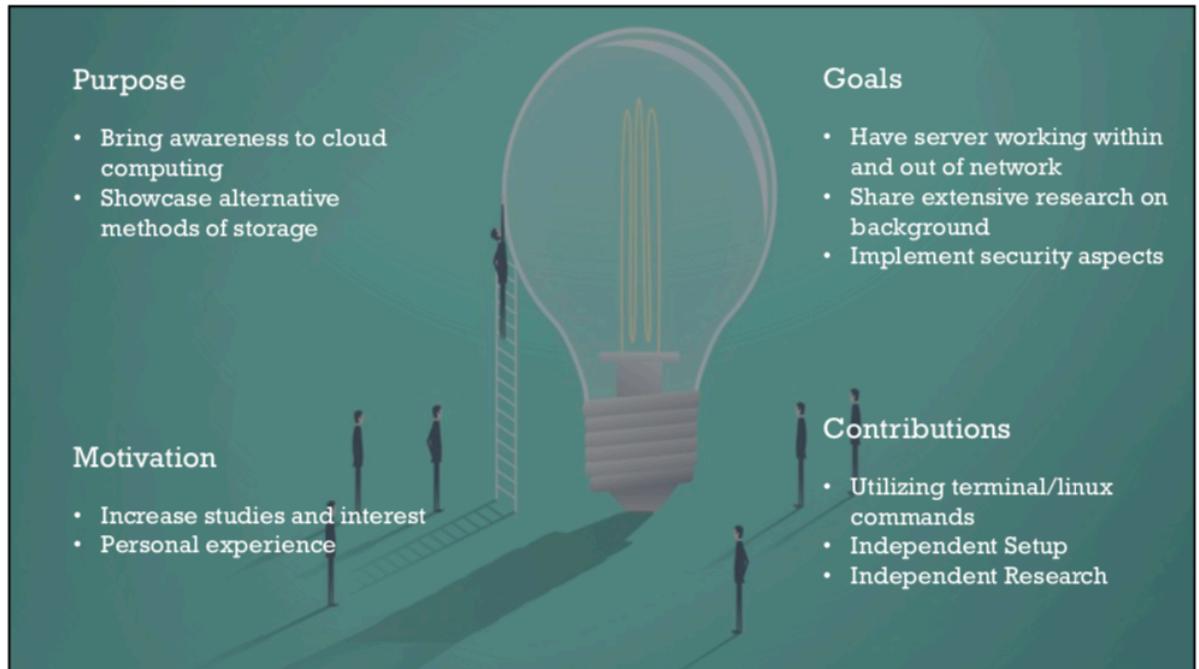
The slide has a dark teal background. In the center, there is a silhouette of a person standing and looking through a telescope. To the left of the person, the word "OVERVIEW" is written in white. To the right of the person, there are two columns of text: "Last Time:" and "This Time:". Both columns contain a bulleted list of topics.

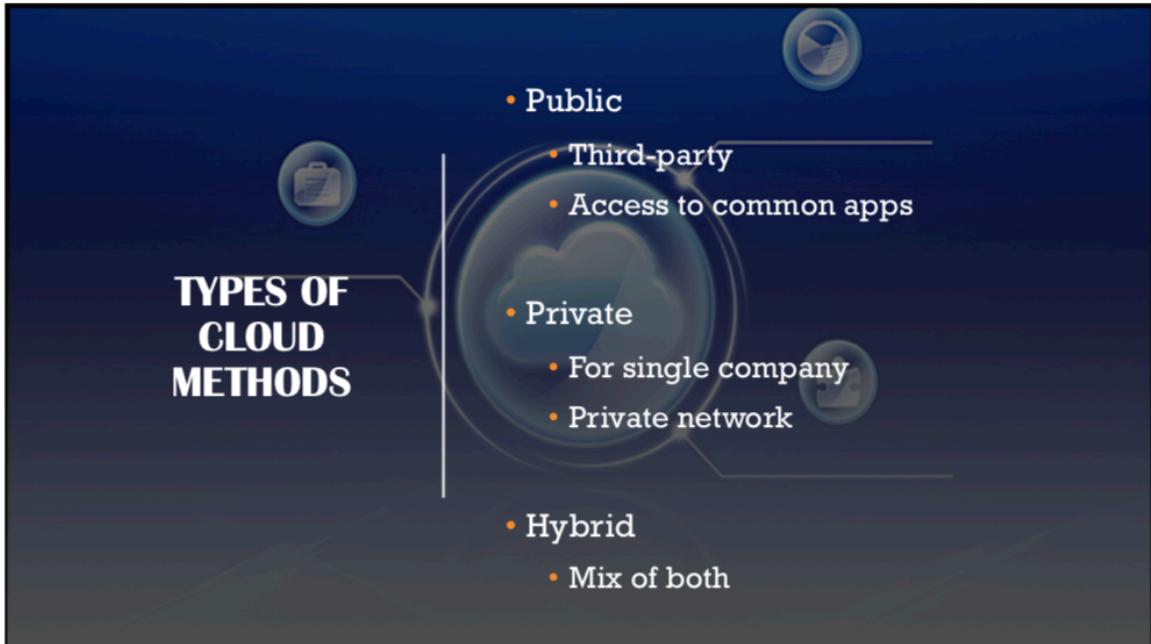
Last Time:

- Purpose, Goals, Motivation
- What is a Cloud?
- Types of Cloud Methods
- History of Cloud Computing
- Cloud Services
- Cloud Storage Providers
- Advantages
- Disadvantages
- Requirements

This Time:

- Hardware Setup
- Nextcloud Installation
- Errors Found
- Demonstration
- Conclusion





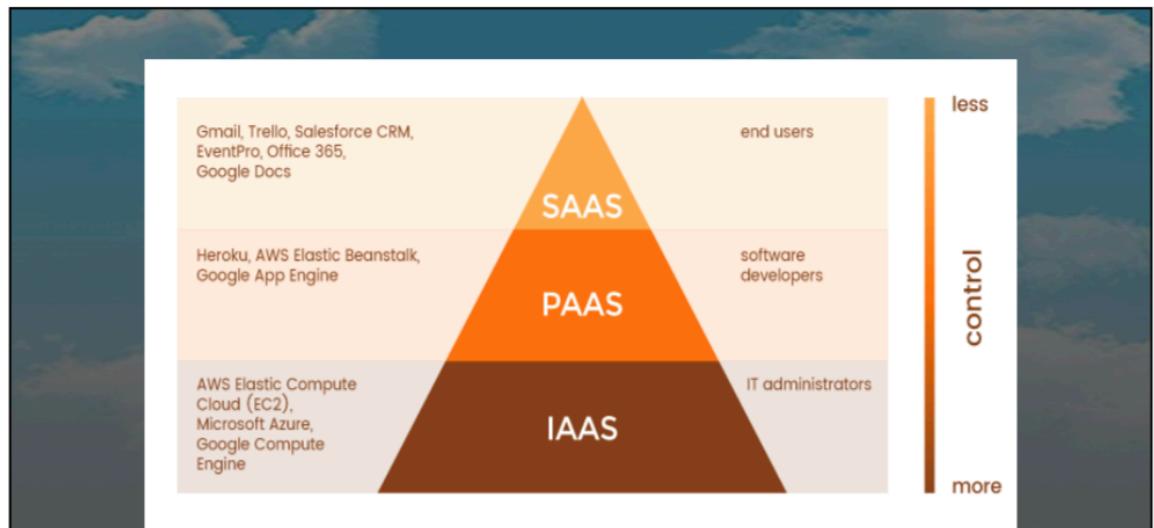
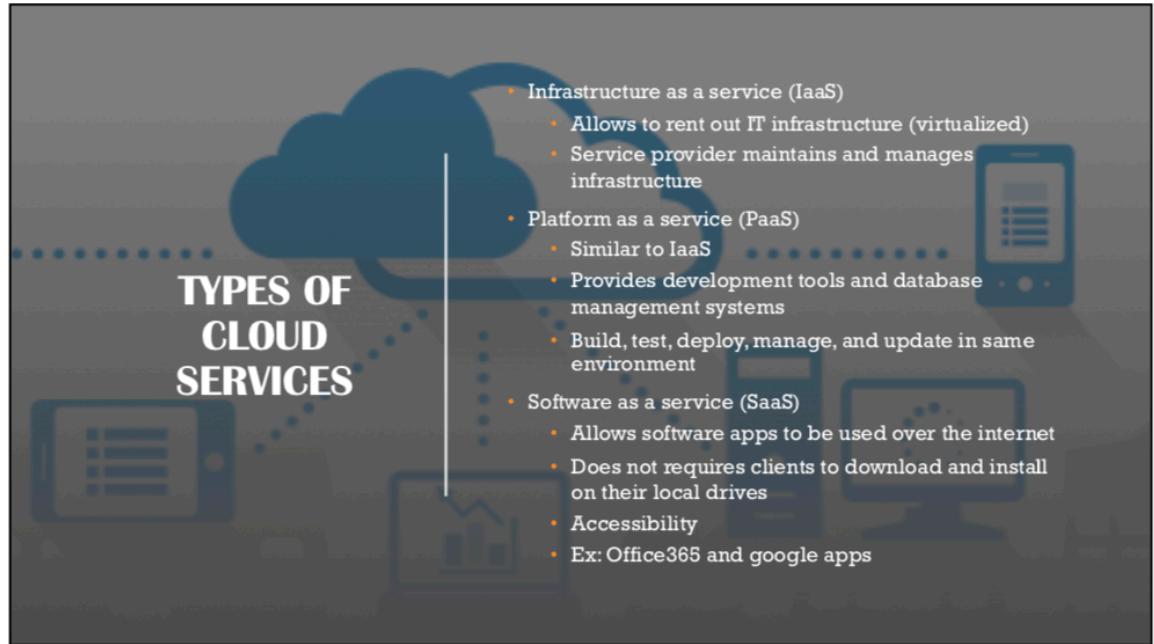


