

Cloud-based Architecture of Raspberry Pi: Personal Cloud Storage

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Abstract- The research explained the reason why we need personal cloud storage. This research will show steps on how to build a personal cloud storage by using credit card size Raspberry Pi (minicomputer), which will help the user to enable cloud storage mode to their external hard drive. However, other cloud storage services like Dropbox, Google Drive, and iCloud gives limited amount of storage. This research will help the users to use (1TB) or above size external hard drive to be use and have access anywhere from any device over internet. Also the second part of this research focus on replace the laptops to raspberry pi that lecturers use in the classroom to play PowerPoint slides, and videos at university.

Universities use laptops to plug and play their educational slides and videos. All these laptops price and maintenance cost lot to the university, if we look deeply just for play slides we do not have to buy a laptop which cost \$300 and also the lecturer have to carry the laptops all the times from the faculty to classes, moreover most of the times the laptops are not available. Overcome above statement, all the laptops can be replaced to "Raspberry Pi" which cost \$35 and it does not need any maintenance.

Keywords: raspberry Pi, cloud storage, cost benefit-analysis, low cost-computing, university classrooms.

I. INTRODUCTION

The aim of this research is to develop a cloud computing project, where the users can use their external hard drive's connected to Raspberry Pi through internet they can have access to anywhere from any device. According to (Jon Brodtkin, 2008) Even though Security, Privacy and Trust issues exists since the evolution of Internet, the reason why they are widely spoken these days is because of the Cloud Computing scenario. Any client/small organization/enterprise that processes data in the cloud is subjected to an inherent level of risk because outsourced services bypass the "physical, logical and personnel controls" of the user.

To develop a cloud computing project where users can have large amount of storage with the help of Raspberry Pi. Most of the user have external hard drive 1 TB (Terabyte) or more but the users cannot carry the external hard drives all the time, whereby this project will benefit the users connect to personal cloud storage over internet. The new technology which will be affordable to everyone and also it will enable the user to use their external hard drives over internet possible.

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Laptops that the lecturers are using for slides provided by Limkokwing University are limited in quantity and most of them are not working (requires maintenance). Replace all the laptops with the Raspberry Pi, which only cost \$35 and does not require maintenance (low maintenance). The laptop cost is above \$300 and need maintenance but the Raspberry Pi cost is \$35 and does not need any maintenance. Raspberry Pi will reduce the cost and effort for lecturers, also it is easy to carry.

Most of the cloud computing services are providing limited storage to the users, at the same time the risk of your data to store at third party is a big issue. Example is the recent incident of exposed nude pictures of the celebrities from iCloud. Which is a clear example that our data is not safe, to overcome these problems this research will come up with the perfect solution with unlimited cloud data storage by the help of "Raspberry Pi".

Rather than store all our media and files on a cloud server in an unknown location, we can keep a cloud at our home and make it personal.

The objectives for this research are

- The primary object of this research is to develop a cloud storage, whereby all the users can connect their external hard drives to raspberry pi and have access everywhere over internet.
- To develop a raspberry pi which can connect to projector and run the slides, videos and also web browsing as well.
- To save the cost for the university by replacing the laptops to raspberry pi, whereby the university can save money and maintenance time as well. Also it will be easy for the lecturers to carry the raspberry pi to classes rather than laptops. The university can save roughly up to RM 200, 000.
- To compare the current cloud computing to the Pi cloud computing. In term of storage because all the cloud computing services provide only limited number of storage to the users or the users have to buy extra storage if they require more space.
- To help the lecturers retrieve files (chapter's slides) from Pi cloud in the classroom. By using raspberry pi in the classrooms will represent the student's creativity and the education level at Limkokwing University.

II. LITERATURE REVIEW

According to William (2014), in order to do effective way of computation, Cloud Computing offers IaaS, PaaS and SaaS levels of service models. The

lowest service model is called Infrastructure as a Service (IaaS), which follows by Platform as a Service (PaaS) and last, but not least Software as a Service (SaaS). Each service model helps to add more functionality and abstraction to the technical details.

