Private Cloud Storage Management for an Organization

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Approval Certificate

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Abstract

A trend towards cloud computing is going on for several years now. Along with this trend, several issues and concerns regarding privacy and security have been emerged. This report starts off by briefly explaining the current challenges of traditional computing, together with the corresponding cloud solutions that moreover explain this rising trend. Mainly, the practice of ‘cloud computing’ is clearly defined and explained, together with a variety of user options. In this work, we have designed and implemented a private cloud management framework that will enable an organization to utilize the cloud services with customized privacy and security. An open-source solution “ownCloud” is used to illustrate the purpose. One particular option is looked at in-depth: establishing a private cloud using an INTEL® NUC 8 HOME MINI PC with Oracle VM VirtualBox. The report gives a step-by-step tutorial for setting up the necessary configurations. Finally, this setup is then compared with other popular commercial cloud services.

Acknowledgement

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Chapter 1

1. Introduction

The Cloud has become a greatly full term over the previous couple of years. It covers several services and technologies that are around for a few time which don't seem to be essentially offered along Winans & Brown, 2009 [25]. Giant cloud vendors provide data center hosting generally combined with web applications, ability with alternative applications and far a lot of. Generally even the internet as an entire is mentioned as 'The Cloud'. to supply clarity, the cloud idea, shown within the image below, is outlined by NIST (National Institute of Standards and Technology) to make a framework which will be wont to classify specific services Mell & Grance, 2011 [26]. It splits the cloud into three service models namely, software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

In SaaS, access to end user applications, such as Gmail, is provided over the Internet or intranet through a thin-client interface. The applications themselves actually run in a datacenter and not on the local terminal Apprenda, 2016 [3]. The PaaS model is designed for software developers. It offers development tools for web and mobile applications over the internet or computer network. Examples are Red Hat OpenShift and Google App Engine. Finally, IaaS, may be compared to home utilities like electricity. Storage and processing power is delivered over the Internet or intranet. This allows for on-demand sharing of data, online backups and much more. However, it is the customer's responsibility to manage everything that is running on the server Kabir, Islam, & Hossain, 2015 [13].

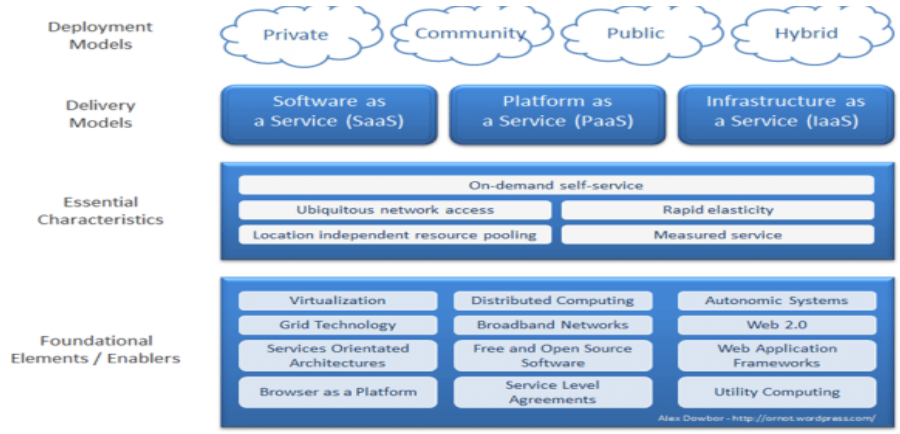


Figure 1:Visual Model of National Institute of Standards and Technology Definition of Cloud Computing.

Public, Private and Hybrid Clouds

Another distinction should be created relating to the readying models between public, non-public or hybrid clouds.e In public clouds, the providers offer their physical resources to multiple Organizations and/or consumers simultaneously. It will host each a group of services and individual services. In private clouds, these resources are not shared. In this case, the service providers dedicate specific computing power, storage and other resources to a single client. We also talk about private clouds when a company/consumer has created its own cloud by investing in resources such as a datacenter. It can then be referred to as an own premises cloud.

Public clouds can be offered more competitively since the providers can make use of economies of scale. However, compared to private clouds, the clients have less control over things such as resource allocation and other configurations. Solutions exist that mix the cost- effectiveness of public clouds with the protection and configurability of private clouds. These are known as hybrid clouds.

Individual services

In private clouds, these resources are not shared. In this case, the service providers dedicate specific computing power, storage and other resources to a single client. We also talk about private clouds when a company/consumer has created its own cloud by

investing in resources such as a datacenter. It can then be referred to as an own premises cloud. Public clouds can be offered more cheaply since the providers can make use of economies of scale. However, compared to private clouds, the clients have less control over things such as resource allocation and other configurations. Solutions exist that mix the cost- effectiveness of public clouds with the safety and configurability of private clouds. These are known as hybrid clouds.

National Institute of Standards and Technology Definition

Characteristics that apply to all or any cloud service models and preparation models are on-demand self-service, resource pooling, broad network access, fast physical property and measured service. According to the NIST definition of cloud computing, a service must have these essential characteristics to be labeled as a cloud solution. 'On-demand self-service' is the ability to hide and adapt the limitations of the system so that it appears to be infinite to the users. 'Resource pooling' means, for multiple users, the resources are combined and assigned dynamically to improve efficiency. With 'broad network access', the resources area unit accessible over the internet through multiple platforms. 'Rapid elasticity' is achieved once the resources are often scaled simply to address ever-changing demand. Next to that, the characteristic of 'measured service' is one that can be seen on any cloud service. The user receives bound restricted resources supported the subscription model. The usage of these resources is shown to the user.

Business Context

In the current fast markets, it is of the essence that companies are flexible to adapt to new opportunities and threats. Therefore, focusing on the core business is increasingly important. Services that merely exist to support the delivery of the core products and core services become subject to outsourcing. In many cases a specialized company can provide the same service more cost-effectively, qualitatively and efficiently. When this is the case, outsourcing is done when it doesn't pose a threat to the company's intellectual property. For almost all firms, IT infrastructure makes up the backbone of their entire operation. Sometimes it includes an in-house built cloud. Factories and other facilities across borders rely on secure connections for day-to-day communication and operation. Establishing and maintaining such infrastructure requires significant investments and in-house knowledge. Although important, in most cases it is not the core business of a

company. Cloud vendors today are able to offer the same, and better, infrastructure in a much more cost-effective way.

Current issues for corporate IT

Data Centers require large investments and are thus fairly fixed assets. With a fixed capacity, it cannot cope with the unbalanced workload that arises from the complexity of current global markets. Also, for startups and SME's, it is difficult, if not impossible, to finance such an investment. As business applications are costly to create/buy and integrate within the company, many of them are outdated and lack the ability to communicate with other application platforms outside the company. This, in turn, can put a strain on overall business performance.

Cloud Solutions

The cloud gives answers to these issues Kabir et al., 2015 [13]. Cloud vendors, thanks to their large scale, are able to efficiently handle spikes in demand. They offer scalability and agility and can afford to keep updating their systems to state-of-the-art technology. Next to that, geographical distribution offers many opportunities in network efficiency but also energy efficiency and cost-savings. Demand can easily be shifted to parts of the world where it is night or to a location where it can currently draw solar power or any other cost-effective source of energy (green computing).

Application portfolio management is also improved thanks to virtualization, by which the partners can be presented with a standardized platform that, in the short-term draws upon all their current applications, in order for the transition to newer technologies to go as smooth as possible.

Overall, cloud computing offers resource efficiency and a modernized and up-to-date IT application portfolio in the short term. Moreover, it offers long-term business advantages such as agility. An example would be an acquisition of another company. Now, it is a painstaking process for the IT department to integrate different systems. These problems are easily overcome by the use of a distributed platform. Financially, the business is also more agile because high capital investments are exchanged with much lower operational costs. This leaves financial room for other business needs.

Security concerns

Many of the basic features that make cloud services so appealing, also make up the foundation of some major security concerns Mazhar Ali, Khan, & Vasilakos, 2015 [2]. Only some concerns are described here. Cloud solutions offer scalability by pooling resources. Many users are tied to the same resource set. This results in the chance of knowledge exposure to alternative users. Next thereto, during this shared surroundings, the safety of the whole service is just nearly as good as its weakest link. An entrant would possibly compromise the full service from this weak link. These shared resources together with scalability inevitably lead to one client using resources that were once allocated to another client. Using data recovery techniques, sensitive data from previous users can easily be exposed Balduzzi, Zaddach, Balzarotti, & Loureiro, 2012 [5]. Next to that, the different cloud service models are interdependent. IaaS can be seen as the basis upon which the Paas is built. Similarly, the applications of the Saas are developed using the PaaS tools. Intruders can take advantage of these dependencies by attacking one model and compromising the other service models that are left exposed. A more obvious risk source are the service providers themselves. Employees with bad intentions might be granted sufficient access to pose a potential threat. From this, it's clear that there square measure still several security, privacy and regulative threats that require to be addressed by the cloud vendors. For large corporations, many of these concerns can be tackled in service level agreements (SLA) with the vendor M Ali et al., 2015 [2]. This way they can already make use of many cloud technologies before planning a full transition to cloud applications and services. Still, legal issues become somewhat harder to tackle when the data is migrated to a datacenter located in a country with different laws.

Customer Context

Large corporations have the power to secure many potential risks of cloud computing by means of tailored contracts negotiated with cloud vendors. This involves ownership of data, IP protection and law enforcement in case of security breaches and much more. In contrast, most individual users don’t have this negotiation power and are left with many concerns. These include the reliability of the service, data security, privacy, increased

dependency upon a third party, fairness and transparency of the unnegotiable terms and conditions and so forth Cunningham, 2013 [27].

Most cloud service providers operate under a freemium model. Limited services are offered for free and the user receives the option to pay for subscription fees depending on the services needed, such as extra storage. The user however, becomes increasingly dependent upon the services that are linked to one another, often including cloud storage, web mail and calendar applications. Therefore, consumers are increasingly led into paying more for cloud service.

Another problem with free cloud services comes from the need for a revenue stream. The service provider can achieve this by collecting and selling user data. This in itself is not necessarily a problem. The problem arises when the transparency of these transactions are questionable. Mostly, users are not aware which data is shared with whom and might find themselves more exposed than anticipated.

Private Cloud Solutions for customers

Setting up your own cloud can thus be very beneficial for a couple of reasons. Cost and privacy reasons have been discussed above. Three important service platforms iCloud, Google Drive and Dropbox all handle similar pricing schemes that include free basic storage and monthly fees for extended storage. Google Drive takes the lead here with 15 GB free storage, which is 3 times more than iCloud's base storage and almost 8 times more than what Dropbox offers for free, 2 GB. For 1 TB of storage, you will pay $9.99 per month on all of these platforms. Given that subscribing for the 1TB plan for 1 year would cost you more than buying a 1 TB hard drive, for many people, the choice is quickly made.

The amount of features is platform dependent but many include a sharing option, auto-sync to local folders and calendar synchronization. Luckily, there are many options available for creating a private cloud with similar features. Solutions range from more expensive ready-to- use NAS devices (Network Attached Storage, cf. below), to very cheap or free software that can be installed on basically any system to achieve similar

goals. All these solutions are based on the same core elements, a storage device, processing power, Internet connectivity and software.

A potential downside can be speed. Whereas file transfer speed within the local network is faster than downloading files over the Internet, outside the boundaries of your network this is usually not the case. For every download from your private cloud, the transfer rate is limited by the upload speed established by your ISP. With the most common ISP's in Bangladesh, Aamranetworks Ltd consumer upload speeds are limited, especially compared to download speeds. Aamranetworks offers upload speeds of 20 Mbps, 50Mbps or 100 Mbps, depending on the service plan. Downloading your files from a cloud service is (after uploading it at the usual upload speed) only limited by your download speed offered by the ISP, which can easily be 100 Mbps.

NAS

A NAS or network-attached storage device is a simple computer, specifically aimed at serving files to a single or multiple users. In many cases, it is used to also provide data redundancy through the use of a RAID array. Here, depending on the RAID level, the data is automatically distributed across the drives. The files are shared using multiple network file sharing protocols such as AFP (Mac OSX), NFS (UNIX) or SMB/CIFS (Windows). Compared to existing cloud services, a NAS is much more sophisticated on certain domains. It has similar storing and sharing capabilities but next to that, it can act as a multimedia server, a print server or a small database server. However, it lacks other features that many cloud services offer such as deduplication and block-level compression.

NAS boxes are often sold with a bundle of applications and are accessible through a 'simple' web interface. QNAP, Synology and Western Digital are well established names in the NAS

Market. However, with these boxes customizability is limited, prices tend to be high and energy consumption is high as well. That is why, you might be better of building a NAS from scratch. Our aim here is to build a system similar to current cloud offerings, for personal use and occasional sharing. Requirements for this system are fairly low and so an INTEL® NUC 8 HOME MINI PC with Oracle VM VirtualBox will do the job.

Chapter 2

2. Background and Literature Review

The following section explains the components needed for a private cloud. Next to that, it specifies the options and the choices that were made. For this project, an INTEL® NUC 8 HOME MINI PC with Oracle VM VirtualBox is used, running Ubuntu 16.04 as operating system. There is an Apache2 server running on it, as well as the file-hosting service OwnCloud and file-sharing service the WebDev. To make it easier to connect to the server permanently, we installed no-ip client software. To provide some level of data redundancy, a daily backup process is scheduled at night using rsync and crontab.

2.1 Intel NUC 8 Home Mini PC

The Intel NUC 8 Home Mini PC is a low cost, low energy mini-computer that is aimed at teachers and students. With it, they are introduced to programming and computers in general. It can be used as any other computer to browse the web, read e-mails etc., but in most cases it will be used for specific projects and for prototyping. When correctly set-up, it can be used as a NAS box, very much like the of-the-shelve-boxes. For this project we will be using the original Intel NUC 8 Home Mini PC. The newer versions are similar but offer improvements in performance and memory size. The original version is currently available for +/- $480 and has the following specifications:

Figure 2: Intel NUC 8 Home Mini PC

Board Form Factor: UCFF (4" x 4"),Processor:Intel®Core™i3-8121U(4MCache) Processor speed: up to 3.20 GHz TDP: 15 W DC Input Voltage Supported: 12-19 VDC

Memory: 4GB LPDDR4-2400, Hard disk: 1 TB M.2 Card Slot (storage) 22x80 RAID Configuration 2.5" HDD/SSD + M.2 SATA/PCIe SSD (RAID-0 RAID-1) Integrated, LAN:10/100/1000 mb, Integrated Wireless: Intel® Wireless-AC 9560 + Bluetooth 5.0 Intel® Virtualization Technology for Directed I/O (VT-d): Yes 6 USB 2.0 ports

2.1.1 Operating System: Ubuntu 16.04 TLS

Ubuntu may be a free and open-source UNIX system distribution supported Debian OS. Ubuntu is formally free in 3 editions: Desktop, Server, and Core for internet of things devices and robots. Ubuntu may be a standard OS for cloud computing, with support for OpenStack and owncloud. There are operating systems out there that are specifically tailored for building home storage devices. They are slimmed-down versions of general-purpose operating systems, focusing on file sharing protocols and features. Its need to install you should follow Minimum System Requirements:

2 Gigahertz dual core processor, 2 GB RAM (system memory), twenty five GB of hard-drive area, VGA capable of 1024x768 screen resolution.

We will use Ubuntu, based on Debian, because it is optimized for the Intel NUC 8 Home mini PC. It offers the flexibility to install other native Linux packages. Next to that, it is fairly well documented.

2.1.2 OwnCloud

ownCloud is a free and open-source suite of file hosting services with which your data is synchronized among all your connected device. It offers the same features as Dropbox and many more such as contact synchronization. Since it is open-source, applications can easily be made to expand the platform. Examples include in-browser video streaming and a photo gallery. Alternatives for ownCloud are Pydio, Sparkleshare and Seafile. Pydio has a nicer GUI than ownCloud, better performance for large data but fewer documentation at the moment. Sparkleshare is more focused towards documents, as it offers build in version control as well as a revision history. Seafile is still very much under development and has less support for file sharing protocols.

ownCloud is basically an application running on the operating system. To be available online, a web server must be installed as well.

2.1.3 Web Server: Apache

For accessing files that are stored on your Mini PC over the Internet via an Internet browser, we will need a web server. It stores, processes and delivers web pages to clients. Basically, a client, being a web browser, asks for a web page or a specific resource by sending an HTTP GET request to the server. The server, in turn, responds by sending the resource via HTTP. To enable uploading of files, the web server can also receive content from its clients.