Fig.1 Cloud Services hierarchy diagram. Graph from Gleb B, Choosing the Right Cloud Service: IaaS, PaaS, or SaaS. 8 August 2017. Web. 20 March 2019.

Dropbox	Google Drive
<ul style="list-style-type: none"> Launched in 2008 2GB of free storage Security <ul style="list-style-type: none"> Uses 256-bit AES encryption States that security is the highest priority Privacy Policy <ul style="list-style-type: none"> Ability to decrypt files If they want to disclose your data to a third party, they can willingly do so Deleting account does not guarantee deletion of data. 	<ul style="list-style-type: none"> Launched in 2012 15 GB of free storage Privacy Policy <ul style="list-style-type: none"> Able to analyze every email or file stored on their system Data retention License to use files uploaded

ADVANTAGES OF CLOUD STORAGE

 Save on cost <p>Eliminates relying on inhouse solutions or HDD</p>	 Offsite management <p>Someone else physically maintains data center</p> <p>Allows IT team to focus their attention on other priorities</p>	 Accessibility <p>Concept of anywhere, anytime</p>
--	--	---



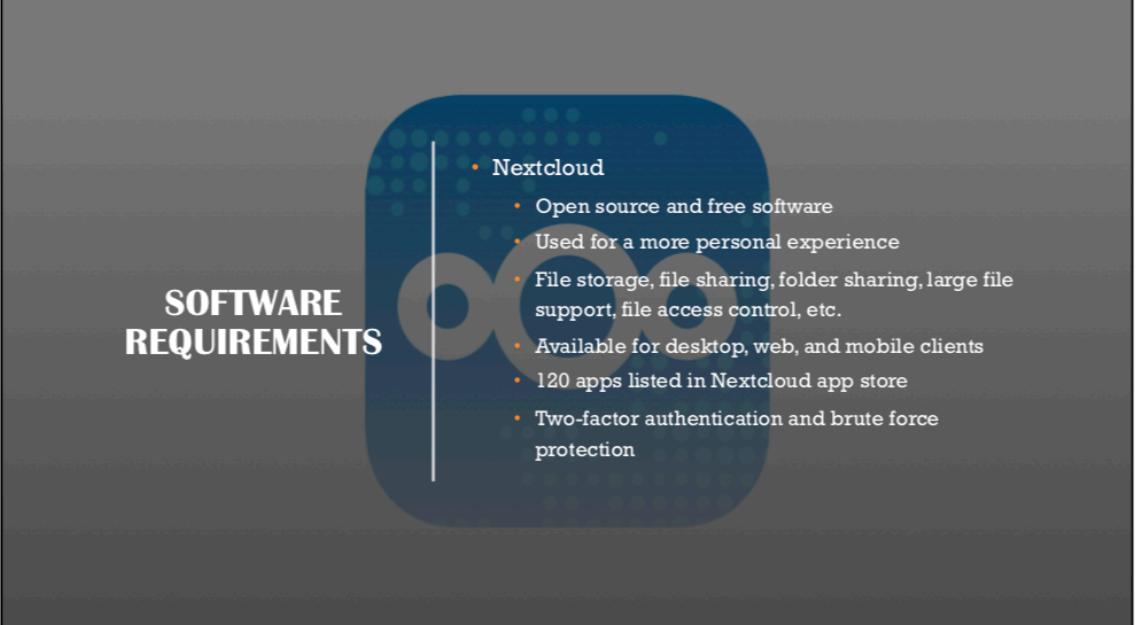
DISADVANTAGES OF CLOUD STORAGE

Security

- Hackers are launching more complex attacks
- Putting your data at risk
- Breaches