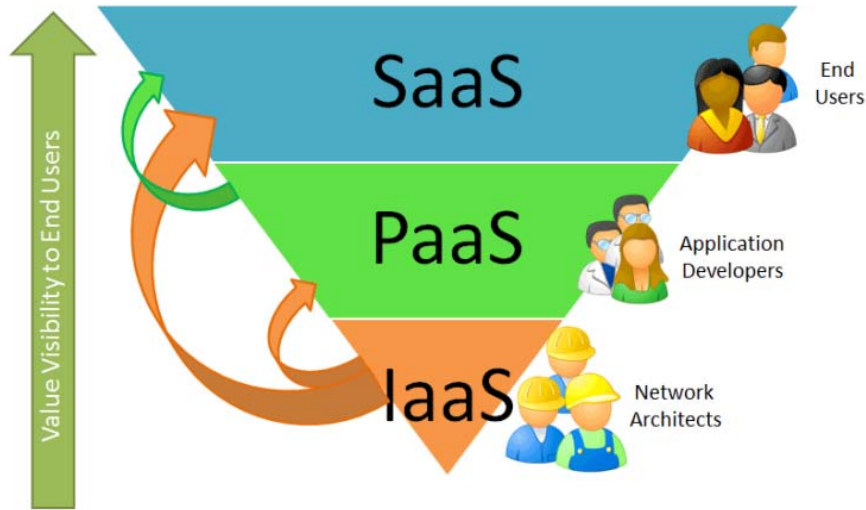


Figure 1: Cloud Computing Stack (Schuller, 2010)

The National Institutes of Standards and Technology (NIST) definition runs to several hundred words but essentially says that:

“Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned” and released with minimal management effort or service provider interaction.”

Armbrust (2009) defined clouds as computers are being able to network anywhere in the world by per-use way to pay for used clouds, the actual meaning of this idea is that the resources that are being used will be paid only. Below will be introduces types of clouds. The first one is the Public Clouds. Armbrust (2009) mentioned that public cloud is the traditional cloud computing that will have the opportunity to access to the computing resources from anywhere of the world. The pay-per-use manner will be used in clouds, as defined the only resources that are being used will be paid by transaction fees. On a superficial level, my findings may seem self-evident: a technology company tells its users what it expects of them and users for the most part agree, so long as the technology holds up. However, if we dig deeper, we can extract some important implications from this research. Following the work of other scholars who look at trust in information and communications technologies, I believe that trust is a more useful concept for studying the implications of new technologies than simply looking at privacy.

a) Cloud Computing Deployment Models

There are four deployment models for cloud computing, depending on the owners requirement, the security issues starts from here.