There are two HTTP servers that are so popular that they make up half of the traffic on the Internet. These are Apache and NGINX (pronounced Engine X). Both are open source and can provide the same basic server solutions. However, they both have their unique features that make them better suited in specific situations Ellingwood, 2015 [8]. Apache is older and is chosen for its flexibility, power and extendibility. It can deliver static and dynamic content internally but has difficulties coping with a large amount of concurrent connections.

NGINX, on the other hand, released in 2004, focuses on scalability in order to meet the requirements of thousands of simultaneous connections. With its light-weight architecture it makes very efficient use of its resources. NGINX only handles static content internally. Dynamic content delivery (such as PHP requests), however, is a task that is passed on to other modules. This means that NGINX needs to communicate with the processor via some protocol such as memcache.

The two HTTP servers also differ on many other aspects such as their module system, their mapping of requests to resources and their configuration systems.

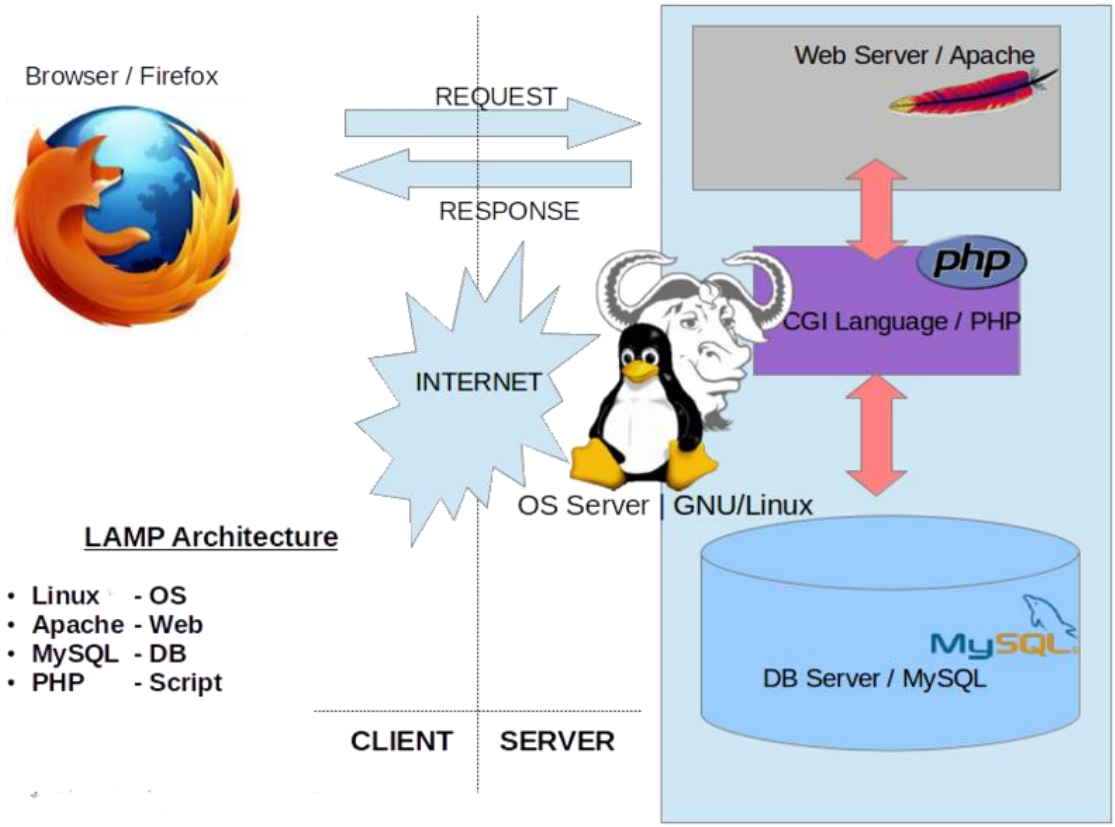


Figure 3: Web Server: Apache

2.1.4 Scripting language: PHP 7.1

Pages and documents can be delivered statically or dynamically. With static web pages, the user simply views a page but cannot alter the information on that page. There is no interaction. The web page is an HTML document that exists at the server-side and which is transferred to the browser when a request comes in. However, this means that the web page does not necessarily show the correct state of the documents that you want to view. This is crucial for good file-sharing services. Next to that, no changes will be seen on the page after deleting or uploading files.

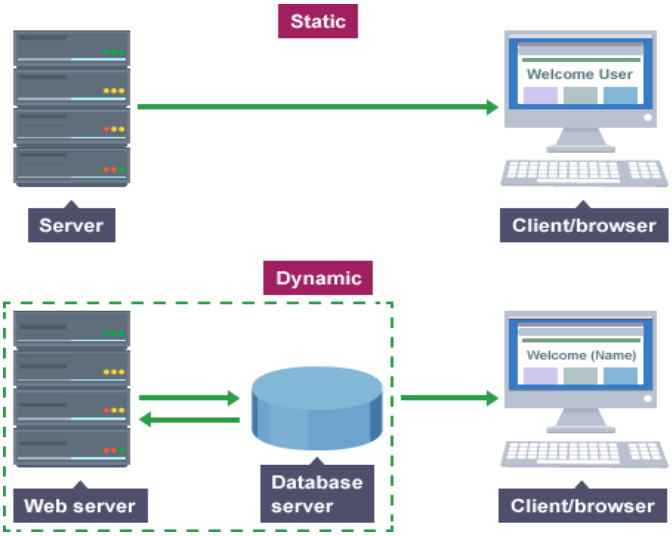


Figure 4: PHP work Static & Dynamic

Dynamic web pages provide a solution for this. They create a live user experience. They can be provided in two ways, either by client-side scripting or server-side scripting.

A server-side dynamic web page is built on-demand by the web server using a scripting language such as PHP, ASP, Perl, etc, to retrieve the necessary information and combine it into an HTML document. Most web servers support scripting languages to achieve this goal. PHP7.1 will be used to create our cloud environment.

With a client-side dynamic web page, the browser itself creates the interaction within the page. Scripting languages such as JavaScript are used to process the web page as it loads and to then reload to change the variable content.

2.1.5 Dynamic DNS service: no-ip

Every Internet-connected household receives an IP address from the Internet service provider (ISP). These IP addresses are mostly dynamic, meaning that the service provider redistributes the IP addresses after a period of time, using the Dynamic Host Configuration Protocol (DHCP). This is done partly to minimize the amount of used IP addresses, given that not all clients will be online at the same time. However, this poses a problem when trying to access a private cloud from outside the local network. All Internet domain names are linked to an IP address, using a table called the Domain Name System (DNS). However, when the IP address of the server, running that domain name

changes, the table is not adjusted automatically. After such a change has occurred, a user won't be able to connect anymore.

A Dynamic DNS (DDNS or DynDNS) service links and updates the most current IP address to connect to a hostname in the DNS. This works by installing a client program on the device that is running the server and setting it up using the same login-information as used on the website of the DDNS provider. The DDNS client sends the correct IP address to the service, which adapts its binding to the domain name, ready to provide it to anyone that enters the domain name.

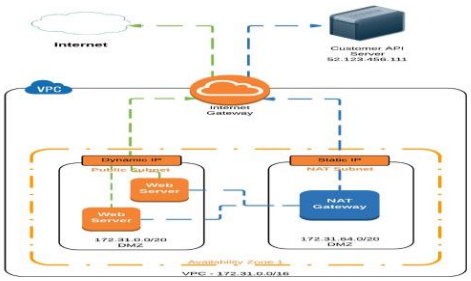


Figure 5: Dynamic DNS service: no-ip

2.1.6 File sharing protocol: WebDAV and NFS

File-sharing protocol include the WebDAV, NFS, FTP and AFP. WebDAV (Web Distributed Authoring and Versioning) is an extension of HTTP with certain file-sharing capabilities. It is mostly used in one of its extensions such as CalDAV, developed for remote calendar access; and CardDAV, which is used to share an address book on a server.

NFS or Network file system could be a distributed filing system protocol, originally designed by the Sun Microsystems. Through NFS, a user will be able to enable a system to share directories and files with others over a network. In NFS file sharing, users and even programs will access data on remote systems virtually as if they were residing on an area machine. NFS is operated during a client-server atmosphere wherever the server is accountable for managing the authentication, authorization, and management of

purchasers, still as all the data shared among a particular file system. NFS (Network File System) additionally lacks good security.

FTP “File Transfer Protocol” is an old protocol that is known for its weak security Steiner, 2010 [21].

Other file-sharing options include SMB (“Server Message Block”), has been the main Windows File Sharing protocol since the 90s. The protocol, although developed by IBM, is proprietary to Microsoft. However, it was revers engineered to create the Samba protocol. Samba allows unix-based systems to share files in a Windows environment and was implemented by Apple in OS X 10.2. Apple itself however, already used another protocol for file-sharing among macs (unix), called AFP (“Apple Talk Filing Protocol”). AFP outperforms SMB in numerous ways including read/write performance and sleep suspend support JPY, 2015 [12]

With Windows Vista, Microsoft has released a new version of SMB, SMB2, which enhances speed, reliability and security. So much even that Apple introduced its own implementation of the SMB2 protocol, named SMBX Dilger, 2013 [7]. It has been pushing SMBX to be its default file-sharing protocol and would only fall back onto AFP for devices that don’t support SMB(X). This way, Windows compatibility is strongly improved. More recently SMB3 was released, with many features not present in AFP such as encryption and SMB multi-channel Ryan, 2016 [18]. Apple will likely decrease support for AFP in favor of SMB3 in the upcoming years. For now, however, AFP is still a great choice in a mac-only environment thanks to its performance, simplicity and documentation.

2.1.7 Data redundancy: Rsync

Rsync (Remote sync) is used to copy and/or synchronize directories and files, both locally and remotely Shrivastava, 2013 [19]. It minimizes the required effort by transferring only the differences between two sets of files. It finds where the differences are located within a file and transfers only those data blocks. The blocks that need to be transferred, are first compressed to consume less bandwidth. By default, rsync compares files and directories on both ends based on the ‘last modified date’ and the size of the file. This will miss differences that don’t appear in these two attributes. The probability of

these type of differences occurring is very slow in a normal user environment. In environments where this occurs often, or where no mistakes are tolerated, the option --checksum offers a thorough checksum comparison. This requires more time to process.

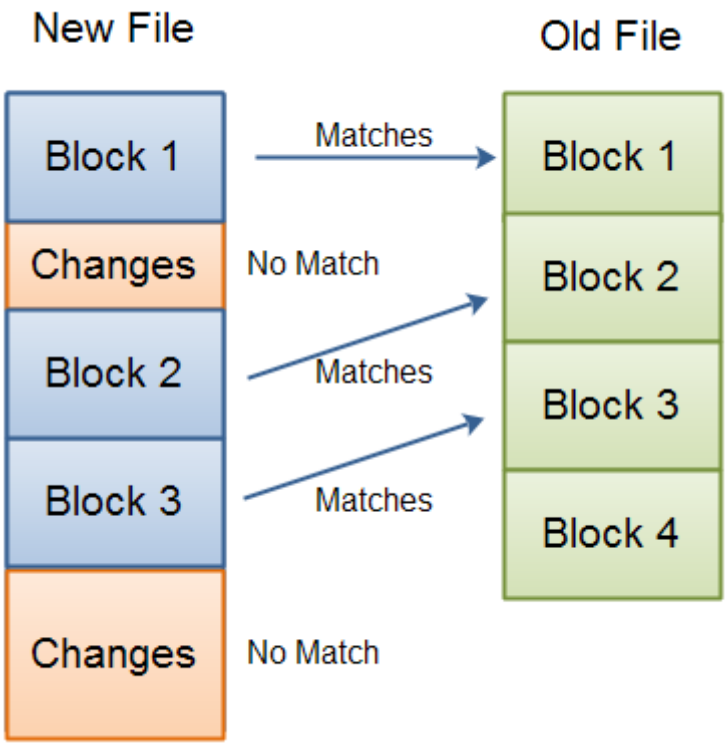


Figure 6: Data redundancy: Rsync

2.2 Private Cloud Computing

Cloud computing is used to describe a range of computing ideas that involve a wide range of computers connected through a distributed communication network like the internet. The National Institute of Standards and Technology's definition identifies "five essential characteristics" of cloud computing:

On-demand self-service: A client will unilaterally avail computing capabilities, like server time and network storage, as required mechanically while not requiring human interaction with every service provider.

Broad network access: Capabilities are accessible over the network and accessed through normal mechanisms that promote use by heterogeneous skinny or thick consumer platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling: The provider's computing resources are pooled to serve multiple customers employing a multi-tenant model, with totally different physical and virtual resources dynamically appointed and reassigned consistent with client demand.

Rapid elasticity: Capabilities will be elastically provisioned and free, in some cases mechanically, to scale quickly outward and inward corresponding with demand. To the buyer, the capabilities on the market for provisioning usually seem unlimited and might be confiscate in any amount at any time.

Measured service: Cloud systems automatically manage and optimize resource use by investing a metering capability at some level of abstraction applicable to the specific type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage will be monitored, controlled, and reported, providing transparency for each the supplier and client of the used service.

Cloud computing in developing countries

The utility of mainstreaming could computing in ICT services of a government is widely acknowledged. It the advantages include but are not limited to reduction or repurposing of on-site ICT personnel through increasing the availability of ICT resources and infrastructure. The need of adopting policies for cloud computing in organizations is becoming more apparent with time and a lot of organizations are taking the lead in adopting this technology. A lot of these organizations are developing their cloud computing capacity these days. The economic benefits of this technology is driving many developing countries like Bangladesh in adopting this technology. Low establishment cost and flexibility are the key motivators in this movement for these countries. Despite many challenges, low-cost and highs-peed ICT infrastructure is made accessible to many organizations across the globe as an online service through cloud computing technologies.

Overall statistics of information storage in cloud server

The desire to share content and to access it on multiple devices can encourage customers to begin storing a third of their digital content within the cloud by 2021, consistent with Gartner, Inc. Gartner aforesaid that simply thirty six percent of client content was keep within the cloud in 2016, however this may grow to seventy percent in 2021.

Processor Growth: Moore's Law Garden Moore, Director of R&D, and Fairchild Semiconductor 1965: semiconductor density doubling each 2 years

Storage Capacity: Exa=1018, Zetta=1021, Yotta=1024. Scales extended from Giga to Yotta in 1991 42% compound annual growth rate (CAGR)

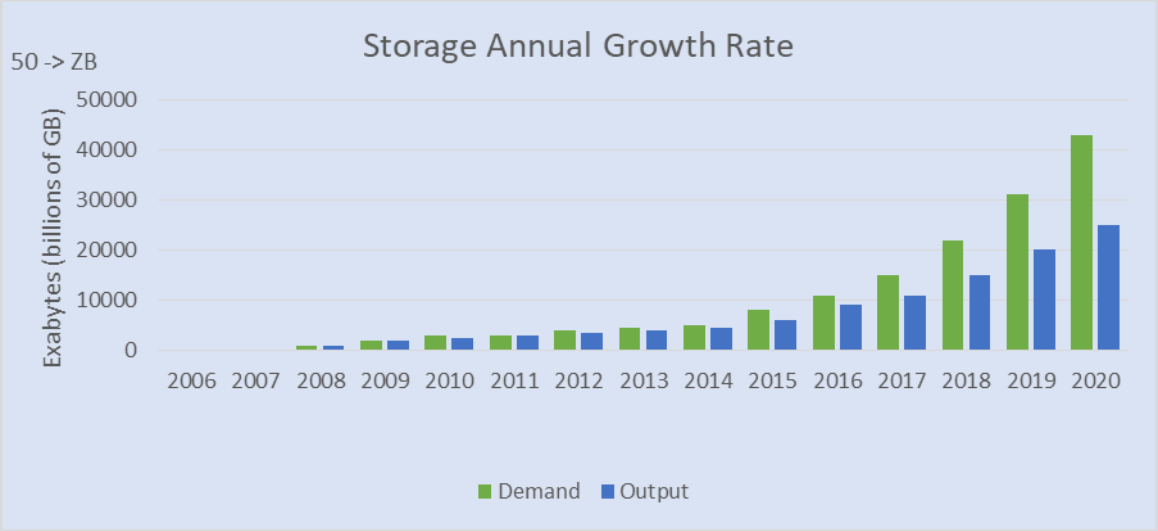


Figure 7: Storage annual growth rate

Global data center traffic

Annual world data center IP traffic can reach 20.6 Zettabytes (ZB) (1.7 ZB per month) by the tip of 2021, up from 6.8 ZB annually (568 Exabytes [EB] per month) in 2016.