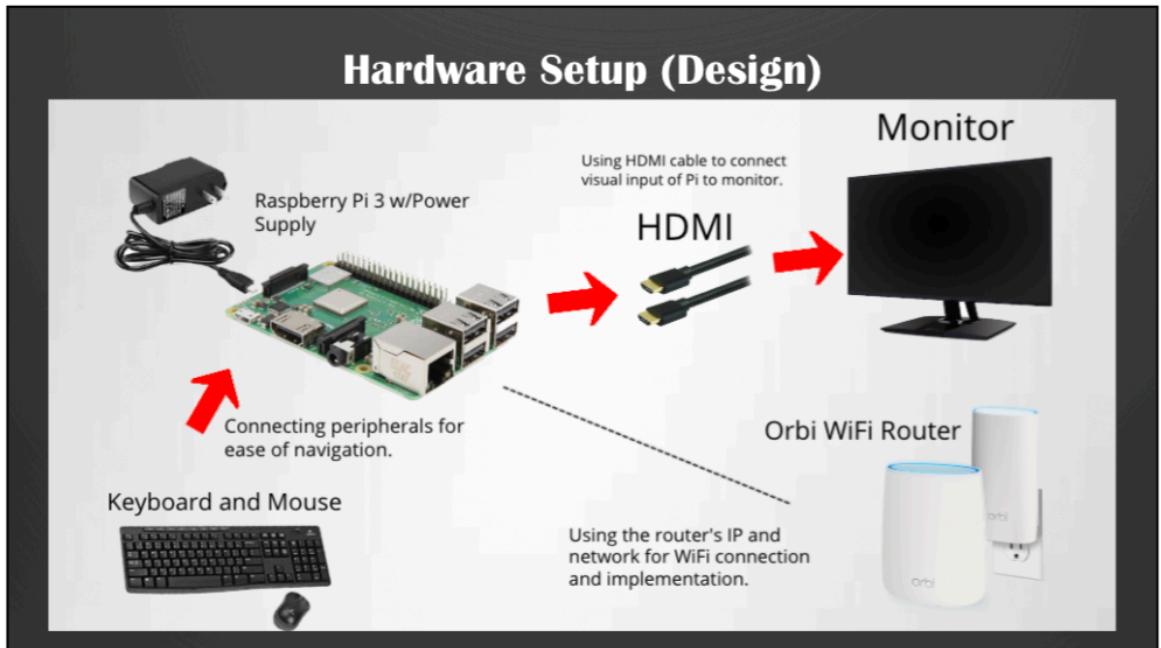
Needs to be connected to internet

- Low latency might delay access to files
- No internet connection = unable to access files

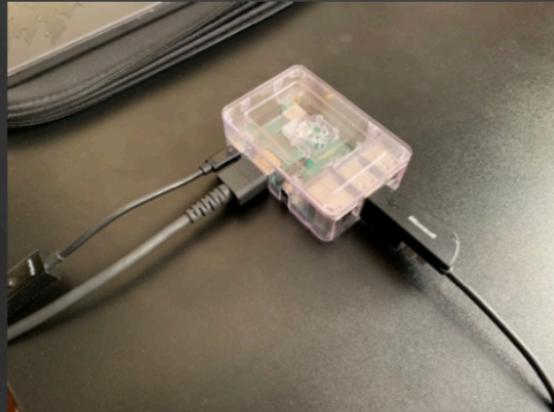


SOFTWARE REQUIREMENTS

- Nextcloud
 - Open source and free software
 - Used for a more personal experience
 - File storage, file sharing, folder sharing, large file support, file access control, etc.
 - Available for desktop, web, and mobile clients
 - 120 apps listed in Nextcloud app store
 - Two-factor authentication and brute force protection