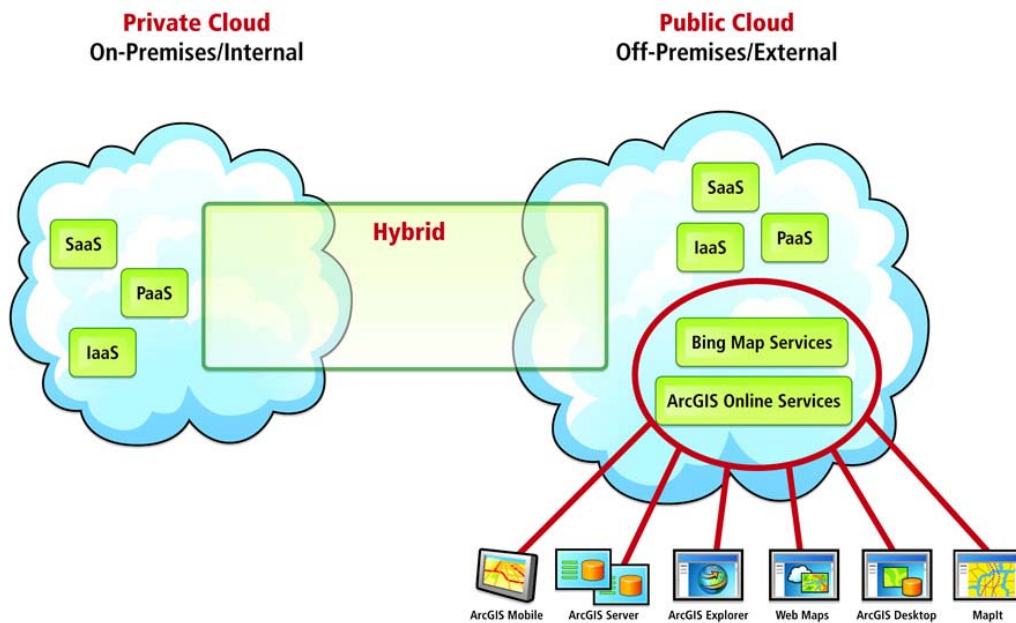


Figure 2: Image representing the clear idea of Cloud Computing Deployment Models

i. *The Public Cloud*

Public cloud computing is based on large-scale offering to general public, the infrastructure is located at premises of provider. The provider owns and manages the cloud infrastructure.

ii. *The Private Cloud*

In this case the infrastructure is provisioned for exclusive use by a single organization. It can be owned, managed, and operated by the organization themselves, a supplier as a third party, or some combination of them. Additionally it can exist on or off premises of the organization (Mell/Grance, 2011). Therefore special forms, can be also considered as a private Clouds. These are listed by some researchers as e.g. virtual private Clouds (e.g. Ried et al. 2011), where the cloud is hosted on dedicated, virtual machines in the data center of the Cloud provider, as well as managed private clouds, where the cloud is hosted by a third party in the data center of the customer.

However, what makes this analysis different than other literature on trust – and what this project is ultimately about on a theoretical level is the nexus of technology, objectivity and trust. A word about each and how they relate is necessary. My analysis and understanding of technology rests on many of the assumptions of actor-network theory, and particularly Bruno Latour’s (1991) quip: “Technology is society made durable.” I have extensively used the metaphor of the black box to exemplify this principle and stay faithful to the central tenets of Raspberry Pi Cloud Storage. The black box represents a network of associated humans and non-humans that has stabilized such that its heterogeneity is reduced and it appears as a homogenous whole. Its associations (i.e., its social

relations) are hidden and become a durable technological entity. Users of this black boxed technology must not understand, follow or even be aware of the internal workings and associations but only need to understand how to use the black box as a whole; they only need to follow the user scripts and interact with the technology’s user interface.

III. METHODOLOGY

Maxwell (2012) has stated that ‘the strengths of qualitative research derive primarily from its inductive approach’. The reason why the inductive approach was used in this research due to the newness of the idea to create your own cloud with Raspberry Pi. A deductive ‘approach to this subject would risk restricting the potential avenues of investigation. The inductive approach necessitated attempting to understand the meaning and the context of people’s responses to the adoption of Cloud Computing. It attempted to uncover unforeseen trends and detect linkages between Cloud Computing and Raspberry Pi.

a) *Data Collection*

The focus is on using qualitative data collection techniques. Qualitative data is data that is focusing on delivering information that can be described with terms and theories. It is not like quantitative research that focuses on the numbers behind a survey or something similar. It focuses on delivering numbers and information in terms of quantity. Qualitative research can be interviews or observations where the research is done on the behaviour or theories (Saunders et.al.2010).

Our research will consist of both primary and secondary data. Primary data is data collected by the researcher using different methods. The primary data

that is collected are often more reliable due to that you know where the data comes from and been following the progression all the way. Primary data sources could be (Kelly 2010):

- Observation when observing a system or a research object to see the details that is important to a research. Requires a lot of resources and time.