Global data center IP traffic can grow 3-fold over future five years. Overall, data center IP traffic can grow at a Compound Annual rate of growth (CAGR) of 25 % from 2016 to 2021.

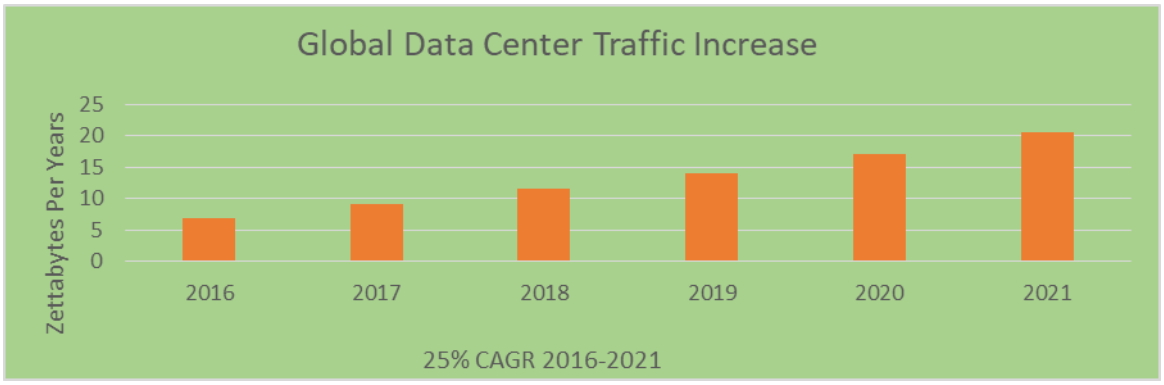


Figure 8: Global Data Center Traffic

Global cloud traffic

Annual world cloud IP traffic can reach 19.5 ZB (1.6 ZB per month) by the top of 2021, up from 6.0 ZB annually (499 EB per month) in 2016.

Global cloud IP traffic can over triple (3.3-fold) over future five years. Overall, cloud IP traffic can grow at a CAGR of 27 % from 2016 to 2021.

Global cloud IP traffic can account for 95 % of total data center traffic by 2021.

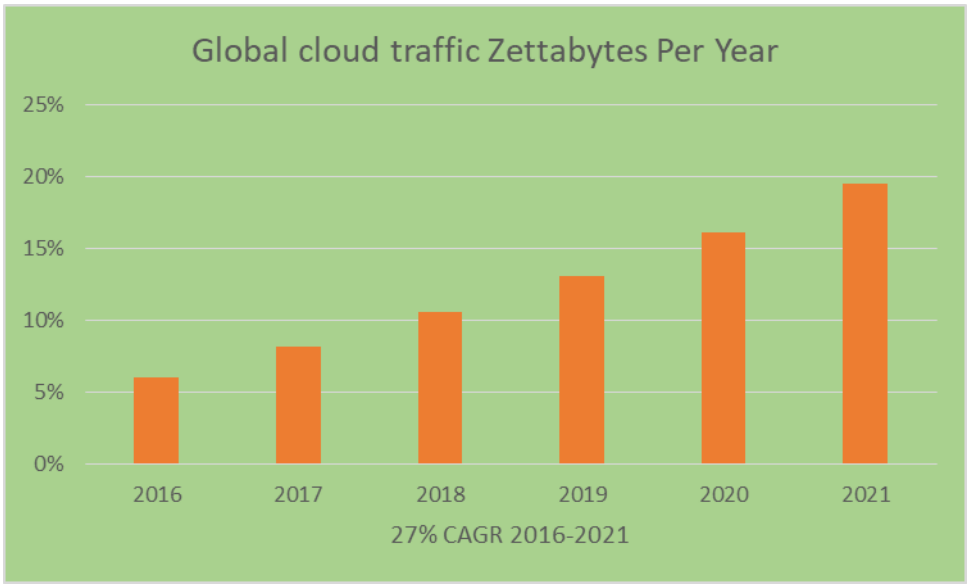


Figure 9: Global Cloud Traffic

Most of those data are from the developed countries like Japan, Australia, US and Germany. The expansion of the distribution of cloud traffic will increase considerably every year. The distributed cloud traffic map of 2017 is shown below.

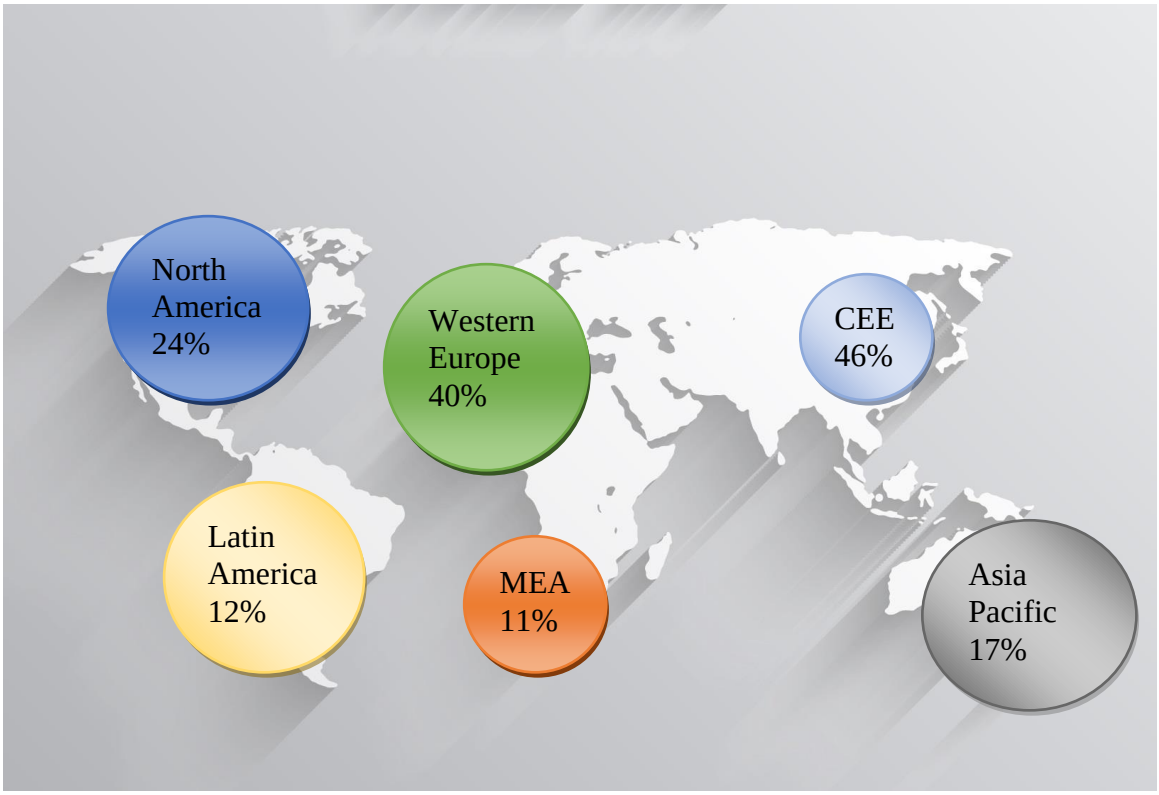


Figure 10: The distributed cloud traffic map of 2017

Report of Gartner Hype Cycle 2017

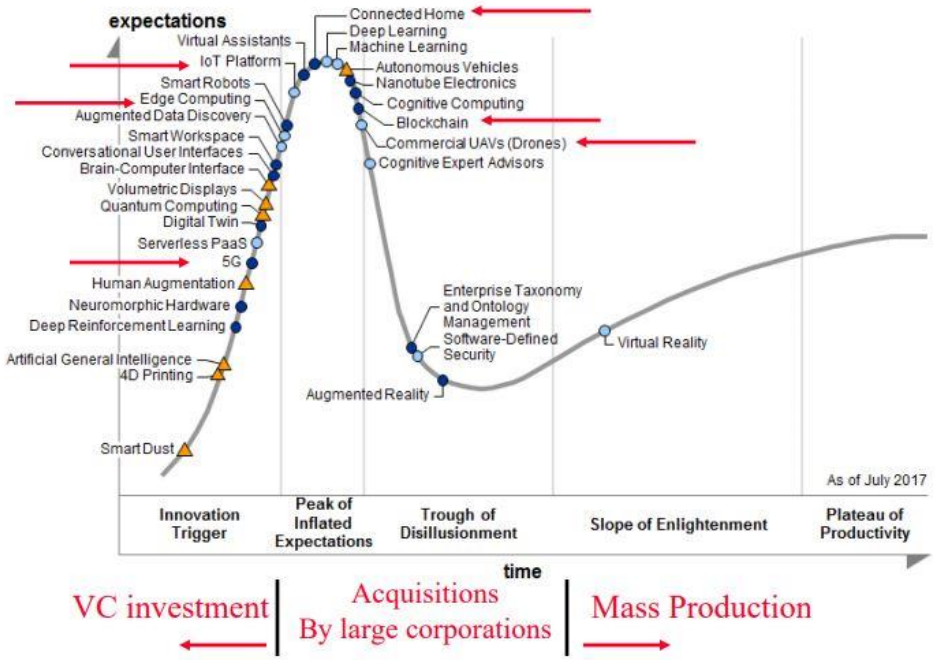


Figure 11: Gartner Hype Cycle 2017

Offers of cloud technology for developing countries

The developing nations, a lot of which are in Asia can benefit from cloud computing and cloud storage services in several ways. Cloud computing services become particularly appealing to these nations because the cloud computing and associated services can evolve with the change in need due to growth in business. The potential benefits are as follows:

- Renting ICT hardware and software cuts expenditure in ICT personnel and devices
- Flexibility in utilizing storage and processing capability based on changing demand
- High-speed access to data and services from cloud and increased flexibility
- Less cost involvement in upgradation of software at greater speed
- Greater security and reliability for application and data are offered by cloud services

2.3 Cloud computing technology in Bangladesh

Bangladesh is not catching up with the rest of the world in adopting cloud computing.

Very few organizations in Bangladesh are exploring the scopes of cloud computing for internal automation and public service delivery. There is a widespread general mistrust in Bangladesh regarding the applicability of cloud computing.

In the following table, we have elucidated some of the opportunities and challenges to adopting cloud computing in organizations and industries in Bangladesh.

Table 1: Challenges and opportunities to mainstreaming ownCloud in Bangladesh

Opportunities	Challenges
Cost potency Service measurability Efficiency in using ICT Dimensions in business Accelerated promotion Innovation ICT capacity development in small and medium sized industries Use of cloud computing for developing of e-learning platforms and establishing e-education Use of cloud computing in developing and implementing enterprise resource for systems and managing customer relationship Use of cloud computing in establishing e-government and e-democracy Use of cloud computing in creating employment opportunity for the youth Green Computing	Security Privacy Change in organizational structure Performance Financial Legal Learning Sanctions Lack of standards

2.4 Opportunities of cloud technology in Bangladesh

Cloud computing could be a framework for mainstreaming social innovation and as well as modernizing ICT. New processes, systems and offerings can be developed using cloud computing platforms for business units. It will create a lot of competitiveness. Cloud computing also helps flip ICT into a more practical and responsive services in business. By making certain on-demand access to pools of trusty infrastructure and services, cloud computing facilitates de-coupling of business initiatives from the ICT capabilities that drive them. A number of the subsequent problems is treated because the cloud offers immeasurable benefits to its purchasers. Cloud computing can offer several benefits to organizations in Bangladesh. A number of them are:

Cost efficiency: The objective of introducing cloud computing in an organizations is to facilitate optimum utilization of ICT resources. Cloud computing also heps cut back expenditure on software and hardware procurement and maintenance by reducing the need of installing software in individual computers. A third party provides the outward lower barrier by eliminating the need of license and purchase of software for occasional use. Therefore, expenses on ICT infrastructure maintenance and operation are also reduced significantly. It is recommended that small and medium sized organizations and firms in Bangladesh that begin business with low capital, utilize the benefits of available cloud computing frameworks.

Service scalability: In case of sudden and unexpected service demands, cloud computing has proven to have significantly higher service delivery capacity. This specification will end up improving ICT service provision. In some applications within which this unheralded demand is related to an amount of time, this specification shows most of its functionalities.

Efficiency within the use of ICT: Organizations and industries in Bangladesh often try to avoid investing in ICT infrastructure and adopting recent technologies. Therefore, the opportunity of cloud computing far exceeds the normal expectation. As adopting cloud computing will not require replacement of the existing hardware, the deal becomes even more appealing in this context. Moreover, the adoption of this new technology will not affect productivity.

Business dimensions: Cloud computing can facilitate diversification of business scopes in a developing country like Bangladesh. It increases the change of growth in business as well as less overhead and greater sustainability without significant increase in expenditure.

Growth: Cloud computing facilitates quick rescaling of services and business. It is particularly helpful for businesses trying to enter a new market and retain existing customer base. This technology has gained popularity in businesses that try to rush up time-to-market for brand new products and services.

Agility: The scopes of ICT use in business is being reset by introduction of could computing. It offers versatility in ICT infrastructure and on-demand evaluation. Instead of modifying business, cloud computing model utilizes ICT as facilitates business lightness.

Adaptability: Cloud computing systems must offer great elastic capabilities. Could computing systems makes client organizations adaptable to changes in the quantity of requests and resource sizes through on-time reaction to these changes. Adaptability of an organization also depends on several environmental conditions, e.g. available resources, expected quality and routes.

Faster-time to market: A business adopts cloud computing for accelerating time-to-market. In order to compete with large industries, small and medium enterprise have to transform their services as fast as possible. By utilizing dynamic ICT infrastructure, they can bring their services to market fast. In contract, large industries thrive through innovation and less overhead.

Innovation: Organizations use cloud computing to limit investment into newer ICT infrastructure and remodel their existing hardware to fit the versatility in demand. These investments can be made toward the business growth without being limited by technological innovation. It also facilitates data analytics, social business and rendering mobile-friendly services. Cloud computing lets organizations and businesses adopt these

kinds of services and link those to develop new and innovative services, which in turn promote growth of those organizations and businesses. By exploiting these innovative features of cloud computing, organizations in Bangladesh can bring structural change and attain development through innovation.

ICT development in small and medium-sized industries: Bangladeshi small and medium-sized industries are faced with the issues in their services due to low ICT budget. Cloud computing provides some opportunities for organization that have low investment power on that infrastructures. These organizations can use cloud computing technologies to expand ICT services.

Using cloud service in developing e-learning and e-education: By exploiting cloud computing technology, Bangladeshi students can access academic services collaboratively and on the far side of the geographic.

Using cloud service so as to develop and implement enterprise resource coming up with systems and clients' relationships management: With regards to implementing enterprise resource planning (ERP) and customer relationship management systems (CRM), Bangladeshi organizations concerns over data security and privacy and high capital investment in ICT. ERP and CRM systems supported by cloud computing can facilitate introduction of innovative services within Bangladeshi organizations.

Using cloud computing service to understand e-government and e-voting: Voting is the pillar of democracy. While establishing e-government in Bangladesh is a priority, the achievements are limited by the investment in ICT resources. Deploying digital systems centrally and catering the services to the mass of 160 million people is a challenge faced by no other. The Government of Bangladesh can utilize could computing to reach its services to the grassroots level. The government can also utilize this technology to introduce e-voting and place a milestone in establishing e-governance. By establishing comprehensive coverage of internet connectivity and policy adoption, cloud computing can be of use in this regard.

Using cloud computing in telecommuting: To enable telecommuting in Bangladesh, the government can use cloud computing technology. It has the potential of bringing global and local teleworking opportunities to the youth of Bangladesh.

Green Computing: Cloud computing facilitates green computing by saving power used by ICT infrastructure. Environmental pollution is reduced by shifting to cloud computing as the existing ICT infrastructure is aggregated and sometimes reduced in quantity.