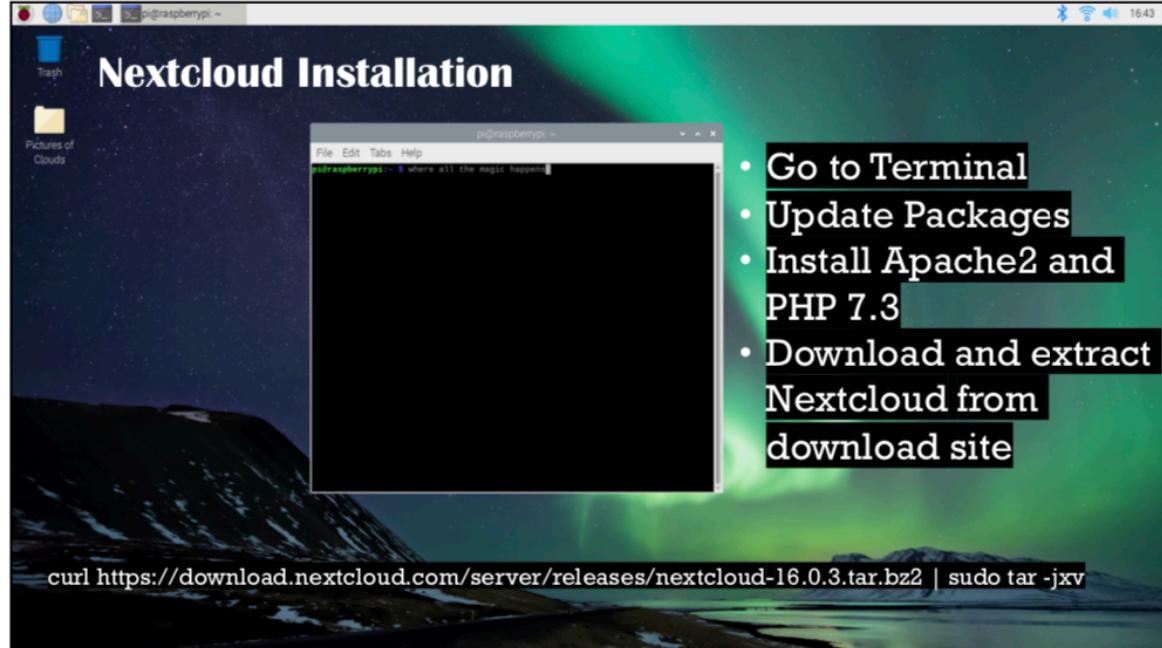


Equipment

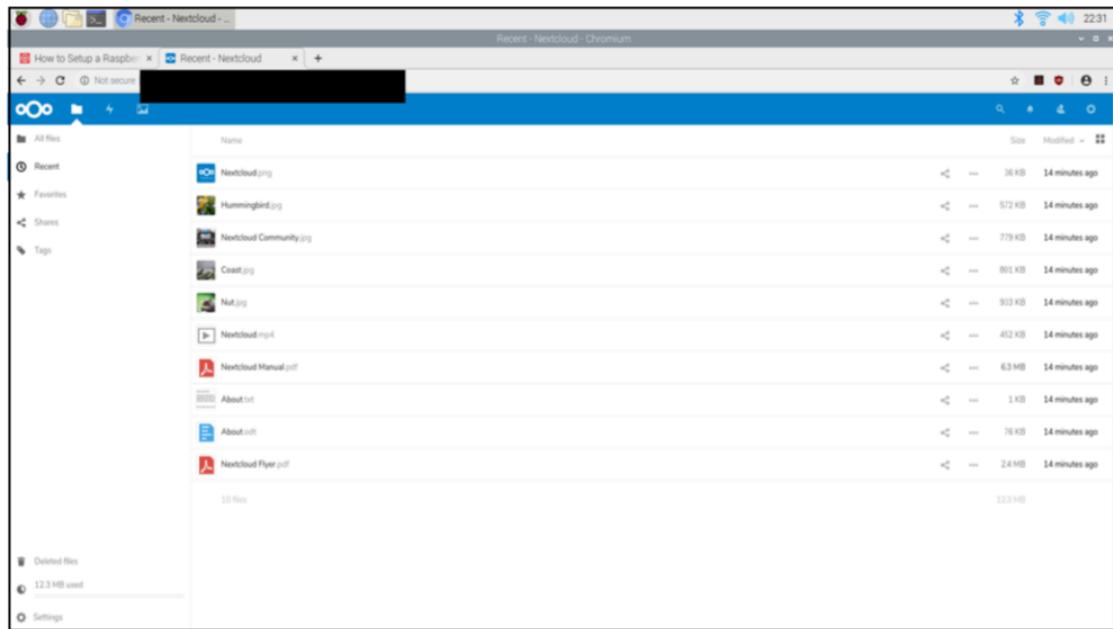
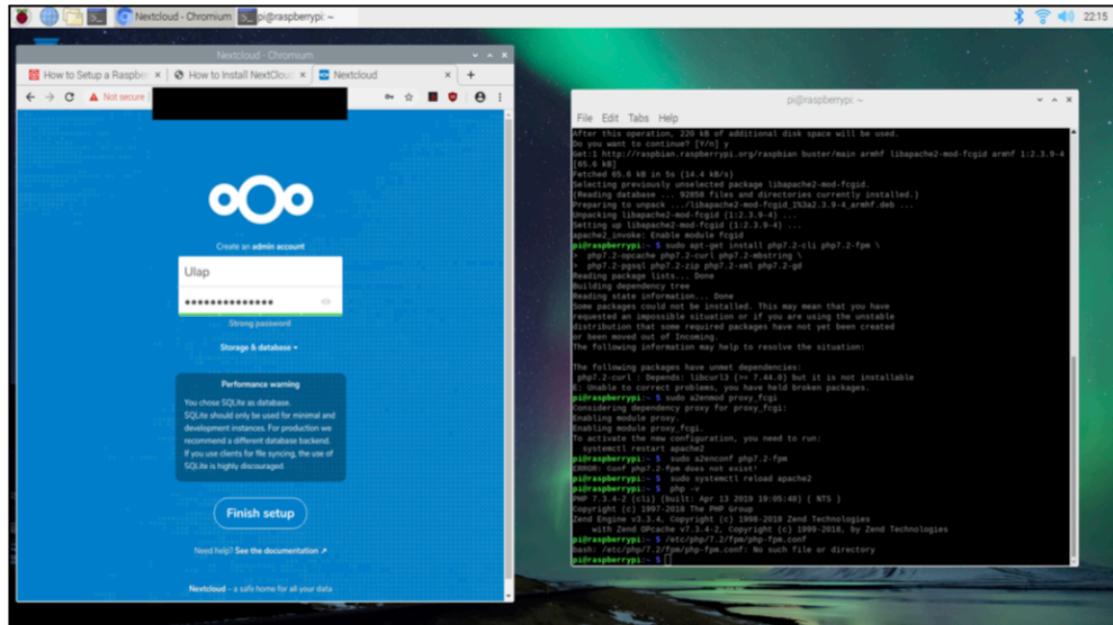