Secondary data are data that is collected from external sources that already exist. The only thing that has to be done is to look for the data you need. Secondary data has the upside compared to primary that it is cheaper to collect but the reliability, validity and accuracy is not as great. You do not know where the data actually comes from and cannot fully trust is against primary data where you have more control.

Secondary data is easier to obtain and cheaper to get also. Some examples of secondary data (Kelly 2010):

- Magazines, Newspapers and Reviews
- Research articles

There is a third data source called tertiary data that is the search tools for obtaining secondary and primary data such as encyclopaedias and indexes. Often it is used in literature search when not knowing where to start searching for a specific topic (Saunders et.al. 2012). Our primary data collection will consist observation in different forms and the secondary data collection will be recent articles in the area of cloud computing and raspberry Pi, internet sources and literature that is within our field of research.

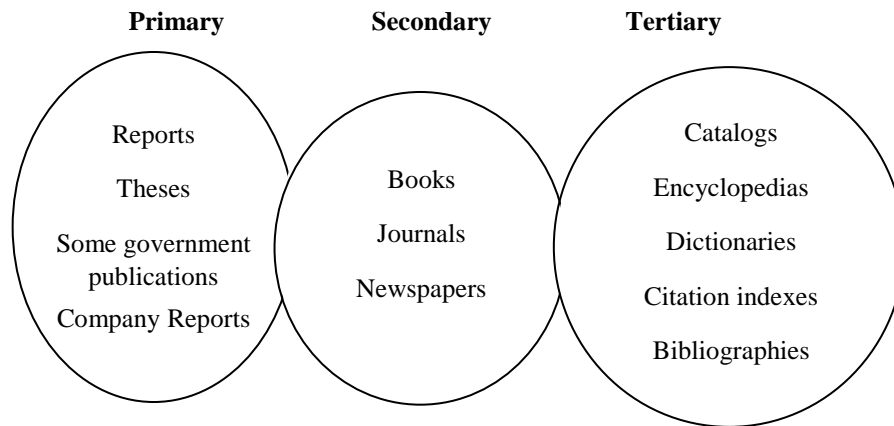


Figure 3: The different literature sources (Saunders et.al. 2009)

IV. RESULTS

Cloud computing is defined by the United States National Institute of Standards and Technology (NIST) as: "A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." (National Institute of Standards and Technology 2011).

In a similar vein, Mather, Kumaraswamy and Latif (2009) add that there are five common attributes of all cloud computing services: shared resources, massive scalability, elasticity, pay as you go and the self-provisioning of resources. While these definitions are technical and bureaucratic, they do provide some starting points to discuss what cloud computing is and how it can be analyzed sociologically. In simpler terms, cloud computing broadly refers to computing services, software and platforms that are not owned individually by users and installed locally on their personal computer, but rather accessed via an Internet connection.

From these characteristics of cloud computing, two ideas are of sociological significance. First, the idea of "convenient, on-demand" (National Institute of Standards and Technology 2011) services fits into the idea of what some authors have called a 'convenience culture.' For example, Tierney (1993) argues that one of the defining features of modernity is the consumption of 'conveniences.' He defines convenience as an "ability to mitigate the effects of bodily limits"; for something to be convenient it must make easy and simple an action that was previously difficult, impossible or troublesome.

```

pi@raspberrypi: ~
login as: pi
pi@192.168.1.81's password:
Linux raspberrypi 3.6.11+ #371 PREEMPT Thu Feb 7 16:31:35 GMT 2013 armv6l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Jul 19 15:11:33 2013 from colin-cflec9259
pi@raspberrypi ~ $ wget http://afterthoughtsoftware.com/files/linux-image-3.6.11-atsw-rtc_1.0_armhf.deb
--2013-07-19 15:25:56-- http://afterthoughtsoftware.com/files/linux-image-3.6.11-atsw-rtc_1.0_armhf.deb
Resolving afterthoughtsoftware.com (afterthoughtsoftware.com)... 46.32.253.15
Connecting to afterthoughtsoftware.com (afterthoughtsoftware.com)|46.32.253.15|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 14248980 (14M) [application/x-debian-package]
Saving to: `linux-image-3.6.11-atsw-rtc_1.0_armhf.deb'

100%[=====] 14,248,980 744K/s in 19s

2013-07-19 15:26:15 (742 KB/s) - `linux-image-3.6.11-atsw-rtc_1.0_armhf.deb' saved [14248980/14248980]

pi@raspberrypi ~ $