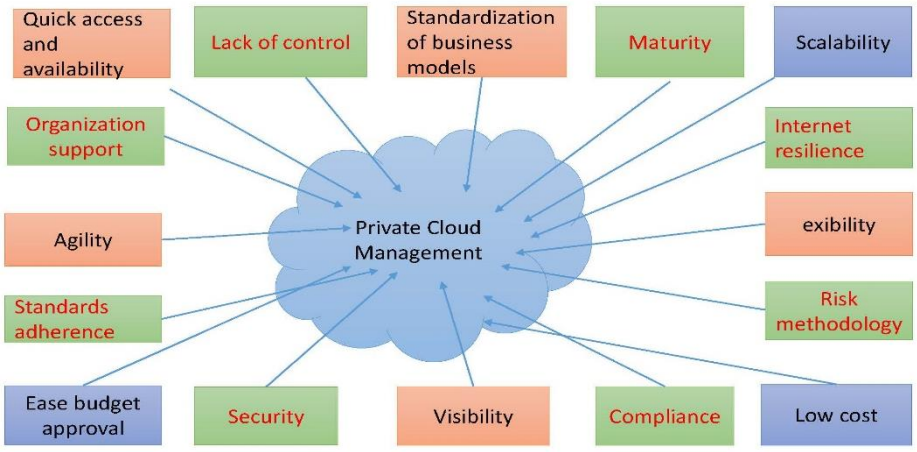


Figure 12: Private Cloud Management solution

Obstacles of mainstreaming cloud technology in Bangladesh

Unlike any new technology, there are challenges and obstacles to introducing cloud computing in Bangladeshi organizations and businesses. It involves extensive change management and capacity development of service providers.

The key obstacles to establishing cloud computing in Bangladesh are as follows:

Concerns over connectivity: Cloud service can be rendered inaccessible due to lack of internet coverage and limited bandwidth as cloud computing technology uses internet as the sole base for providing service. The organizations that deploy cloud computing in Bangladesh will inevitably face more cloud-based security threats than the past. Data leaks from user environments will still remain a challenge after cloud computing is adopted.

Concerns over Security and privacy: Though cloud computing has been proven globally to provide greater security to data, the perception of storing data in cloud begets a lot of negative feedback from the government officers. As cloud computing has made data more secure through reducing dependency on individual devices, hackers have started adopting novel techniques for luring the users in to revealing sensitive information

or to gain access to data stored in the cloud. Several instances of hacking of data in cloud have been reported globally, though rare and limited to high value corporate targets.

Change in structure: It is imperative that government organizations and industries in Bangladesh analyze their business processes for compatibility with cloud computing and overcome any obstacle before the technological switch is made. Some skills like project management and contract management ought to be considered for capacity development of the staff.

Financial: An organization planning to switch to cloud computing must consider that though cloud computing reduces overall cost of rendering a service, it shifts a lot of capital cost to operational cost. The budgeting method needs to adopt to this change as well to address this technological shift.

Legal: The local laws and legislations govern storage and transmission of data from cloud services provided by companies in every country. Therefore, caution has to be taken in choosing cloud service providers, specially located in foreign countries. Countries that frequently make it to the list of terrorism or international blacklists shoud be avoided at all costs when procuring cloud computing services.

Learning: It is important that the government agencies and industries that adopt cloud computing invest in ICT capacity development of their staff.

Lack of standards: As there is no established standard for providing cloud computing services, the consistency of services are sometimes below the desired level. Therefore, the government agencies must develop and publish their own standards and guidelines for procuring cloud computing and services.

Chapter 3

3. Methodology

This section is written as a tutorial in order to provide clarity in case this project needs to be reproduced. It is based on multiple tutorials with similar goals in mind. First, ownCloud is installed [26] [29] [30] [35](Gus, 2015a; Koff1979, 2012; Mayank, 2016; Young, 2015) and made available over the Internet (Gus, 2015b). Next, direct file sharing is enabled [34] (Thijxx, 2012). Furthermore, data redundancy is provided with rsync.

Table 2:Multiple Tutorial how to configure owncloud step by step with my mini PC

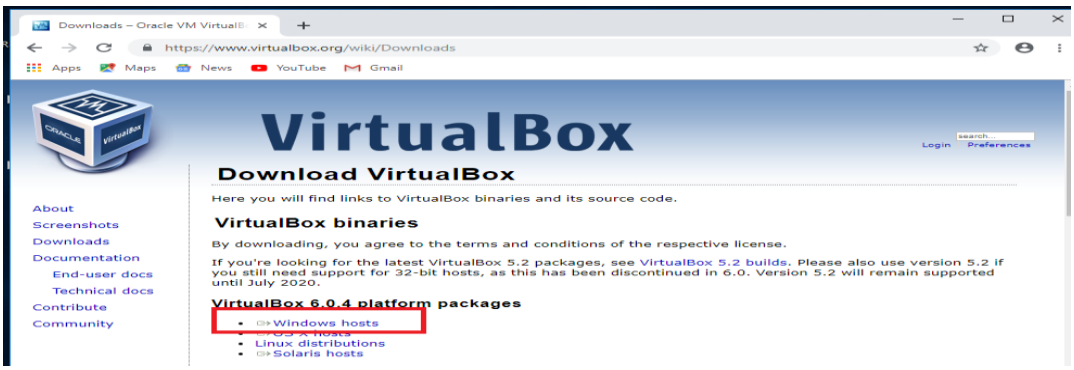
Name	When used
Hardware	Intel NUC 8 Home Mini PC Hard Disk 1 TB Ethernet cable 2 USB thumb drives Windows to SSH onto the an Oracle VM VirtualBox
Installing Oracle VM VirtualBox	We used 12 Step
Installing “Ubuntu 16.04 LTS” on VirtualBox 6.0.4	We used 20 Step
Installing and Setting up the Ubuntu 16.04 LTS and preparing for ownCloud	• First update the Ubuntu and all its packages to avoid errors down the line. • Setting up web server: apache • Setting up MariaDB Server • Scripting language PHP • Create OwnCloud Database • Setting up ownCloud • Enable SSL for Secure External Access • MikroTik Port Forwarding or Port Mapping for External Access • DDNS configuration

Hardware used: Intel NUC 8 Home Mini PC, Hard Disk 1 TB, Ethernet cable, 2 USB thumb drives, Windows to SSH onto the an Oracle VM VirtualBox

Own Cloud: Installing "oracle vm virtual box" Into a host "windows" pc: Install the free "Oracle VM Virtual Box" package program into a "Windows" pc. Then you'll be able to produce a limitless variety of "virtual machines" that run varied versions of "Windows", "MS-DOS", "Unix", and "Linux" computers. Basic info regarding "Oracle VM Virtual Box" ("Virtual Box") may be found at http://www.virtualbox.org/. Stepwise directions for putting in "virtual box"

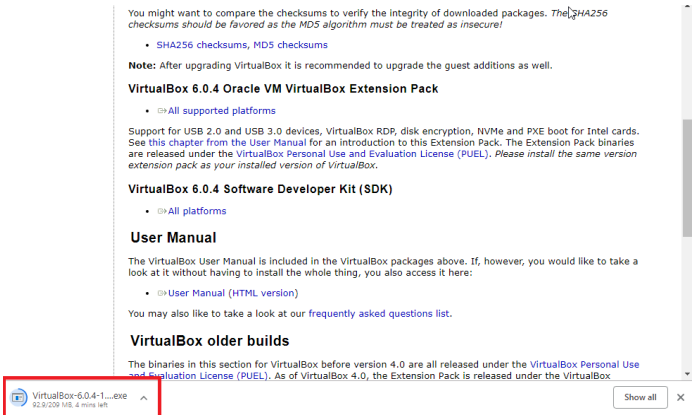
Step 1: begin an online browser like "Internet Explorer" or "Google Chrome".

Step 2: visit http://www.virtualbox.org/wiki/Downloads it's like this:



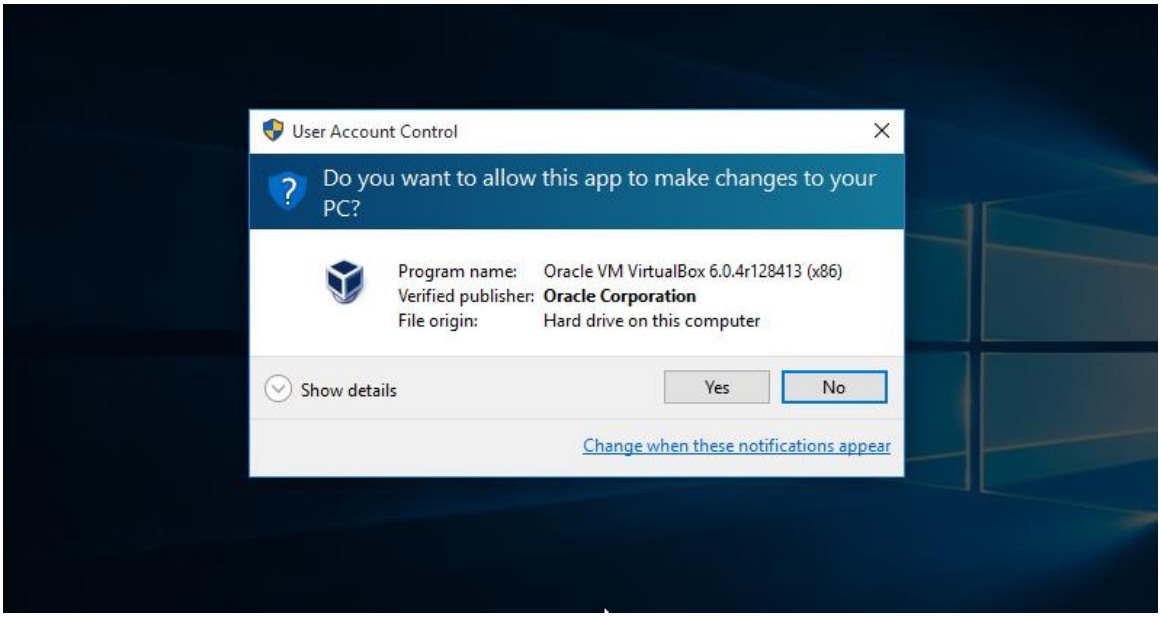
Step 3: Click on “Windows hosts”

Step 4: The standing of the file transfer are going to be displayed:



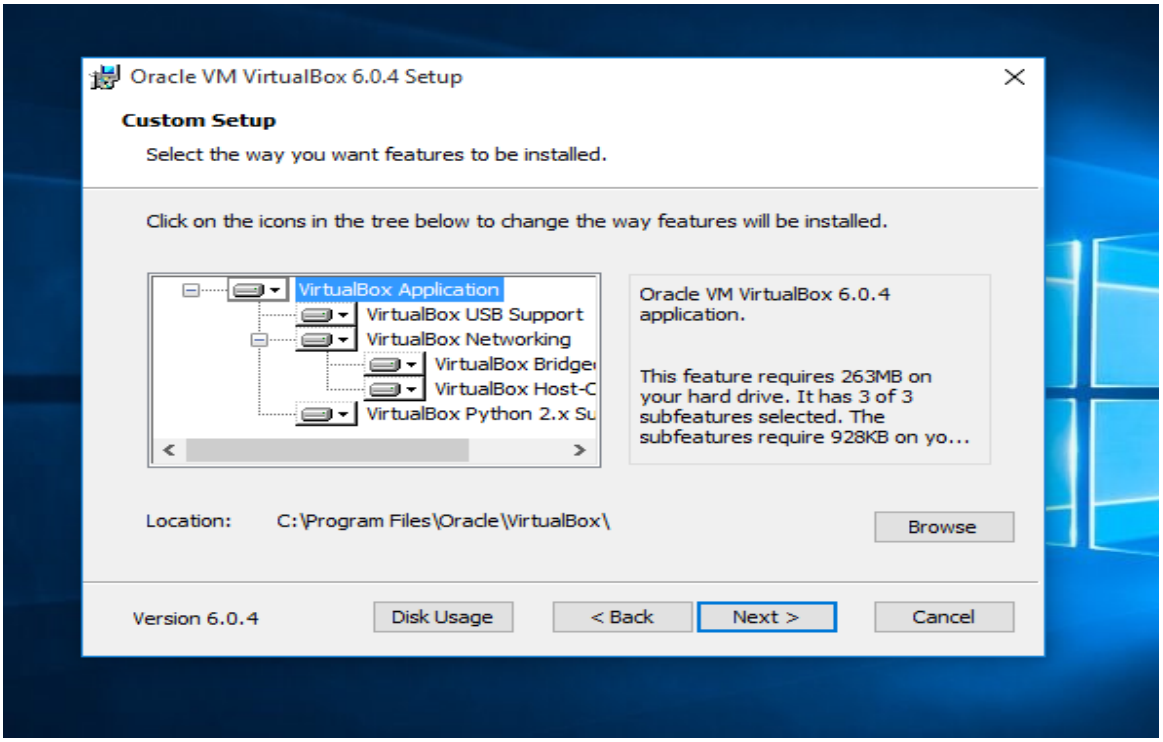
Step 5: Click on the "Run" button of the "Download complete" box:

Step 6: Click on "Yes" button of the "Windows - Security Warning" box:

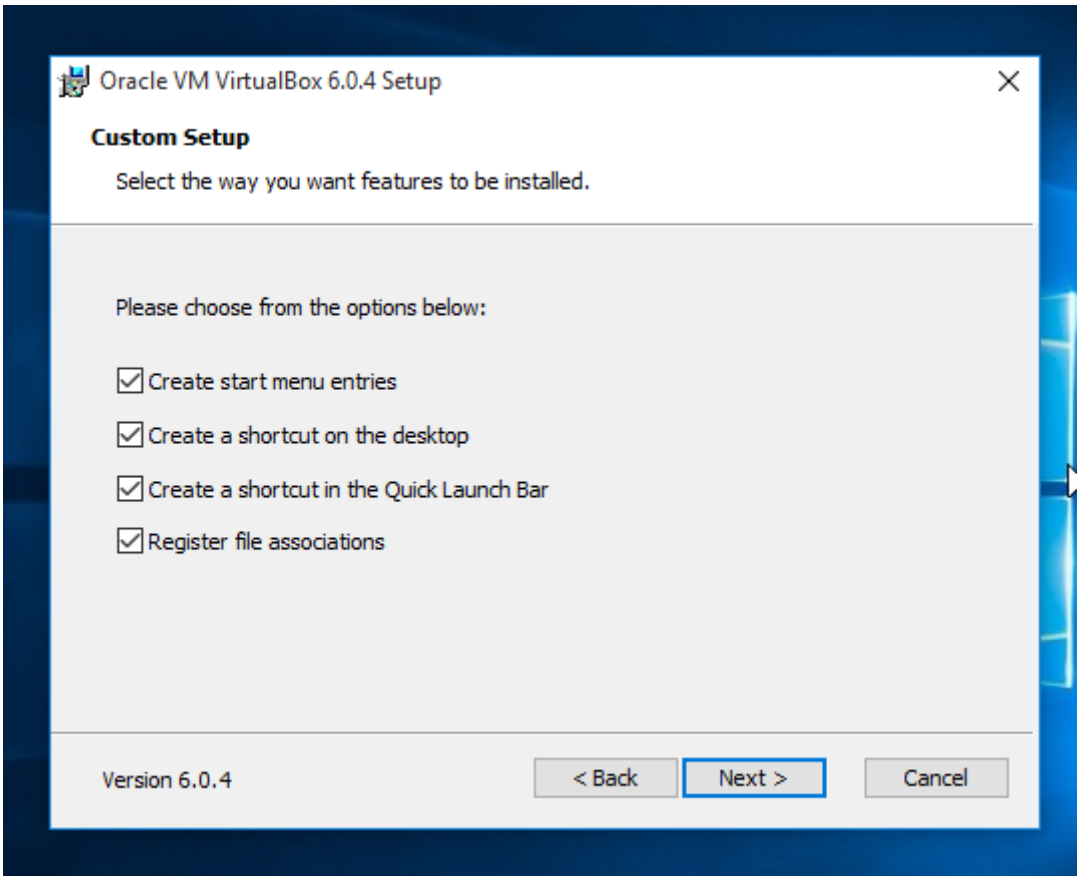


Step 7: Click on the "Next" button of the "Welcome...” box:

Step 8: Click on the "Next" button of the "Custom Setup" box:

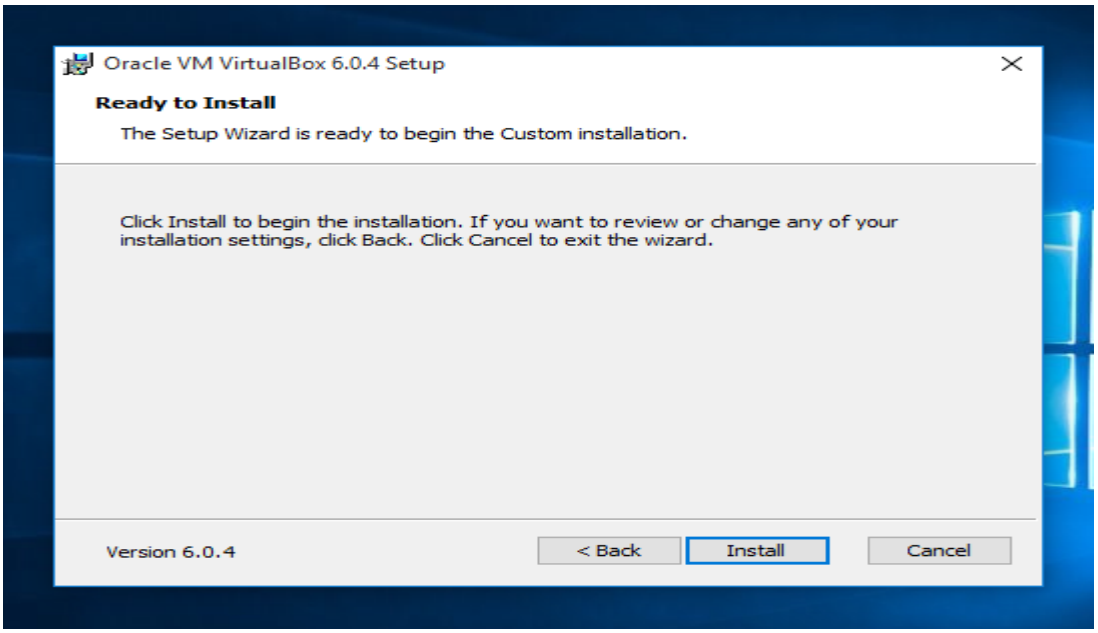


Step 9: Take away the checkmark from "Create a road within the fast Launch Bar and click on Next button:



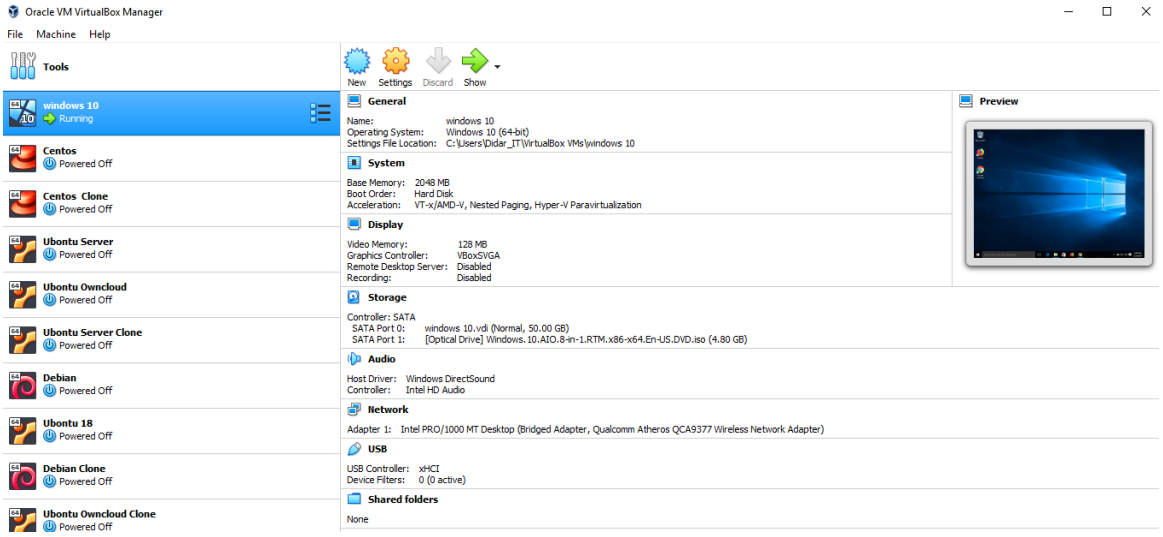
Step 10: Click on the "Yes" button of the "Custom Warning...” box:

Step 11: Click on the "Install" button of the "Ready to Install" box:



Step 12: Click on the "Finish" button of the "Installation is complete." box:

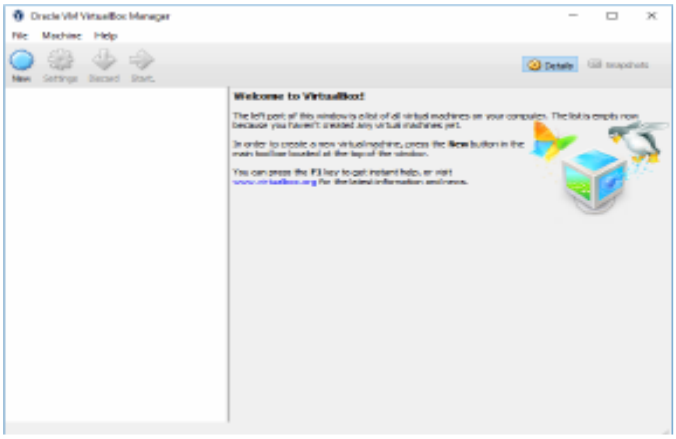
Step 13: an "Oracle VM Virtual Box Manager" window are going to be displayed. After you produce some virtual machines, the "Oracle VM Virtual Box Manager" window can seem like this:



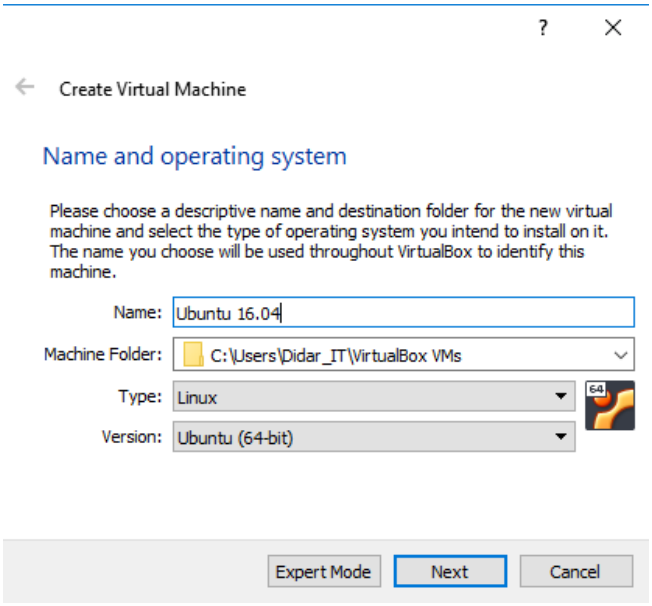
Each virtual machine that you simply produce are going to be shown within the left pane of the "Oracle VM Virtual Box Manager" window. To start out any virtual machine, use the left push button to double-click on its listing within the left pane of the "Oracle VM Virtual Box Manager" window.

Installing "Ubuntu 16.04 LTS" on Virtual Box 6.0.4: After downloading the Ubuntu 16.04 ISO file from http://www.ubuntu.com step by step directions for putting in "Ubuntu 16.04 LTE" on Virtual Box 6.0.4

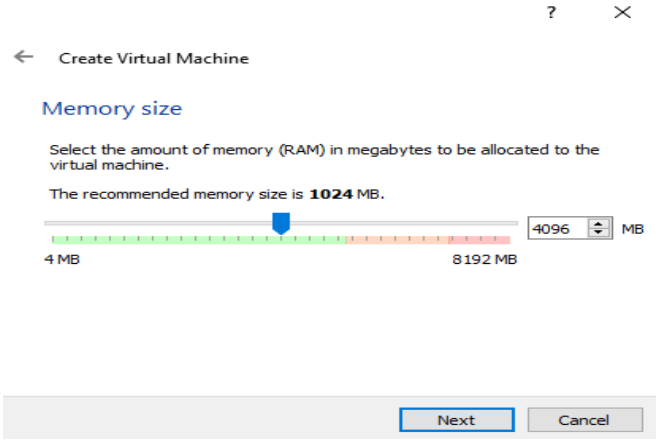
Step 1: Double click the Oracle VM Virtual Box on the desktop Click the New icon (or choose the Machine item from menu bar and select New…



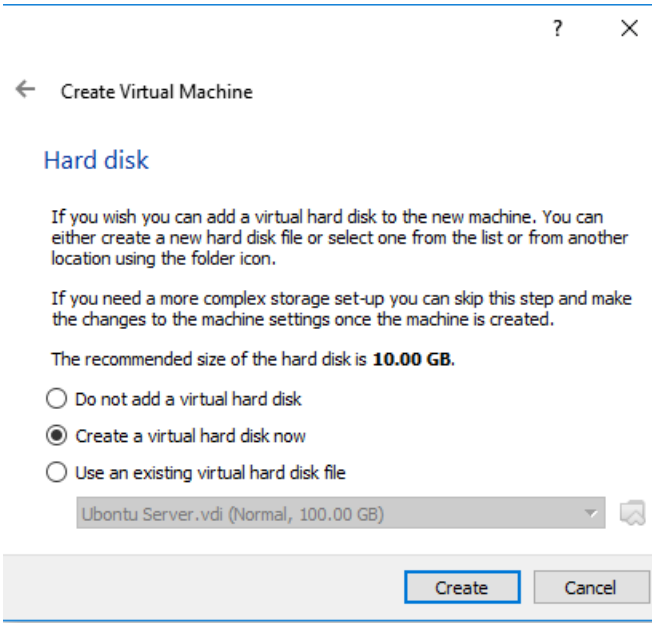
Step 2: Enter the name for your virtual machine (i.e., the guess OS name) and click on the next button



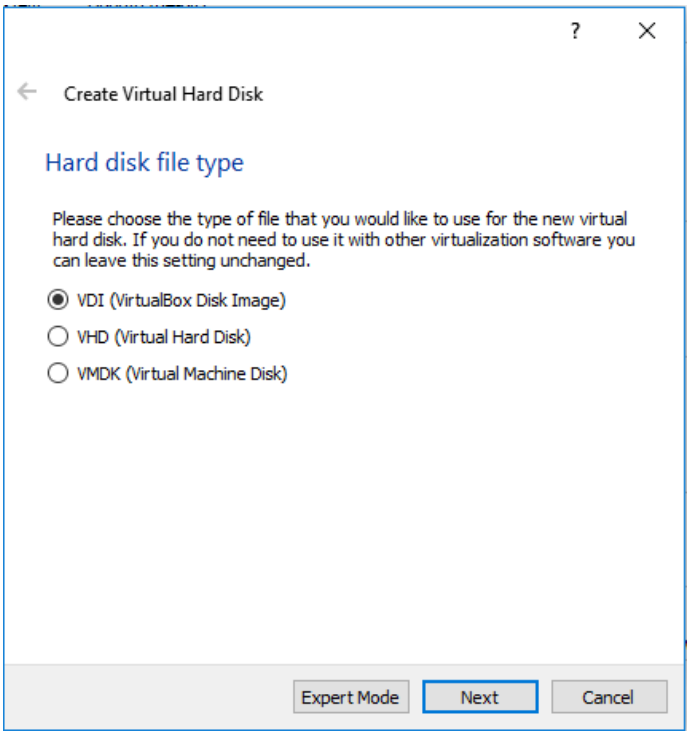
Step 3: choose the memory size (e.g., 1GB or 4GB) and click on the next button



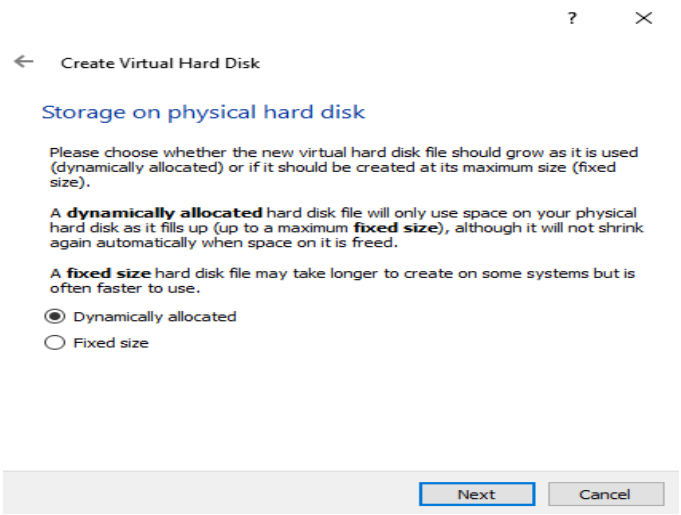
Step 4: choose the produce a virtual magnetic disc currently possibility and click on the create button



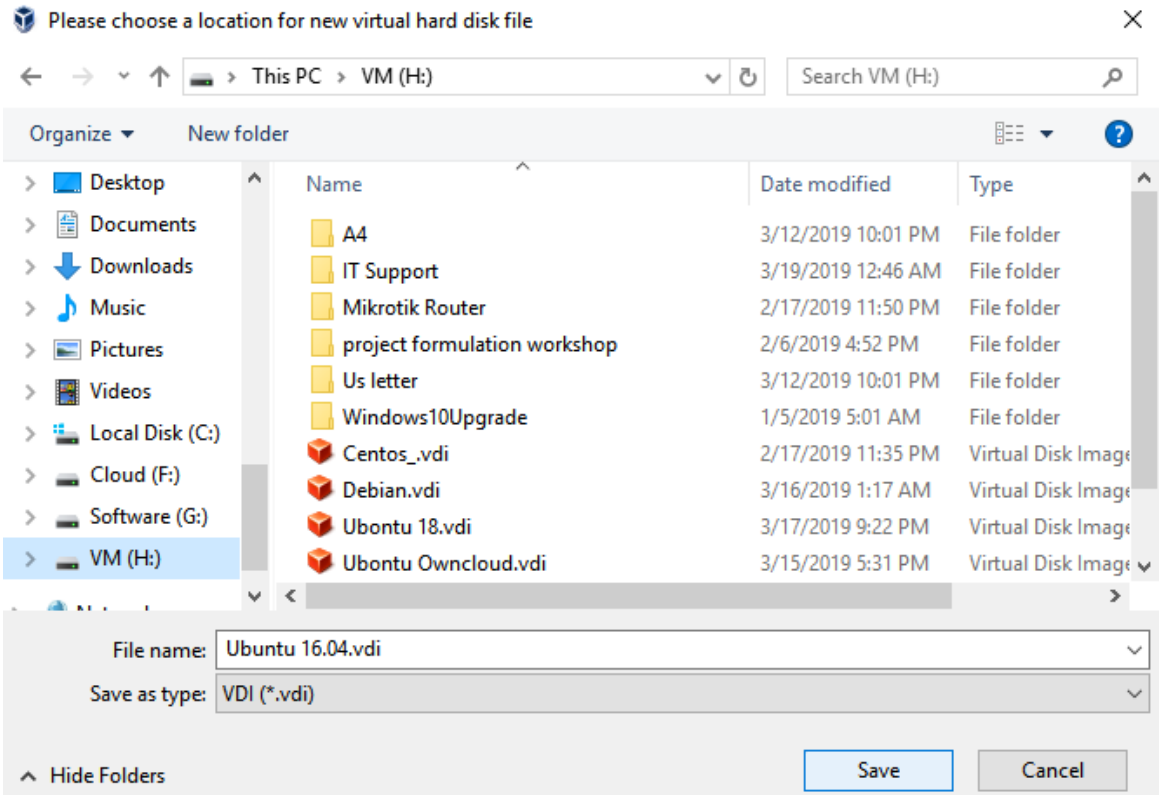
Step 5: choose the VDI (Virtual Box Disk Image) possibility and click on the next button



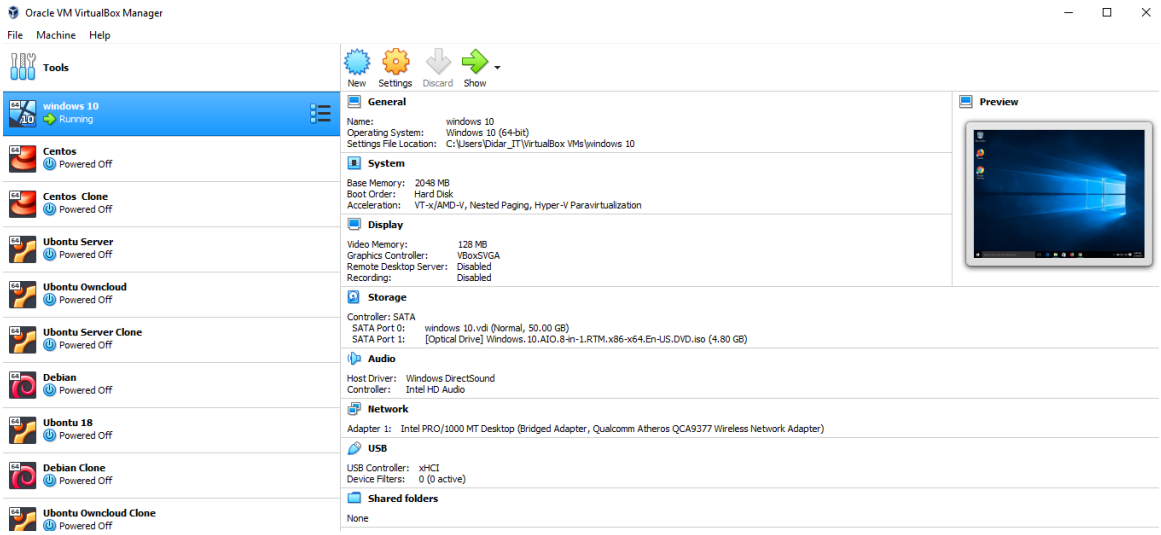
Step 6: choose the dynamically allotted possibility and click on the next button