Hardware Setup (Reality)



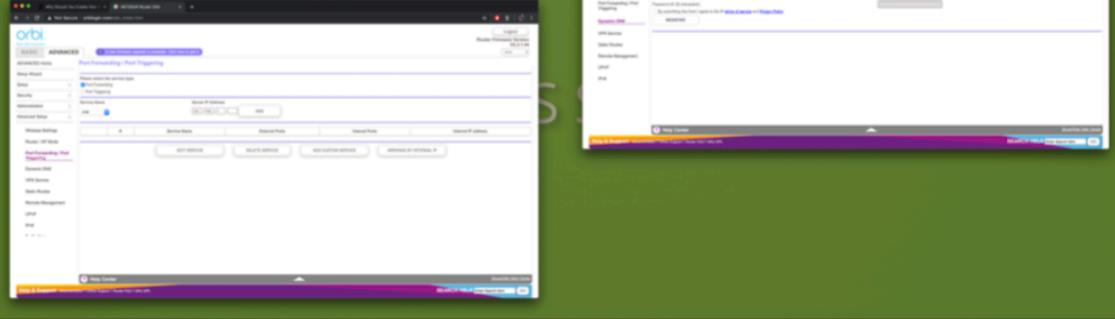


<pre>pi@raspberrypi: /var/www</pre> <pre>nextcloud/apps/files/lib/getStorageStats.php nextcloud/apps/files/lib/Command nextcloud/apps/files/composer/composer.json nextcloud/apps/files/composer/autoload.php nextcloud/apps/files/composer/composer/ nextcloud/apps/files/composer/composer/autoload_classmap.php nextcloud/apps/files/composer/composer/autoload_psr4.php nextcloud/apps/files/composer/composer/LICENSE nextcloud/apps/files/composer/composer/autoload_static.php nextcloud/apps/files/composer/composer/autoload_namespaces.php nextcloud/apps/files/composer/composer/autoload_real.php nextcloud/apps/files/lib/Capabilities.php nextcloud/apps/files/lib/Settings/ nextcloud/apps/files/lib/Settings/Admin.php nextcloud/apps/files/lib/Service/ nextcloud/apps/files/lib/Service/TagService.php nextcloud/apps/files/lib/Command nextcloud/apps/files/lib/ScanAppData.php nextcloud/apps/files/lib/Command/Scan.php nextcloud/apps/files/lib/Command/DeletephanedFiles.php nextcloud/apps/files/lib/Command/TransferOwnership.php nextcloud/apps/files/lib/Helper.php nextcloud/apps/files/lib/ImportApp.php nextcloud/apps/files/lib/App.php nextcloud/apps/files/lib/Activity/ nextcloud/apps/files/lib/Activity/FavoriteProvider.php nextcloud/apps/files/lib/Activity/Provider.php nextcloud/apps/files/lib/Activity/Settings nextcloud/apps/files/lib/Activity/FileDeleted.php nextcloud/apps/files/lib/Activity/Settings/FavoriteAction.php nextcloud/apps/files/lib/Activity/Settings/Filefavorite.php nextcloud/apps/files/lib/Activity/Settings/FileChanged.php nextcloud/apps/files/lib/Activity/Settings/FileRestored.php nextcloud/apps/files/lib/Activity/Settings/FileCreated.php nextcloud/apps/files/lib/Activity/Settings/File.php nextcloud/apps/files/lib/Activity/Filter nextcloud/apps/files/lib/Activity/Filter/FilterChanges.php nextcloud/apps/files/lib/Activity/Filter/Favorites.php nextcloud/apps/files/lib/Controller nextcloud/apps/files/lib/Controller/ApiController.php nextcloud/apps/files/lib/Controller/VideoController.php nextcloud/apps/files/lib/Controller/SettingsController.php nextcloud/apps/files/lib/BackgroundJob nextcloud/apps/files/lib/BackgroundJob/CleanupFileLocks.php nextcloud/apps/files/lib/BackgroundJob/DeleteOrphanedItems.php nextcloud/apps/files/simplelist.php nextcloud/apps/files/appinfo/ nextcloud/apps/files/</pre>	<pre>pi@raspberrypi: /var/www</pre> <pre>nextcloud/apps/files/videooplayer/videojs/src/font/ nextcloud/apps/files/videooplayer/videojs/src/font/vs.woff nextcloud/apps/files/videooplayer/videojs/src/font/vs.ttf nextcloud/apps/files/videooplayer/videojs/src/font/vs.svg nextcloud/apps/files/videooplayer/videojs/src/font/vs.eot nextcloud/apps/files/videooplayer/videojs/src/videojs nextcloud/apps/files/videooplayer/videojs/src/lang/ nextcloud/apps/files/videooplayer/videojs/src/lang/vi.js nextcloud/apps/files/videooplayer/videojs/src/lang/de.js nextcloud/apps/files/videooplayer/videojs/src/lang/zh.js nextcloud/apps/files/videooplayer/videojs/src/lang/ru.js nextcloud/apps/files/videooplayer/videojs/src/lang/zh-hk.js nextcloud/apps/files/videooplayer/videojs/src/lang/st.js nextcloud/apps/files/videooplayer/videojs/src/lang/tr.js nextcloud/apps/files/videooplayer/videojs/src/lang/ca.js nextcloud/apps/files/videooplayer/videojs/src/lang/fr.js nextcloud/apps/files/videooplayer/videojs/src/lang/cz.js nextcloud/apps/files/videooplayer/videojs/src/lang/ja.js nextcloud/apps/files/videooplayer/videojs/src/lang/es.js nextcloud/apps/files/videooplayer/videojs/src/lang/ko.js nextcloud/apps/files/videooplayer/videojs/src/lang/ar.js nextcloud/apps/files/videooplayer/css/ nextcloud/apps/files/videooplayer/css/style.css nextcloud/apps/files/videooplayer/img/ nextcloud/apps/files/videooplayer/img/volume-bar.png nextcloud/apps/files/videooplayer/img/poster.png nextcloud/apps/files/videooplayer/img/app.svg nextcloud/apps/files/videooplayer/img/vjs-volume-level.png nextcloud/apps/files/videooplayer/screenshot.jpg nextcloud/apps/files/videooplayer/appinfo/ nextcloud/apps/files/videooplayer/appinfo/info.xml nextcloud/apps/files/videooplayer/appinfo/app.php nextcloud/apps/files/videooplayer/appinfo/signature.json nextcloud/resources/ nextcloud/resources/config/ nextcloud/resources/config/mimetypesmapping.dist.json nextcloud/resources/config/ca-bundle.crt nextcloud/resources/config/mimetypealiases.dist.json nextcloud/resources/codesigning/ nextcloud/resources/codesigning/root.crt nextcloud/resources/codesigning/root.crl nextcloud/resources/codesigning/core.crl nextcloud/resources/codesigning/core.crt</pre>
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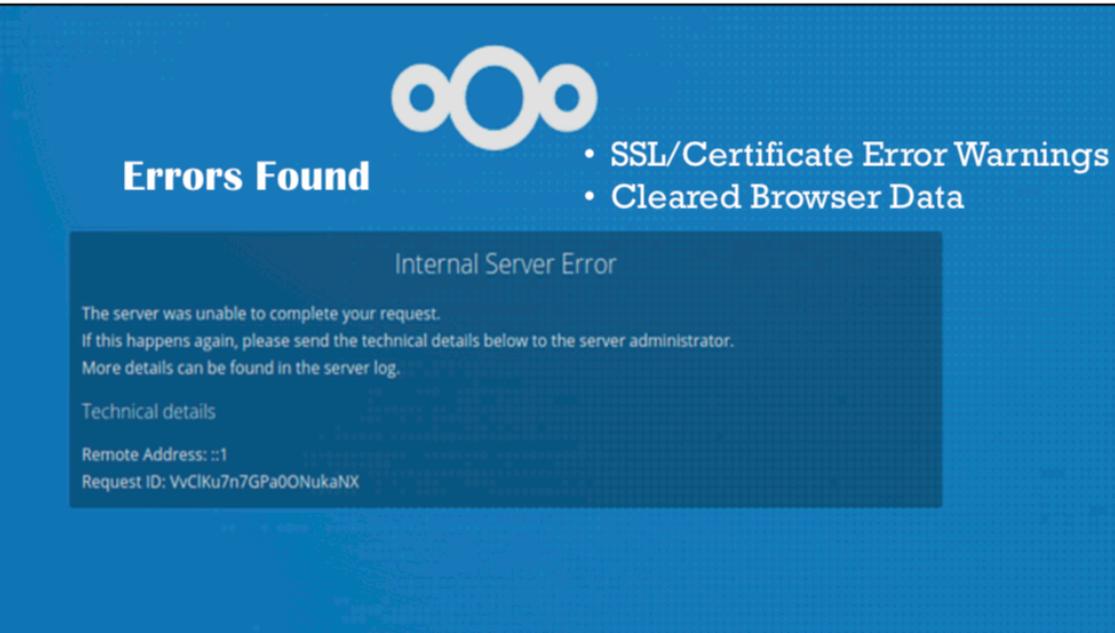