```

Figure 4: Checkout operator computer with Raspberry Pi installation

a) Raspberry Pi Setup with Owncloud

This is the second installment of the guide to install Owncloud on Raspberry Pi.

There has been certain changes with the latest version of Owncloud 7, and this guide should be able to help you to sail through smooth. Without much ado about what is Owncloud (which you already know) let's dive deep into tech details.

Setup admin account

While setting up the admin account you should provide the path to your data folder. You can ideally set this to your NAS drive or external drive, which you may have mounted. Owncloud will complain and not proceed with admin account if the data directory path is not readable & writable by the user www-data. Also it should not be readable by "others".

b) Setup Mount / Auto Mount USB Hard Drive on Raspberry Pi

Follow the simple steps in the order mentioned below to have your USB drive mounted on your Raspberry Pi every time you boot it.

These steps are required especially if you are setting up a Samba share, or a 24x7 torrent downloader, or alike where your Raspberry Pi must have your external storage already mounted and ready for access by the services / daemons.

Step 0.

Plug in your USB HDD / Drive to Raspberry Pi

If you are using a NTFS formatted drive, install the following

```
sudo apt-get install ntfs-3g
```

Step 1.

Log on pi using ssh terminal and execute:

```
ls -l /dev/disk/by-uuid/
```

You will see something like the following:

```
lrwxrwxrwx 1 root root 10 Jan 1 1970
0AC4D607C4D5F543 -> ../../sda1
```

Note down the value of the UUID --> 0AC4D607C4D5F543

Step 2.

Create a location for mount point:

```
sudo mkdir /media/NASDRIVE
```

Give proper permission:

```
sudo chmod 770 /media/NASDRIVE
```

Step 3.

Get the uid, gid for pi user and group with id command (usually 1000)

Step 4.

Mount the USB Drive and then check if it is accessible at /media/NASDRIVE

```
sudo mount -t ntfs-3g -o uid=1000, gid=1000, umask=007/dev/sda1 /media/NASDRIVE
```

Note:

ntfs-3g for NTFS Drives

vfat for FAT32 Drives

ext4 for ext4 Drives

Step 5.

Now, we will configure RasPi to do this after every reboot:

Take a backup of current fstab and then edit

```
sudo cp /etc/fstab /etc/fstab.backup
```

```
sudo nano /etc/fstab
```

Add the mount information in the fstab file (replace UUID with your own):

```
UUID=0AC4D607C4D5F543 /media/NASDRIVE ntfs-3g
uid=1000, gid=1000, umask=007 0 0
```

Step 6.

Reboot

```
sudo reboot
```

Step 8. (Optional, required if using as data storage for Owncloud)

If you are configuring ownCloud's data directory on your NAS drive, it should be having a 770 permission for www-data user. You can simply add user www-data to pi group, since it's already having 770 as permission as set above in fstab.

```
sudo usermod -a -G pi www-data.
```

In studies of black boxed technologies, objectivity is always implicit but rarely explicitly discussed. Part of this is likely due to the self-evidence of the objectivity of black boxed technologies. Technological entities are objective in multiple senses of the word: one, they are objects; and two, they behave consistently. Users of a black boxed technology who behave in accordance with the user scripts should expect the technology to behave the same way every time. Its internal workings and associations are reduced such that users provide an input and expect consistent outputs from the black box. The objectivity of technologies is, in this sense, very self-explanatory. Nevertheless, using the metaphor of the black box highlights a key point about the nexus between objectivity and technology: objectivity is an effect of a network or association's durability and stabilization. It is precisely when a network becomes black boxed that it becomes seen as objective. It is when those contingent associations and subjective actors are reduced (in other words, when the social has been reduced) that a technology that behaves consistently and objectively appears.