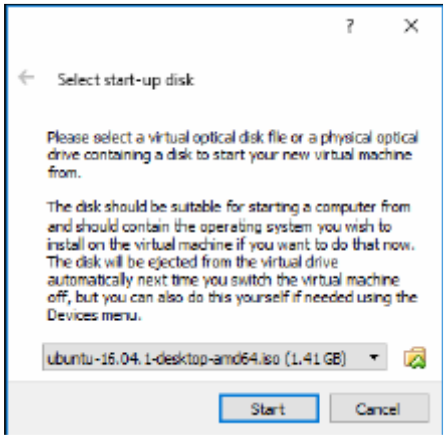
Step 7:Click the folder icon to pick out the situation wherever you would like to store your new virtual machine file, choose the dimensions for the virtual hard disk, and click on the create button



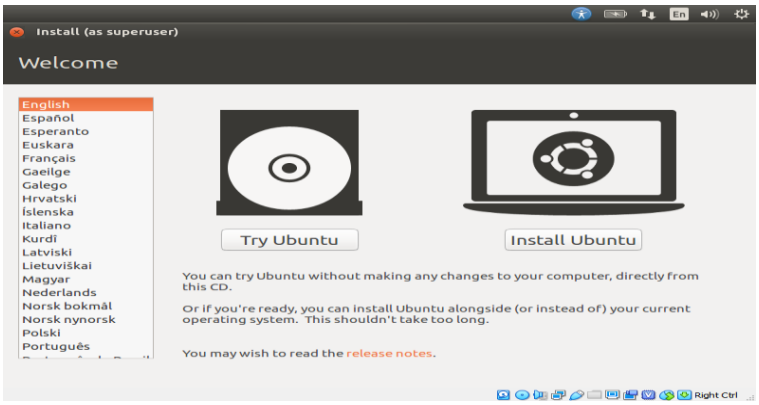
Step 8: Click the beginning icon (i.e., the inexperienced right arrow)



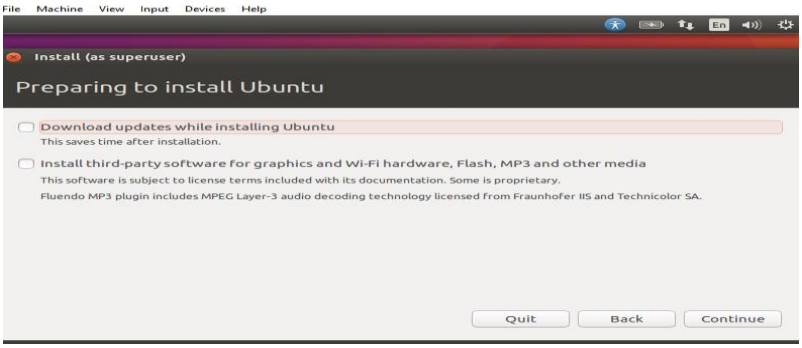
Step 9: Click the folder icon to pick out the downloaded file ubuntu-16.04.02-desktop-amd64.iso (e.g., C:\Users\didar\Downloads), click the beginning button and watch for a short while



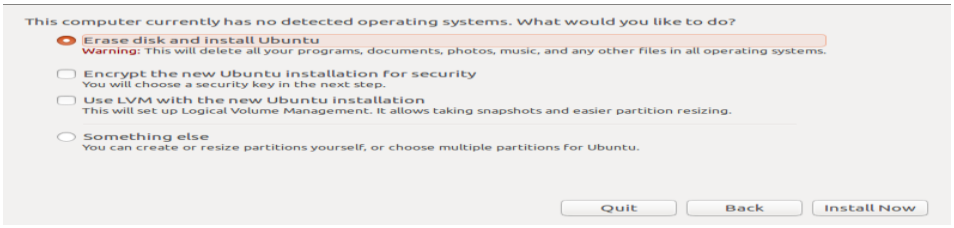
Step 10: Click the Install Ubuntu option



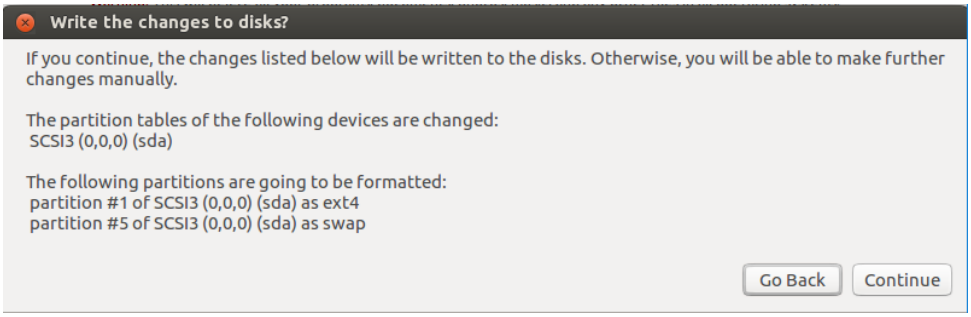
Step 11: Click the Continue button



Step 12: Click the Install currently button



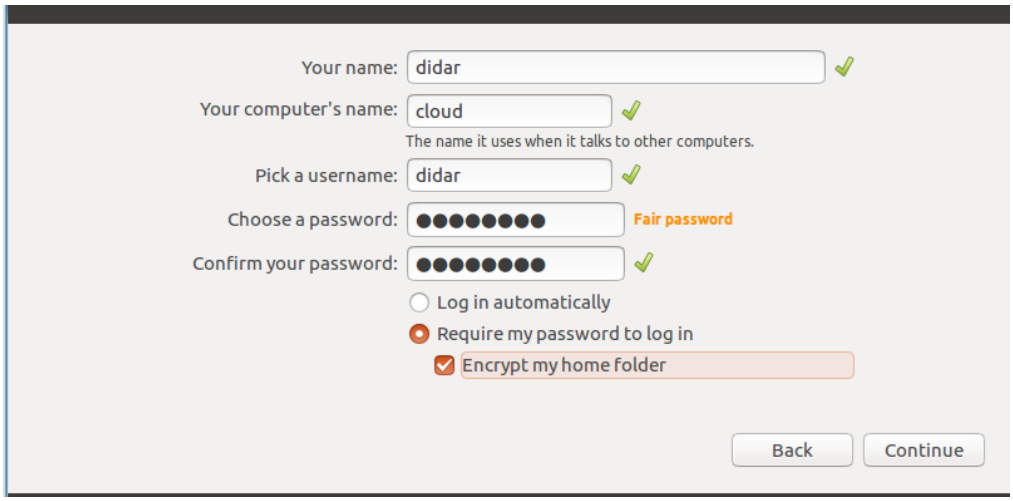
Step 13: Click the Continue button



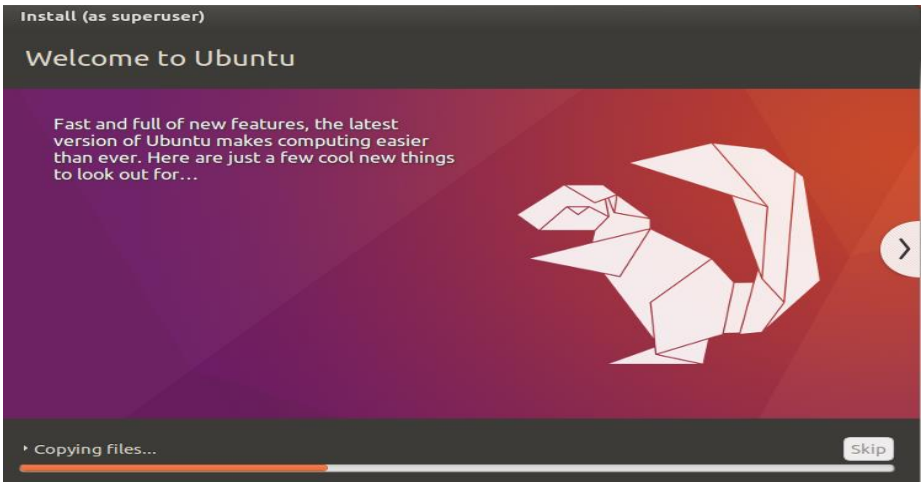
Step 14: choose your location (e.g., Port of Dhaka) and click on the Continue button

Step 15: choose the keyboard layout (e.g., Bangla) and click on the Continue button

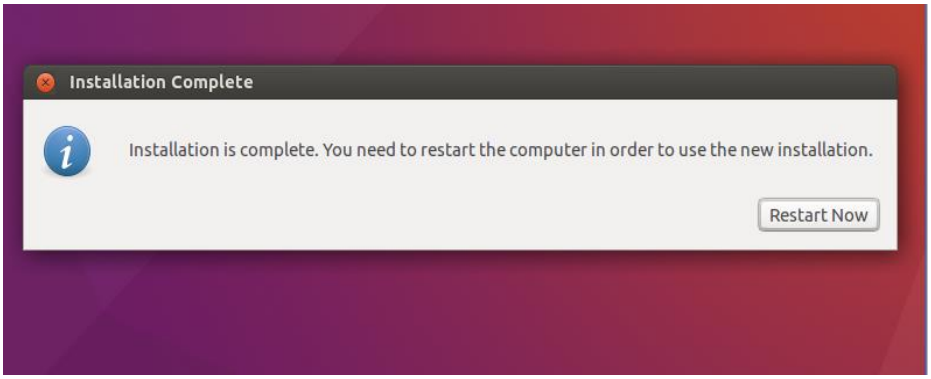
Step 16: Enter the account info, and click on the Continue button



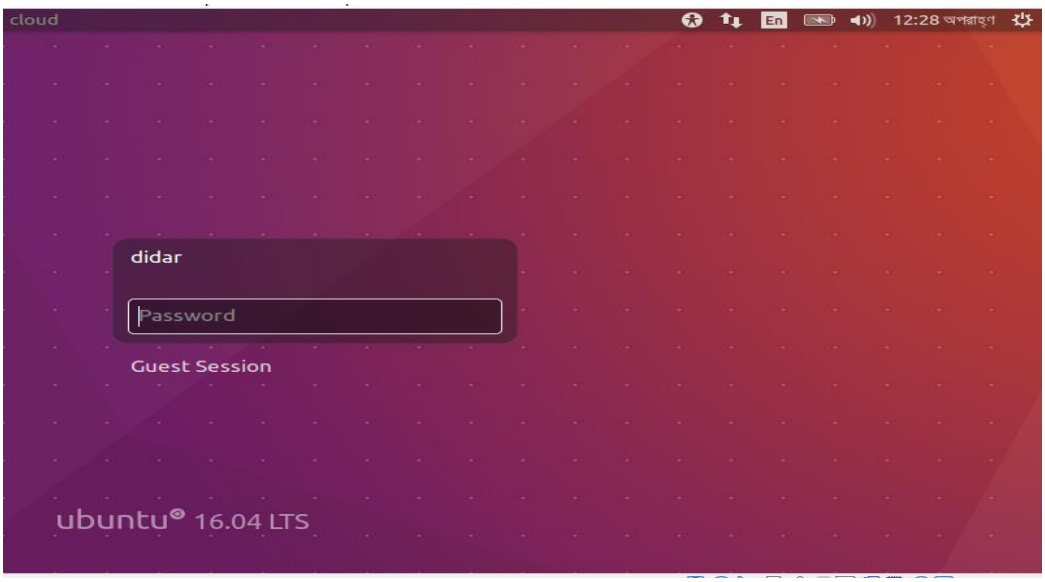
Step 17: You watch for the installation method to complete



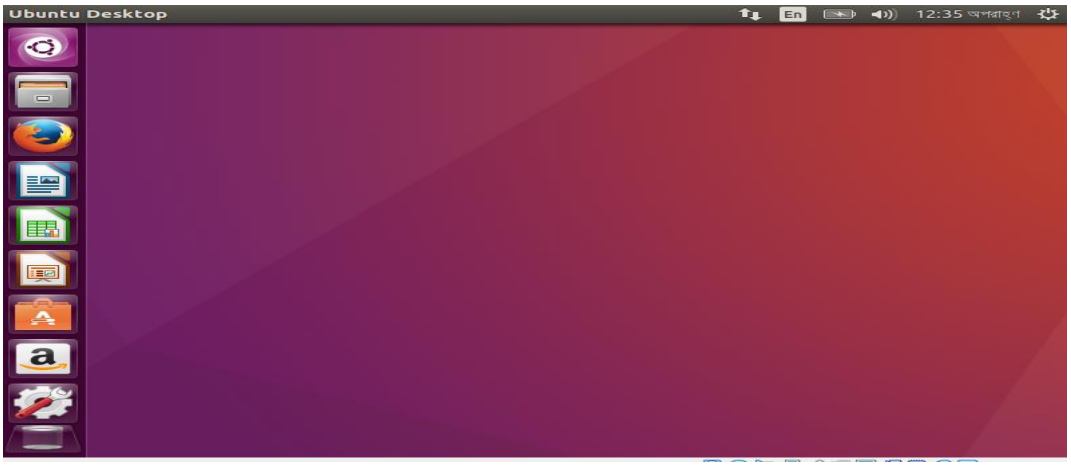
Step 18: Click the Restart now button and wait



Step 19: Enter your password and press the Enter key



Step 20: currently Install Complete your Ubuntu 16.04 LTS OS.



Installing and Setting up the Ubuntu 16.04 LTS and preparing for introducing ownCloud, follow the steps below:

First update the Ubuntu and everyone its packages to avoid errors down the line.

```
sudo apt-get update
sudo apt-get upgrade
```

Setting up Apache web server:

Insert the command

```
sudo apt install apache2
```

Run the commands below to disable directory listing.

```
sudo sed -i "s/Options Indexes FollowSymLinks/Options FollowSymLinks/" /etc/apache2/apache2.conf
```

After installing Apache2, run the commands below for Apache2 service to stop, begin and change

```
sudo systemctl stop apache2.service
sudo systemctl start apache2.service
sudo systemctl enable apache2.service
```

Setting up database Server: MariaDB Server is one in every of the foremost common database servers within the world. It's created by the first developers of MySQL and bound to keep open supply. MariaDB is used as a result of its quick, climbable and sturdy, with an upscale system of storage engines, plugins and plenty of alternative tools build it terribly versatile for a good form of use cases. For installing MarisDB, run the command:

```
sudo apt-get install mariadb-server mariadb-client -y
```

To prevent, begin and alter MariaDB service to perpetually commence once the server boots, run the commands:

```
sudo systemctl stop mariadb.service
```

```
sudo systemctl start mariadb.service
sudo systemctl enable mariadb.service
```

After that, run the commands below to secure MariaDB server.

```
sudo mysql_secure_installation
```

When prompted, answer the queries below by following the guide. Enter current Arcanum for root (enter for none): simply press the Enter

```
Set root password? [Y/n]: Y
New password: Enter password
Re-enter new password: Repeat password
Remove anonymous users? [Y/n]: Y
Disallow root login remotely? [Y/n]: Y
Remove test database and access to it? [Y/n]: Y
Reload privilege tables now? [Y/n]: Y
```

Restart MariaDB server

```
sudo systemctl restart mariadb.service
```

Scripting language PHP: Hypertext Preprocessor could be a general programing language originally designed for web development. Pages and documents it may be delivered statically or dynamically. "Static" suggests that unchanged or constant, whereas "dynamic" suggests that dynamic or active. For installing PHP and connected Modules, Run the commands below:

```
sudo apt-get install software-properties-common -y
sudo add-apt-repository ppa:ondrej/php
```

Upgrade or update the PHP version.

```
sudo apt update
```

To Run PHP and the connected modules, run the commands:

```
sudo apt install php7.1 libapache2-mod-php7.1 php7.1-common php7.1-mbstring php7.1-xmlrpc php7.1-soap php7.1-apcu php7.1-smbclient php7.1-ldap php7.1-redis
```

php7.1-gd php7.1-xml php7.1-intl php7.1-json php7.1-imagick php7.1-mysql php7.1-cli php7.1-mcrypt php7.1-ldap php7.1-zip php7.1-curl –y

To open FPM PHP default file. The PHP configuration file has to be changed so it'll permit affordable file sizes. Here, it's modified to 2 GB:

sudo nano /etc/php/7.1/apache2/php.ini

Then create modification, insert the commands sequentially within the file and save it.

file_uploads = On
allow_url_fopen = On
memory_limit = 256M
upload_max_filesize = 2048M
display_errors = Off
date.timezone = America/Florida

Create OwnCloud Database: At this stage, all the necessary packages have been installed and configuring the database server can be started by running the following commands.

sudo mysql -u root –p

Now a owncloud database needs to be created by running the command:

CREATE DATABASE owncloud;

Create a database user called ‘user’ with a password

CREATE USER ‘didar'@'localhost' IDENTIFIED BY ‘D!d@r123';

The USER needs to be granted full access to the database

GRANT ALL ON owncloud.* TO ‘didar'@'localhost' IDENTIFIED BY ‘D!d@r123' WITH GRANT OPTION;

The changes need to be saves and Exit.