Nextcloud Installation (Steps Scrapped)

- Port Forwarding
- Dynamic DNS
- Mounting External Drive



Errors Found



- SSL/Certificate Error Warnings
- Cleared Browser Data

The server was unable to complete your request.
If this happens again, please send the technical details below to the server administrator.
More details can be found in the server log.

Technical details

Remote Address: ::1
Request ID: VvCIKu7n7GPa0ONukaNX

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27.146790 2019] [mpm_prefork:notice] [pid 2360] AH00169: caught SIGTERM, shutting down
34.435814 2019] [ssl:warn] [pid 455] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
34.437103 2019] [ssl:warn] [pid 455] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
36.440396 2019] [ssl:warn] [pid 498] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
36.448565 2019] [ssl:warn] [pid 498] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
36.462767 2019] [mpm_prefork:notice] [pid 498] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal op
36.462826 2019] [core:notice] [pid 498] AH00094: Command line: '/usr/sbin/apache2'
11.202727 2019] [mpm_prefork:notice] [pid 498] AH00169: caught SIGTERM, shutting down
11.528072 2019] [ssl:warn] [pid 3286] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
11.528268 2019] [ssl:warn] [pid 3286] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
11.657318 2019] [ssl:warn] [pid 3287] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
11.657427 2019] [ssl:warn] [pid 3287] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
3.11.673383 2019] [mpm_prefork:notice] [pid 3287] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal op
6.34.997646 2019] [mpm_prefork:notice] [pid 3287] AH00094: Command line: '/usr/sbin/apache2'
6.42.689766 2019] [ssl:warn] [pid 454] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
6.42.690912 2019] [ssl:warn] [pid 454] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
6.44.624637 2019] [ssl:warn] [pid 497] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
6.44.624837 2019] [ssl:warn] [pid 497] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
56.44.648189 2019] [mpm_prefork:notice] [pid 497] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal op
56.44.648202 2019] [core:notice] [pid 497] AH00094: Command line: '/usr/sbin/apache2'
21.44.406112 2019] [mpm_prefork:notice] [pid 497] AH00169: caught SIGTERM, shutting down
21.44.928250 2019] [ssl:warn] [pid 3366] AH01906: Init: (127.0.1.1:443) You configured HTTP(80) on the standard HTTPS(443) port!
21.44.946241 2019] [mpm_prefork:notice] [pid 3366] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal op
23.52.632763 2019] [mpm_prefork:notice] [pid 3366] AH00169: caught SIGTERM, shutting down
23.52.633009 2019] [ssl:emerg] [pid 3656] AH02572: Failed to configure at least one certificate and key for 127.0.1.1:443
23.52.633035 2019] [ssl:emerg] [pid 3656] AH02311: Fatal error initialising mod_ssl, exiting. See /var/log/apache2/error.log for more information
23.52.633035 2019] [ssl:emerg] [pid 3656] AH02311: Fatal error initialising mod_ssl, exiting. See /var/log/apache2/error.log for more information
25.31.440213 2019] [ssl:warn] [pid 3775] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
25.31.440433 2019] [ssl:warn] [pid 3775] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
31.31.575420 2019] [ssl:warn] [pid 3776] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
31.31.575612 2019] [ssl:warn] [pid 3776] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
31.31.592259 2019] [mpm_prefork:notice] [pid 3776] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal op
31.43.40.799182 2019] [core:notice] [pid 3776] AH00094: Command line: '/usr/sbin/apache2'
31.43.48.723822 2019] [ssl:warn] [pid 456] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
31.43.48.727850 2019] [ssl:warn] [pid 456] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
31.43.50.648189 2019] [ssl:warn] [pid 498] AH01906: 127.0.1.1:443:0 server certificate is a CA certificate (BasicConstraints: CA == TRUE !?)
31.43.50.648307 2019] [ssl:warn] [pid 498] AH01909: 127.0.1.1:443:0 server certificate does NOT include an ID which matches the server name
23.43.50.676565 2019] [mpm_prefork:notice] [pid 498] AH00163: Apache/2.4.38 (Raspbian) mod_fcgid/2.3.9 OpenSSL/1.1.1c configured -- resuming normal operat
23.43.50.676753 2019] [core:notice] [pid 498] AH00094: Command line: '/usr/sbin/apache2'

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Demonstration