V. CONCLUSION

What are some repercussions of this analysis of Raspberry Pi ownCloud storage, users, cloud computing, and data privacy? OpenSSH is an application that allows you to securely access Linux systems remotely over the network. You can use OpenSSH simply for secure file sharing. But it also

allows you to log on to a system and control it over the network, even using the GUI, just as if you were sat in front of it. The default installation of Linux on your Raspberry Pi should have "SSH daemon" running. This means that your Raspberry Pi is listening on port 22 for a remote computer asking to make a connection to it. In your case, this will probably mean your normal desktop or laptop computer.

In Chapter Two, I found that there is a dearth of existing literature on Raspberry Pi personal cloud storage and data privacy that examines the role of user agency and that trust is one conceptual tool to avoid this problem. In Chapter Three, I outlined how using principles from Raspberry Pi and bring it in a shape to personal cloud storage, theory one could study trust and reimagine the role of user agency in discussing cloud computing. In particular, I outlined the methodological principles of Akrich's (1992; Akrich and Latour 1992) user scripts and description and the principle of co-production to look at how users and technologies are mutually working on each other. In applying these principles to my case study in Chapters Four and Five, I found that Raspberry Pi personal cloud storage, prescribed trust and privacy protection on its users, while maintaining security as its domain. Users, for the most part, accepted this script; however, some varying levels of trust were observed in users. What was noteworthy about the analysis in Chapter Five, however, was how in instances of breakdown, these user scripts and trust fall to pieces. This has led me to the conclusion that only when trust is shattered does privacy and the trade-off of personal privacy for use become contested and negotiable.

My example of cloud computing, and more specifically Raspberry Pi cloud storage, can highlight this principle. As discussed in the introduction, cloud computing is a great example of a heterogeneous assemblage. It is not a simple technological artefact but is rather an idea that encompasses a wide range of computing programs, hardware and human actors in order to be realized. Through my analysis of users of Raspberry Pi cloud storage, I have found that many of these users simply accept the user scripts of this program; they interact with Raspberry Pi cloud storage as a black boxed technology. They do not need to question or understand how Raspberry Pi cloud storage. Or how cloud computing more generally functions, they just need to know how to interact with Raspberry Pi cloud storage's user interface. To them, Raspberry Pi cloud storage is a program to store and synchronize files to be accessed at a later date, not a heterogeneous network of associated human and non-human actants.

When exploring technology and objectivity in this way, it is possible to conceptualize the understanding of trust I have put forth in this analysis. Trust simply becomes a necessary by-product of the stabilization and reduction of heterogeneous

associations, and the perceived objectivity of a technological entity. Technologies, here understood as stabilized networks, objectivity and trust all necessitate one another. Black boxed technologies are trusted to behave as expected, to behave objectively. If there is distrust in the technology, it is not perceived as completely objective; there is room for error. If the heterogeneity of a network is not completely reduced, there is more room for distrust as users must now trust each of the heterogeneous associations and not simply the homogenous black boxed technology.

Thus, technology, objectivity and trust go hand in hand; they all appear simultaneously as a heterogeneous network is reduced, stabilized and made durable. My findings, in Chapter Four and particularly Chapter Five thus suggest that Raspberry Pi cloud storage as a case study of cloud computing is not a completely stabilized technology, though it is well on its way. It is stable enough that users for the most part trust the technology and behave in accordance with its user scripts. However, there is still a concerted effort on the part of Raspberry Pi cloud storage to communicate its objectivity and trustworthiness and to further reduce its heterogeneity and the marginality of some users.

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