FLUSH PRIVILEGES;

EXIT;

Setting up own Cloud: Download Owncloud File and extract latest OwnCloud unharness files in the root directory

```
cd /tmp && wget https://download.owncloud.org/community/owncloud-10.0.8.zip
unzip owncloud-10.0.8.zip
sudo mv owncloud /var/www/html/owncloud/
```

For lining the appropriate ownCloud accesses to the users, run the following commands:

```
sudo chown -R www-data:www-data /var/www/html/owncloud/
sudo chmod -R 755 /var/www/html/owncloud/
```

Configuring Apahce2 File for website: Create Ooncloud configuration file by running the following command. A new configuration file with the name owncloud.conf will be created.

```
sudo nano /etc/apache2/sites-available/owncloud.conf
```

At this stage, insert the commands given below into the owncloud.conf file and save it upon replacing the domain name (highlighted) and root directory location.

```
<VirtualHost *:80>
    ServerAdmin admin@didarprivatecloud.com
    DocumentRoot /var/www/html/owncloud/
    ServerName didarprivatecloud.com
    ServerAlias www.didarprivatecloud.com

    Alias /owncloud "/var/www/html/owncloud/"
    <Directory /var/www/html/owncloud/>
      Options +FollowSymlinks
      AllowOverride All
      Require all granted
        <IfModule mod_dav.c>
         Dav off
        </IfModule>
      SetEnv HOME /var/www/html/owncloud
      SetEnv HTTP_HOME /var/www/html/owncloud
    </Directory>

   ErrorLog ${APACHE_LOG_DIR}/error.log
    CustomLog ${APACHE_LOG_DIR}/access.log combined
 </VirtualHost>
```

Save the owncloud.conf file and exit

To enable the OwnCloud and Rewrite Module in the virtualhost, run the following commands.

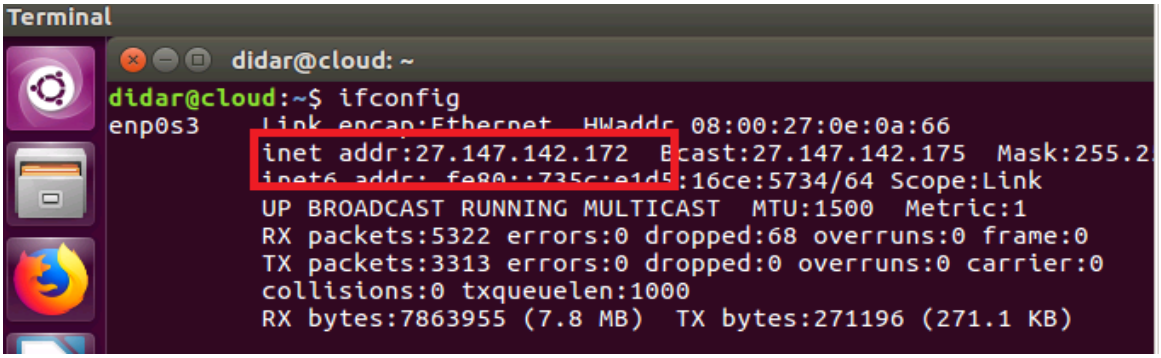
```
sudo a2enmod rewrite
sudo a2enmod headers
sudo a2enmod env
sudo a2enmod dir
sudo a2enmod mime
```

To load the modified settings, restart the webserver by running the following command.

```
sudo systemctl restart apache2.service
```

Access Owncloud from the LAN: To access ownCloud from within the network, reveal the IP address of the owncloud by running the following command:

Ifconfig

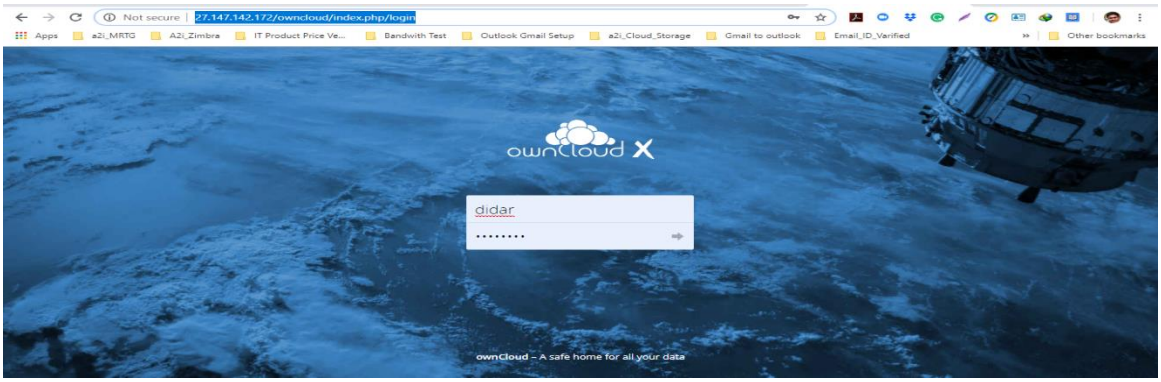


Locate the IP address of the Ubuntu server, 192.x.x.x or 10.x.x.x

Type in the LAN IP in the browser like this:

http://LANIP/owncloud

http://27.147.142.172/owncloud/index.php/login



Enable SSL for Secure External Access:

Open the terminal and run the following command:

sudo a2enmod ssl

Create a new directory for the self signed certificate:

sudo mkdir /etc/apache2/ssl

Create the self-signed certificate and the server key that protects it, and placing both of them into the new directory:

sudo openssl req -x509 -nodes -days 365 -newkey rsa:2048 -keyout /etc/apache2/ssl/owncloud.key -out /etc/apache2/ssl/owncloud.crt

Note: The above certificate is valid for 365 days. We have mentioned validity days in the command. The lines that need changing are the following:

ServerName IP :443
SSLEngine on
SSLCertificateFile /etc/apache2/ssl/owncloud.crt
SSLCertificateKeyFile /etc/apache2/ssl/owncloud.key

Now we'd like to setup the certificate:

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

```
<?php
$CONFIG = array (
  'instanceid' => 'ocvev75wv5ja',
  'passwordsalt' => '1a7H5vfPJ6uRURPu2TCkbuhK4nayyw',
  'secret' => 'D9oiMZXBx/0fmHCrE2moa0r9xAdlvh57qgb11U5ahb5d1M2B',
  'trusted_domains' =>
  array (
    0 => '192.168.10.182',
    1 => '27.147.142.172'
  ),
  'datadirectory' => '/var/www/html/owncloud/data',
  'overwrite.cli.url' => 'https://27.147.142.172/owncloud',
  'dbtype' => 'mysql',
  'version' => '10.0.8.5',
  'dbname' => 'owncloud',
  'dbhost' => 'localhost:5432',
  'dbtableprefix' => 'oc_',
  'dbuser' => 'didar',
  'dbpassword' => 'D1123456',
  'logtimezone' => 'UTC',
  'installed' => true,
);
~
~
~
~
~
-- INSERT --                                                    12,49
```

Enable SSL

sudo a2ensite default-ssl
sudo service apache2 restart

MikroTik Port Forwarding or Port Mapping for External Access: MikroTik Port Forwarding or Port Mapping could be a NAT application that's accustomed send a request from MikroTik IP address and port range combination to a neighborhood IP address and port range. as an example, if you have got a OwnCloud Server in your private/local space and wish to access this local server from outside of your native space (from internet/public), you'll be able to apply MikroTik port forwarding or port mapping and might simply access your Owncloud Server. Port forwarding configuration in MikroTik Router isn't thus troublesome task. I will show the way to simply set up MikroTik Port Forwarding or Port Mapping victimization Winbox.

Network Diagram

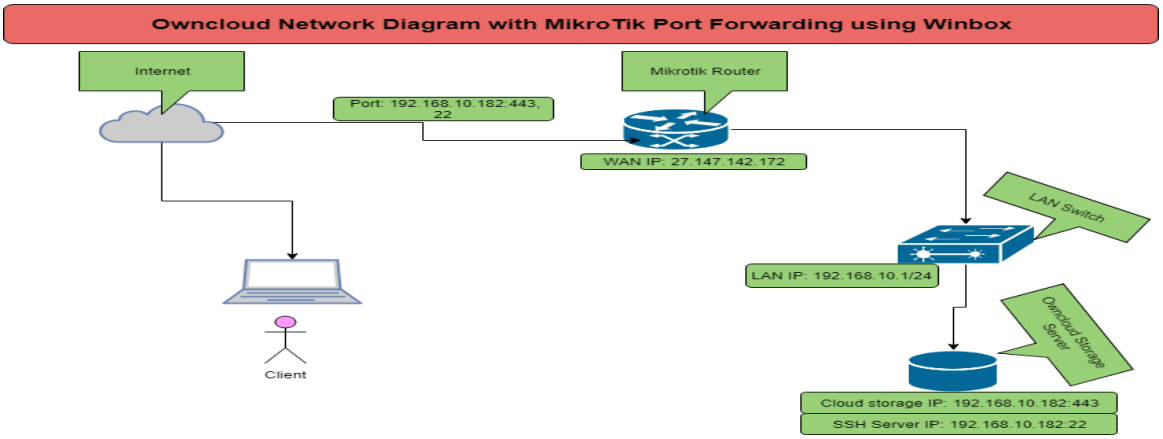


Figure 13: MikroTik Port Forwarding Network Diagram

In this network, MikroTik Router's ether1 interface is connected to WAN having IP address 27.147.142.172/29 and ether2 interface is connected to a local area network switch having IP block 192.168.10.0/24. There are 2 servers (Owncloud /Web Server, and SSH Server) in internal network and these are solely accessible from local area network. Configuring MikroTik Port Forwarding, these servers is accessible from out of this internal network (from internet/public) and that I can show the way to configure MikroTik Port Forwarding to access these internal servers from internet or public network.

MikroTik Port Forwarding Configuration: MikroTik port forwarding is used for a lot of functions. Among these, I'll solely show the subsequent 2 often used functions.

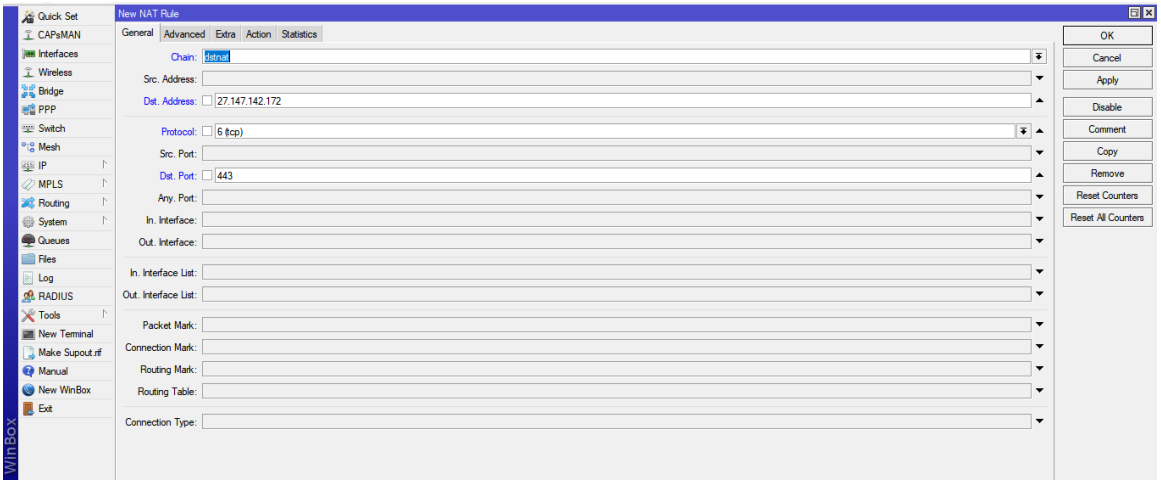
- Port Forwarding to Internal Owncloud/Web Server
- Port Forwarding to Internal SSH Server

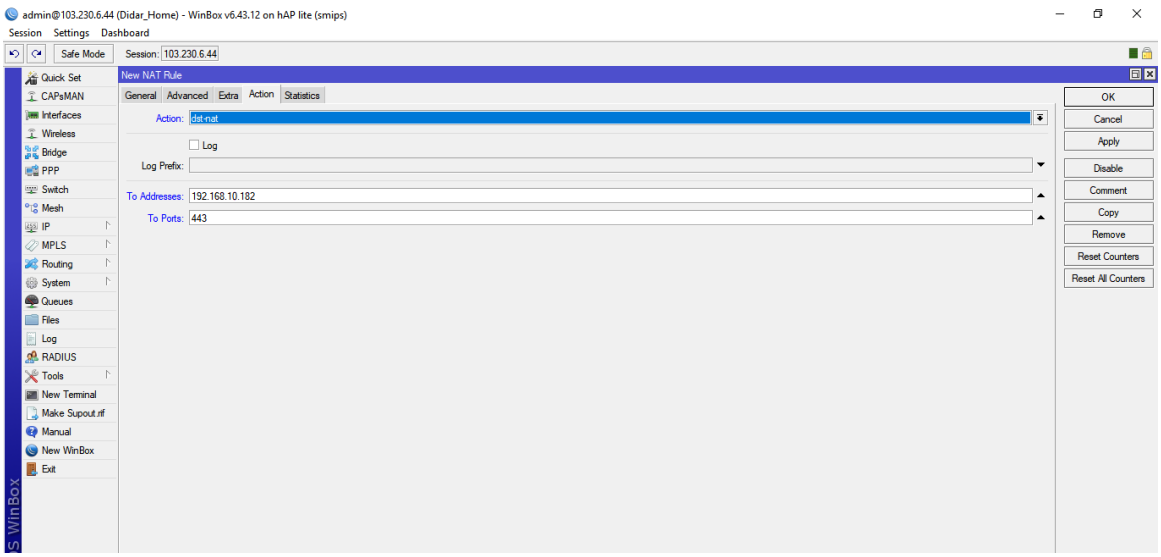
Port Forwarding to Internal private cloud/Web Server: in keeping with the network diagram, there's a personal cloud Server (IP: 192.168.10.182) in internal network and currently it's solely accessible from internal network. Configuring MikroTik Port Forwarding, this non-public cloud Server will be accessible from out of this internal network and also the following steps can show a way to put together MikroTik Port Forwarding to access this internal non-public cloud Server from internet/public space.

Login to MikroTik Router mistreatment Winbox with admin privilege credential.

Go to IP > Firewall menu item and click on NAT tab and then click on PLUS SIGN (+). New NAT Rule window will appear: In General tab, select dstnat from Chain dropdown menu. Place MikroTik WAN IP (27.147.142.172) in Dst. Address input field and select TCP from Protocol dropdown menu so place 443 in Dst Port input field as a result of we all know private cloud/ web Server works on TCP port 443. Click on Action tab and select dst-nat choice from Action dropdown menu. Place web Server IP (192.168.10.182) in To Addresses input field so place 443 in To Ports input field.

Click Apply and OK button.





Port forwarding configuration to internal Private Cloud/Web Server has been completed. Now type MikroTik WAN IP (https://27.147.142.172) in any Web browser from outside of your internal network and you will find your website in your browser successfully.

Note: You must allow HTTPS service or TCP Port 443 in your Private cloud/Web Server firewall otherwise you cannot find your website from public network.

Port Forwarding to Internal SSH Server

We also have a SSH Server (IP: 192.168.10.182) in our network diagram and we want to access this server from outside of our internal network. MikroTik Port Forwarding

configuration to access this SSH Server from public network is shown in the following steps.

Login to MikroTik Router using Winbox with admin privilege credential.

Go to IP > Firewall menu item and click on NAT tab and then click on PLUS SIGN (+). New NAT Rule window will appear.

In General tab, choose dstnat from Chain dropdown menu. Put MikroTik WAN IP (27.147.142.172) in Dst. Address input field and choose tcp from Protocol dropdown menu and then put 22 in Dst Port input field because we know SSH Server works on TCP port 22.

Click on Action tab and choose dst-nat option from Action dropdown menu. Put SSH Server IP (192.168.10.182) in To Addresses input field and then put 22 in To Ports input field.

Click Apply and OK button.

Port forwarding configuration to access internal SSH Server has been completed. Now we will be able to access our SSH Server from public network successfully by using any SSH client (Putty or SSH Secure Shell Client).

Now we need to add the WAN IP to do this open the Own cloud config file, enter:

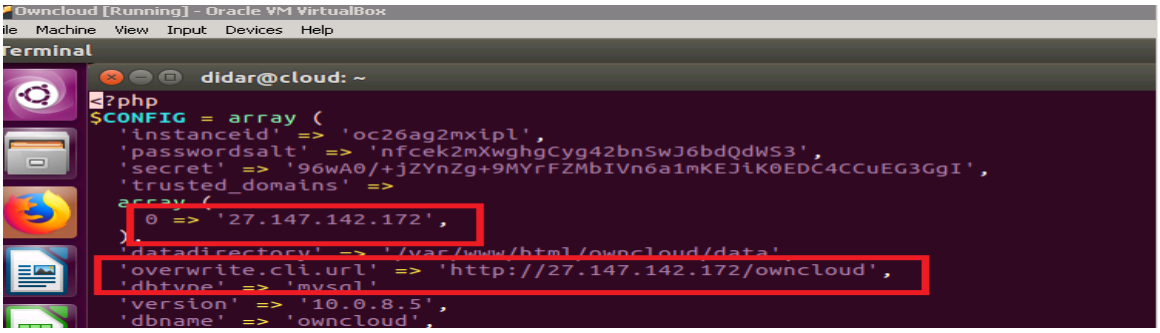
sudo nano /var/www/html/owncloud/config/config.php

Here add the WAN IP Your new entry should look something like this:

1=> ’27.147.142.172’

To update the URL of the overwrite.cli.url line with your WAN IP Address.

'overwrite.cli.url' => 'https://27.147.142.172/owncloud',



Hidden is the WAN IP.

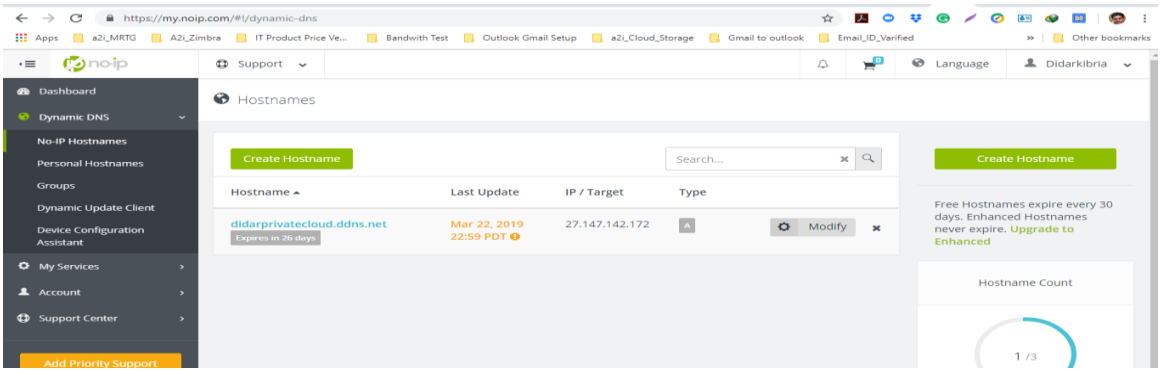
To access ownCloud from other networks: enter the WAN IP in browser. i.e. "https://27.147.142.172/owncloud".

Accessing ownCloud from inside the network: Enter the private IP in browser. i.e "https://192.168.10.182/owncloud"

Arrange external access: Up until now, the ownCloud platform has been available only locally. To provide a true Dropbox alternative, it is necessary to expand its reach over the Internet. This requires a few actions such as installing a DDNS service, reserving a local IP address for your Mini PC Owncloud, port forwarding and changing some configuration files that were used above.

DDNS configuration: As stated in the theoretical section of the report, noip will be used as a DDNS service (Auti, 2014). The DDNS service is needed when your ISP assigns you a public IP address that changes periodically. If this is not the case, this step can be

skipped. First, you need to register a domain name at the website www.noip.com. We chose the domain name didarprivatecloud.ddns.net. Notice that noip correctly binds this to the current external IP address. However, we need a Dynamic Update Client (DUC) that updates this binding periodically so that the domain name can keep redirecting the traffic to the changing IP address.



NOIP client installation: In many routers, a DDNS client is already implemented. This can be checked by logging in to the router's settings page. In many cases, this can be reached under 27.147.142.172. Follow the guidelines on the DDNS settings page to synchronize it with your DDNS service provider. In case the router does not provide this service, a client needs to be installed so that the Ubuntu can provide this service itself.

First you need to create a directory for NOIP, go to that directory and download the NOIP software into that directory. After extracting, the downloaded file can be removed. Next, the client can be installed and started. After installing, it prompts you to fill in the login credentials used for the NOIP service. It then finds the domain name didarprivatecloud.ddns.net. The other parameters will be left at default. With this, the client will send the IP address every 30 minutes

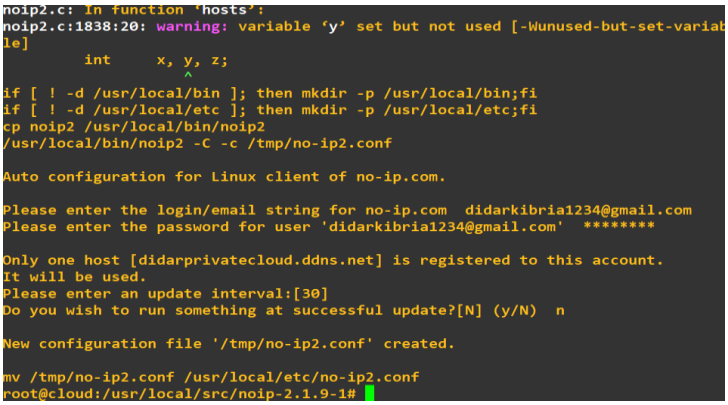
The following commands are required:

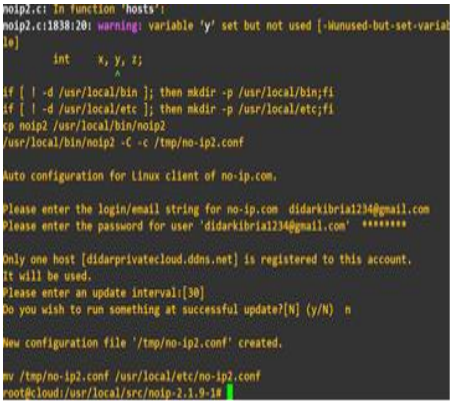
cd /usr/local/src/

wget http://www.no-ip.com/client/linux/noip-duc-linux.tar.gz

tar xf noip-duc-linux.tar.gz

cd noip-2.1.9-1/ make install





noip client configuration

Start on reboot

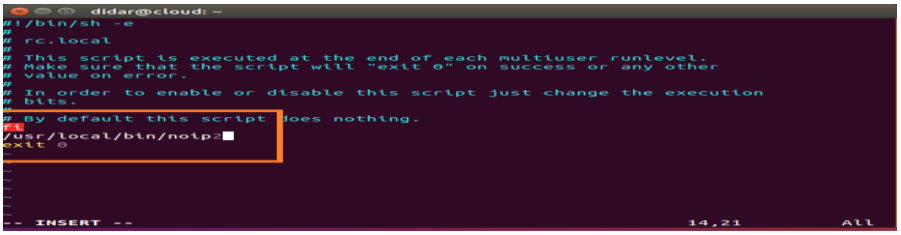
To start it automatically, the rc.local file needs to be adapted:

sudo vim /etc/rc.local

add the following between the lines:

fi
/usr/local/bin/noip2
Exit 0

so that it looks like this:



Apache2 reconfiguration

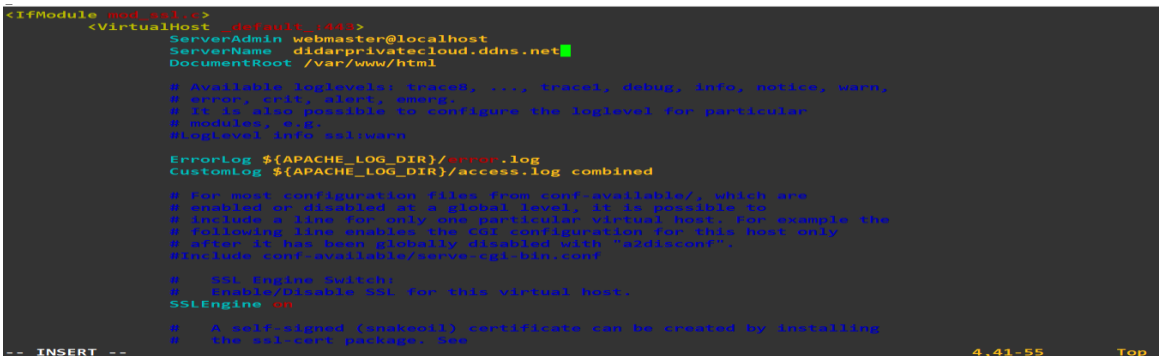
The Apache2 configuration file should be changed as follows:

sudo vim /etc/apache2/sites-available/defaults-ssl.conf

The server name values now point to the local IP address of the Private cloud server.This needs to be changed into your external IP address, or your domain name:

Previously: 27.147.142.172

Now: didarprivatecloud.ddns.net.



Also, some ISPs might block the use of port 80 (http) or port 443 (https) for personal use. For me, that was the case. It can save you a lot of trouble changing the listening port for https to something else like port 443, in the same configuration file. Check the availability of ports first to avoid conflicts. We will only use the secure https protocol. That is why port 80 can be left unchanged.

ownCloud reconfiguration: Now, ownCloud still needs to add the new domain to its trusted list. These domains are listed in the ownCloud config file:

sudo vim /var/www/html/owncloud/config/config.php

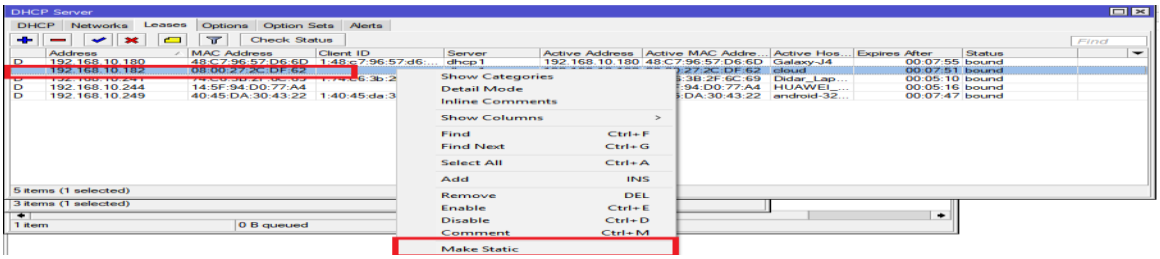
Simply add a line below the trusted domains with your external IP (either a domain name or an IP address, depending on whether or not your ISP assigns IP's dynamically). Also prevent ownCloud from overwriting it. The config file should look like this:

Restart the Apache service:

sudo service apache2 restart

Router reconfiguration

DHCP reservation: The router functions as a DHCP server, dynamically assigning IP addresses to the devices on your local network. Every time a client boots up, a DHCP lease negotiation occurs. The cloud should be reachable at all times. NOIP makes sure our home network is reachable. However, the IP address of the cloud might still change due to a reboot. This needs to be avoided. The router can be set to manually assign IP addresses to specific clients. To do this, in your web browser, go to the IP address of your router. Login and go to DHCP. Depending on the manufacturer, the interface looks different but should have similar options. Add the cloud to the list of static IP addresses.



DHCP reservation

Chapter 4

4. Results

Private Cloud setup vs to commercial cloud

Having followed all the steps provided above, has led to a product that can serve as a true alternative to commercial cloud services. The cloud offers a convenient way to access and share your files at home and on the go. With the ownCloud platform, the administrator has a wide set of tools to create user groups and appropriate permissions, link different calendars and contacts, offer live-collaboration, include chat, and many more. This way, ownCloud outperforms competitors such as Google Drive, that don't provide these administrator tools to adapt the service to your needs. As explained, the disadvantage of having the files reside on your network, is that the speed at which you can access them externally is limited to your upload speed. Externally, commercial cloud services clearly outperform the cloud.

Also, unlike Dropbox, the files are not stored on your local drive, leaving storage capacity for other data. Although less safe as Dropbox, the daily backup provides a simple way to avoid losing data in case one of the drives crashes. Added to this is the security argument of controlling your data in a private environment. No privacy issues can come up and as owner of your data, you know exactly where your data is and who might have access to it.

The use of the low-cost, low-powered cloud means that interaction with the system can take quite some time.

Comparison to NIST definition for cloud computing

In order to be identified as a cloud solution, the Mini PC configuration should answer certain criteria as stated in section 1.1. The comply with the NIST definition, the following characteristics need to be fulfilled: on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service. The Raspberry fulfils limited on-demand self- service as it requires only adaptations from the administrator to

add extra storage capacity when the current configuration seems to become insufficient. This means that, this requirement is only fulfilled in case of multiple users. Next, the resource pooling characteristic is not fulfilled. The system is not able to dynamically reassign its resources in a multi-tenant model. When multiple users access the system simultaneously, the system will treat these request similarly. However, measured service is a feature that ownCloud provides. The user is able to see how much has been used so far. The cloud pc set-up provides limited rapid elasticity in the sense that it is relatively easy to change the storage capacity but the processing power is more fixed. When an expandable computer would have been used to set up the service, this would have been more easy to do. Finally, the system is available over the Internet via two different interfaces. This fulfills the broad network access requirement.

In practice, the cloud pc with ownCloud can be seen as a true Cloud computing service that is worth the effort of setting up.

Chapter 5

5. Conclusion

Automatic synchronization with local folder

Here, we assume that the user wants to use a separate folder for files that need to be made available online. It would however, be equally possible to synchronize any local folder with the ownCloud using rsync in a similar fashion as how it is used to provide data redundancy. This way, the user keeps a local copy of the file, which is synchronized with the server in a background process. This has the advantage of independence of a reliable Internet connection. On the other hand, this requires local storage capacity.

Future Work

In near future, we want to create a connection between several of small clouds based on our OwnCloud solution into cloud federation and test this the solution on greater organizations to create connections between their departments. We assume that the modularity of the solution with the possibility of autonomous connecting additional units (separate instance of OwnCloud solution) allows better scalability and flexibility than centralized solutions.

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7. Appendix A

Acronyms and Abbreviation

AFP	Apple Filing Protocol
CSA	Cloud Security Alliance
DDNS	Dynamic Domain Name Server
DUC	Dynamic Update Client
DHCP	Dynamic Host Configuration Protocol
FTP	File Transfer Protocol
HTTPS	Hyper Text Transfer Protocol Secure
ICT	Information and Communication Technologies
IT	Information Technology
IaaS	Infrastructure as a service
ISP	Internet service provider
LAN	Local Area Network
NFS	Network File System
NOIP	Notice Of Intended Prosecution
NAT	Network Address Translation
NIST	National Institute of Standards and Technology

PCM	Private Cloud Management
PaaS	Platform as a service
PHP	Hypertext Preprocessor (Personal Home Page)
SMBX	Super Mario Bros. X
SSH	Secure Shell
SaaS	Software as a service
SMB	Server Message Block
SQL	Structured Query Language.
SSL	Secure Sockets Layer
VM	Virtual machine
VDI	Virtual Box Disk Image
WebDAV	Web Distributed Authoring and Versioning
WAN	Wide area network